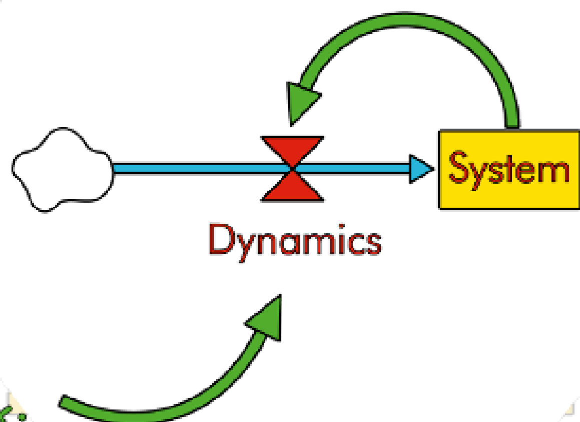
Money and Macroeconomic Dynamics



Accounting System Dynamics Approach

Edition 6

Kaoru Yamaguchi

Money and Macroeconomic Dynamics

Accounting System Dynamics Approach

Edition 6 (Draft Version)

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Preface to the Edition 6

Edition 6 is a major overhaul of the previous edition 5. First, a previous core chapter 5 is split into two chapters; Chapter 5 introduces new classification table of money according to our new duel definitions of money, and Chapter 6 analyzes creation process of debt money under fractional reserve banking system by clarifying flow and stock approaches. Secondly, Chapter 9 (previous chapter 8 titled "Aggregate Demand Equilibria") on the Keynesian macroeconomic model is comprehensively rewritten and split into a trilogy of IS-LM models. Chapter 9 starts with the analysis of traditional short-run IS-LM model. Chapter 10 analyses loanable funds and endogenous money IS-LM models. Chapter 11 expands to long-run IS-LM model. This trilogy proposes a paradigm shift from the traditional exogenous money IS-LM model to the endogenous money IS-LM model.

This edition 6 is completed, during my visit of 4 years (2019-22) in Turkey, through my graduate causes: Econ 505 (Monetary Theory) as a master program, and Econo 617 (Special Topics in Economic Dynamics) as a Ph.D. program. In Dec. 2019 a new-type of coronavirus (COVID-19) broke in Wuhan, China, and spread out at an unexpected speed world-wide, causing a global pandemic. Since spring semester, 2020 through fall 2021, we had no choice but to offer these lectures online. Under such hard time, this edition would not have been made possible without weekly discussions with my students on line. In addition, Yokei Yamaguchi, a young researcher in Japan, has been a constant source of encouragement to this edition. I'm truly grateful to all of them.

Following the Great Depression of 1929, two proposals were made, to avoid such socio-economic disasters, by the two great economists in those days; The General Theory of Employment, Interest and Money by John M. Keynes (1935) and 100% Money by Irving Fisher (1935). This book started as an off-road journey in 2013 in order to integrate these two preeminent proposals, and provide an alternative solution called *Public Money System*. Nine years have passed since then. With this new edition 6, I strongly feel my off-road journey is finally getting on a mainstream journey. It is the author's genuine hope that this edition 6 would become a new economic vaccine against a looming calamity of world-wide recessions caused by COVID-19.

June 24, 2022

Kaoru Yamaguchi, Ph.D.

At the Social Sciences University of Ankara

Republic of Turkey

Preface to the Edition 5

After a completion of the edition 4.0 as an electronic book in Jan. 2019, I had an opportunity to provide lectures based on this book for advanced Ph.D. and Master classes in economics at the Social Sciences University of Ankara. This opportunity gave me a chance to revisit Chapters 1 through 8 in detail, and revise them whenever needed. I do truly appreciate for valuable comments given by the Ph.D. and Master students in my classes.

Since no hard copies of the book have been made available except its first edition in Japan in 2013, I have distributed pdf files of the book, lecture by lecture, in my classes. Gradually I have strongly felt a need for hard copies of my book as a quick reference in my classes. Under such circumstances, I happen to obtain a possible publication of this book. I'm very grateful for this unexpected opportunity.

At the moment of writing this preface, a new-type of coronavirus (officially called Covid-19), which broke in Wuhan, China, in Dec. 2019, has spread at an unexpected speed world-wide in 3 months and became a global pandemic. This global pandemic is slowing global economic activities all of sudden, and is feared to be a trigger of yet another Great Depression since 1929. Following the Great Depression of 1929, two proposals were made, to avoid such socio-economic disasters, by the two great economists in those days; The General Theory of Employment, Interest and Money by John M. Keynes (1935) and 100% Money by Irving Fisher (1935). This book tries to integrate these two preeminent proposals, and provide an alternative solution against a looming Great Depression. It is the author's genuine hope that this edition would become a new economic vaccine against such a looming calamity.

April 1, 2020

Kaoru Yamaguchi, Ph.D.

At the Social Sciences University of Ankara

Republic of Turkey

Preface to the Edition 4

Since the publication of first edition of this book in Nov. 2013, more than 5 years have passed. I'm pleased to share with the reader that the macroeconomic method of Accounting System Dynamics first proposed in the book is getting accepted, though gradually, among young economists and researchers of macaroeconomics who are not fully content with the current mainstream macroeconomic modeling such as Neoclassical DSGE and New Keynesian models.

Since the publication of the first edition, our economic world is experiencing the so-called *Blockchain Revolution*. Our first edition through edition 3.1 have overlooked this revolution which is drastically changing the way we theorize macroeconomic activities. Under these circumstances, I have strongly felt a necessity to reconsider futures of the public money system in the age of blockchain revolution.

In this edition of 4.0, therefore, I have wholly paid attention to electronic public money, or crypto-public money, as *money of the futures*, following the discussions on public money system in the previous editions. Specifically, Part V of Electronic Public Money is newly added to this edition. It consists of a single additional chapter, Chapter 17, that demonstrates electronic public money as money of the futures.

With this new addition, I have strongly felt that my long journey toward a better world through Public Money System becomes immensely closer to its final destination. The remaining fine-tuning works will be left to the younger generations of economists and researchers.

January 26, 2019

Kaoru Yamaguchi, Ph.D.

At the Social Sciences University of Ankara

Republic of Turkey

Preface

My Off-Road Journey for A Better World

Futures Studies

In early 1980's, I was told by one of the graduate colleagues at the University of California, Berkeley, that if I continue the research involving Marx and Keynes in addition to neoclassical theory, I would never get a good job offer in the United States. He was right. It was a time for Reganomics which has eventually evolved to the era of globalization in 1990's. Paying little attention to his thoughtful suggestion, I pursued my Ph.D. thesis on the subject "Beyond Walras, Keynes and Marx - Synthesis in Economic Theory Toward a New Social Design", which, alas, became a start of my off-road journey. Main part of the thesis was luckily published with the same title Yamaguchi (1988), yet it has been left unnoticed among main stream economists.

When I started teaching at the Dept. of Economics, University of Hawaii at Manoa, I almost lost my energy to continue the research on neoclassical mathematical theory for academic survival, because the theory seemed to be totally detached from the economic reality. It was in those discouraged days when my introduction to the futures studies and Prof. Jim Dator, then secretary general of the World Futures Studies Federation, took place by chance in Hawaii in 1987. Upon arrival to Japan next year, I immediately joined the Federation, and became very active on futures studies for more than ten years since then.

Among the activities of futures studies I have been involved, a major one was the organization of futures seminar series in Awaji Island, Japan, with an objective to establish a future-oriented higher institution dubbed the Network University of the Green World (http://www.muratopia.org/ NUGW). The seminars had been held for seven years from 1993 through 1999, then suspended due to the lack of fund. In the book based on the first seminar in 1993, I have proclaimed that

> Thus, what has been missing in industrial-age scientific research, and hence in the academic curricula of present-day higher institutions, is a study of interrelated wholeness and interdependences (Yamaguchi, 1997, p.200).

In order to fill the missing niche, I have tried, with a help by the seminar participants, including Novel laureate Jerome Karle, to establish a new wholistic field of study dubbed FOCAS, meaning Future-Oriented Complexity and Adaptive Studies, in vain. Yet, my conviction on the need for such futures studies for higher education continued to remain as worth being upheld. Faced with the threat of our survival due to climate changes and environmental disasters, future-oriented studies of interrelated wholeness and interdependence is, I believe, more urgently needed for solving these complex problems, since solutions offered by fragmented professionals at the current higher institutions might be the causes of another problems as Asian wisdom connotes. For our survival and sustainability, we need future-oriented higher education which provides wholistic visions and solutions to the present complex problems caused by fragmented science and technology of the present-day higher education. This conviction became a fruit of reward for me at the cost of abandoning neoclassical economic research in a traditional academic stream.

System Dynamics

Throughout the future-oriented activities later on, I was luckily led to the systems view, specifically a method called system dynamics, by chance. It seemed to me a totally new field of study that makes a heavy use of computer simulation for analyzing dynamic behaviors of system structures in physics, chemistry, engineering, environmental studies, business and economics, and public policies, to name a few, in a uniform fashion. In short, its methodology can uniformly cover many fragmented fields of studies, and in this sense it seemed for me to be able to share a similar interdisciplinary vision with future-oriented studies. After many years' frustration on the futures studies, I've jumped in the fieled by attending its international conference in Istanbul, Turkey, in 1997. Since then I have been continually attending the system dynamics conferences up to the the present day.

It didn't take much time to realize that, due to its interdisciplinary nature, system dynamics is also facing a similar difficulty in finding an academic position as a discipline in the current extremely fragmented higher educational system, as future-oriented studies have been suffering similarly. In other words, system dynamics and futures studies can have no comfortable places in the current universities. The only difference is the use of computer in the former, and the use of our brain in the latter.

Hence, it seemed to me that future-oriented studies and system dynamics constitute two major fields of future's higher education, using our brain on the one hand and computer on the other hand for a study of interrelated wholeness and interdependence in order to attain human and environmental sustainability. In fact, it has been repeatedly argued at the international conferences whether system dynamics is merely a tool or discipline. For me it seemed to be not to the point and accordingly a fruitless argument.

On the contrary, the following description by Prof. Jay Forrester, a founder of system dynamics, on the nature of system dynamics looked to me to the point.

> Such transfer of insights from one setting to another will help to break down the barriers between disciplines. It means that learning in one field becomes applicable to other fields. There is now a promise of reversing the trend of the last century that has been moving away from the "Renaissance man" toward fragmented specialization. We can now work toward an integrated, systemic, educational process that is more efficient, more appropriate toward a world of increasing complexity, and more compatible with a unity in life Forrester (1989a).

It is a useless effort to search for an appropriate academic citizenship at the current fragmented higher education. In this sense, it seems to be a right choice to introduce the visions and methods of system dynamics to the K-12 education where academic fragmentation does not yet break down into the learning process. The reader may visit a creative learning Web site for its successful introduction at http://clexchange.org.

I felt I have finally been led to a right truck, after more than a decade-long off-road journey, toward a better world. If I had stayed at the economics profession, I would have never encountered system dynamics as most economists are currently still unaware of it. What I have learned from system dynamics is the importance of system design.

My continuing off-road journey got refurbished with this spirit of system design. In the falls of 1998 and 1999, I had a chance to visit MIT where I was introduced systems thinking and system dynamics for the first time as if I was a first-hand learning student by Prof. John Sterman and his doctorate students as well as Prof. Jay Forrester and his undergraduate team of Road Map project (educational self-learning system dynamics program through Web). This became my off-road journey of no return from system dynamics in my profession.

Accounting System Dynamics

Instead of being forced to stay in the economics profession, I was luckily given a chance to teach system dynamics at two management schools in Japan; first at the Osaka Sangyo University in Osaka, then Doshisha Business School in Kyoto. System dynamics obtained its first citizenship in this way as academic subject to be taught in the fragmented higher educational system in Japan.

Eventually, as a faculty member of management and business schools, I strongly felt it necessary to cover accounting system in my system dynamics class. Yet, my search for SD-based accounting system turned out to be unsuccessful, giving me an incentive to develop a SD method of modeling financial statements and accounting system from a scratch. I started working on the SD-based accounting system in the summer of 2001 when I was spending relatively a quiet time on a daily rehabilitation exercise in order to recover from the physical operation on my shoulder in June of the same year. This retreat environment provided me with an opportunity to read books on accounting intensively. My readings mainly consisted of the introductory books such as Franklin J. Plewa and Friedlob (1995), Ittelson (1998), Kremer and Case (2009), Tracy (1996) and Tracy (1999), since my knowledge of accounting was limited in those days[1]. Through such readings, I have been convinced that system dynamics approach is very effective not only for understanding the accounting system, but modeling many types of business activities. This conviction fruitfully resulted in my presentation on the principle of accounting system dynamics at the 21st international conference of the System Dynamics Society in New York in 2003 Yamaguchi (2003), which became a turning point in my off-road journey.

Rekindled in Berkeley, California

In the same summer of 2003, I was luckily offered an 8 months' sabbatical leave, and came back to Berkeley in almost 18 years since I left in 1986, this time as a visiting scholar at the Haas School of Business, not the Economics Department. My old friend, Nobie Yagi, from Berkeley days kindly provided his second house on his site for my family's stay, which gave me a good opportunity to talk with him almost daily. He received Ph.D. in finance and options trading from Berkeley around the same time as I did.

Conversation with him, together with my research environment at the business school rekindled my interest in economics, specifically macroeconomics and finance again. Even so, in those days I have already taken an off-road journey away from main stream economics, and decided to investigate it from my off-road side way. Specifically, I resolved to start reconstructing macroeconomic theories on the basis of the principle of accounting system dynamics which was completed in the same summer.

Since then, being led by the inner logic of accounting system dynamics and macroeconomics, I have spent almost my entire off-road journey on a step-by-step construction of macroeconomic models, which turned into a series of presentation of papers such as Yamaguchi (2004b), Yamaguchi (2005), Yamaguchi (2006) and Yamaguchi (2007). This series of macroeconomic modeling was completed in 2008 as Yamaguchi (2008) with a follow-up analytical refinement method of price adjustment mechanism in Yamaguchi (2009) next year.

An Oasis in Wellington, New Zealand

Second good luck visited me on my off-road journey as two months' short sabbatical leave in 2009 at the Victoria Management School, Victoria University of Wellington, New Zealand. Prof. Robert Y. Cavana, a well-known leading scholar in system dynamics, kindly hosted my visit. This good luck enabled me to review the above paper series uniformly for the publication of this book.

[1] In addition to these books, a paper dealing with corporate financial statements Bianchi (2002) was published in 2002. However, current research for modeling financial statements is independently carried out here with a heuristic objective in mind.

Almost daily conversation with him over lunch, as well as a lovely research environment in Wellington, encouraged me to keep working on the draft. Without this stopover in New Zealand as an oasis in my off-road journey, the draft would not have been completed.

National Model

I was a late comer to the research community of system dynamics. While my step-by-step macroeconomic modeling was advancing, some researchers have kindly suggested at the conferences that I should review the research papers on the National Model project that was led by Prof. Jay Forrester with several Ph.D. students at MIT.

Unfortunately, the national model itself was not available and its related papers were scattered around. Under such situation, my survey managed to cover the following papers Forrester (1979), Forrester (1980), Forrester (1981), Forrester (1984), Forrester (1989b), Forrester (1990), Forrester (1996), Forrester (1997a), Forrester (1997b), Forrester (1998), Forrester (1999), Forrester (2003), Graham (1984), Hines (1987), Sterman (1985), Sterman (1986). Yet, the review of these papers only gave me an impression as if I were, with my eyes closed, touching various parts of an elephant without knowing what the elephant looks like. During the 23rd international conference of System Dynamics Society in New York, July, 2005, in which I presented a SD-based Keynesian model, I have strongly felt that my research cannot advance without understanding a whole picture of National Model, because my modeling approach, I feared, might have been already taken by the National Model project team.

Without losing time, in September of the same year, I visited Prof. Jay Forrester in his office at MIT. We spent almost two hours on discussing about his National Model. He told me that the national model is still going on, and I may have no chance to take a look at it until it's completed. Even so, the conversation turned out to be very fruitful to me, out of which I got convinced that my modeling approach on the basis of accounting system dynamics is quite different from his modeling method. This conviction gave me an energy to continue my off-road journey in my own way. At the same time, I truly hoped that the national model would be completed in the near future.

In the spring of 2007, I was invited to review the Ph.D. dissertation of David Wheat at the University of Bergen, Norway, whose title is "The Feedback Method: - A System Dynamics Approach to Teaching Macroeconomics Wheat (2007)". His model, written by Stella software, seemed to me to be a simple version of the National Model. In this sense it became the first macroeconomic (national) model ever presented to the public. In the following year, at the 26th international conference of System Dynamics Society, Athens, Greece, I have presented a complete macroeconomic model, written by Vensim, on the basis of accounting system dynamics Yamaguchi (2008).

US Congressional Briefing

After a completion of my macroeconomic model in 2009, I was taking a rest in a foggy day at a vista point on my off-road journey. Financial crisis triggered by the bankruptcy of Lehman Brothers in 2008, followed by a series of government debt crises in the US and EU, blew away thick fog and all of a sudden a lofty peak of better world I've been searching for emerged in front of me. It was a peak of new macroeconomic system of public money. When I looked back the trail I followed so far, it turned out to be a macroeconomic system of debt money.

A glimpse of this new peak of hope drove me again into writing papers Yamaguchi (2010) and Yamaguchi (2011) toward a better world. On the next day of the presentation of my paper Yamaguchi (2011) at the 29th International Conference of the System Dynamics Society in Washington DC, that is, on July 26, 2011, I was invited by the Congressman Dennis Kucinich to present the findings of my macroeconomic simulations on the workings of public money system at the US Congressional Briefing. This unexpected invitation recharged my driving energies toward a steeper trail on my off-road journey.

The peak of the better world is a green and sustainable world. It will be described in the last chapters of 12, 13, 14 and 15 (Part IV). Coincidentally this turned out to be the reinvigorated world of MuRatopian economy I've vehemently pursued in my dissertation in 1980's as a new social design.

Beyond

While working on my dissertation on "Beyond Walras, Keynes and Marx", I was once visited by a daydream that an academic torch of economic thoughts has been handed over from Karl Marx to John M. Keynes and from Keynes to me. It occured unexpectedly when I happened to realize the fact that Keynes was born in the year 1883 when Marx passed away, and I was born in the year 1946 when Keynes passed away. Since then I've been enslaved by a sense of scientific mission, though the reader may laugh at its mirage, that I should carry on and go beyond their economic thoughts for a better world.

Modern macroeconomic foundation was laid by the Keyne's esteemed book: The General Theory of Employment, Interest and Money published in 1936. When I encountered the title for the first time as a young student of economics, I got puzzled and confused by the order of "employment, interest and money". Nowadays, students may have no such puzzles because almost all macroeconomic textbooks start with the analysis of GDP that determines the level of employment, followed by the aggregate demand that constitutes GDP such as consumption and investment. Then interest and money supply are introduced as a determinat of investment. Under the Keynesian analytical framework, money has been all the time treated as an adjunct to the macroeconomic system; that is, money has been regarded as an exogenous entity, not as an endogenous one. This may be the reason why employment comes first, followed by interest and money comes last in the title of the book.

On the contrary, the title of this book, though it deals with similar subjects as Keynes, starts with the analysis of money and interest, followed by macroeconomic dynamics. The book is founded on the method of Accounting System Dynamics. Accounting system has been the most rigorous method in social science, while system dynamics has been the robust foundation of dynamic analysis (that is, differential equations) in natural science since Newton. In this sense, this methodology could be said to provide the most robust tool for analyzing the structure of macroeconomic behaviors. This analytical method that is being applied to the macroeconomic analysis has revealed that *money matters by all means* or *money is all the time endogenous* as the reader may be convinced by going through the book. In other words, without money comprehensive macroeconomic models are first of all unable to be constructed. Money continues to sit in the center of all macroeconomic behaviors. This is why the title of this book becomes "Money and Macroeconomic Dynamics". In the Keynesian sense, the title of the book may be called "The General Theory of Money, Interest and Employment. The torch of Keynes' General Theory is now to be carried over in a thoroughly reversed order!

Moreover, it lights up the macroeconomic systems analyzed in Part II and III of the book as a *debt money* system in which Walras, Keynes and Marx used to live and we are living today, while it illuminates the macroeconomic systems designed in Part IV as a *public money* system in which we'll live in the near future as a sustainable world beyond the current debt money system.

Let me stop my off-road journey at this point. It is my hope that the reader will continue this off-road journey to the summit, so that, as travelers and hikers increase, it eventually becomes a main road journey for a better and green world.

With many thanks to those who guided me and offered a cordial help during my off-road journey, on my birthday:

June 24, 2013

Kaoru Yamaguchi, Ph.D.

At the Japan Futures Research Center
Awaji Island, Japan

Acknowledgments

First of all, I would like to give my cordial thanks to those who have helped me during my off-road journey: Jim Dator, Matthias Ruth, Jay Forrester, John Sterman, Nobie Yagi, Robert Y. Cavana, David Wheat, Andrew Ford, Dennis Kucinich.

I have started using this draft as a main reference in my MBA classrooms since 2009. Feedback comments and suggestions from my students, Hisashi Deguchi, Hiroyuki Hori and Nobuo Nishi, turned out to be very helpful to improve the draft, for which I do express my acknowledgments. Prof. Yutaka Takahashi has read the draft and given me some valuable comments, to whom I am very grateful.

Meanwhile, I have taken opportunities to offer the SD workshops at the 28th International Conference of the System Dynamics Society, in Seoul, Korea, July 29, 2010, at the 29th Conference in Washington DC, USA, July 28, 2011, and at the 30th Conference in St. Gallen, Switzerland, July 26, 2012, under the theme: An Introduction to Macroeconomic Modeling – Accounting System Dynamics Approach. Many SD researchers and students from the conferences have participated in the workshops and gave me very valuable suggestions and comments on my analytical method of macroeconomic modeling, convinced me simultaneously that it's on the right track, for which I truly thank them all.

Additionally I was given invaluable opportunities to present the contents in Part IV: Macroeconomic Systems of Public Money at the 6th, 7th and 8th Annual AMI (American Monetary Institute) Monetary Conferences in Chicago, USA, in 2010, 2011, and 2012. I truly thank Stephen Zarlenga, the director of AMI, and Jamie Walton, the AMI researcher, for providing these opportunities, and conferences participants, specifically Joe Bongiovanni, for their worthy comments and suggestions. These turned out to be very prolific for deepening my analyses.

Finally, I do warmheartedly appreciate the patience of my families; Naomi, Daichi and Yokei for my relinquishing fun time with them on holidays due to my off-road journey. Latest edition 5.0 would not have been completed without intensive and in-depth exchanges of ideas with Yokei Yamaguchi, a young researcher at the Japan Futures Research Center.

Gassho!

A Quick Tour of the Off-Road Journey

Let us now begin with a quick tour of the author's off-road journey. The reader is recommended to follow chapter by chapter to fully comprehend the macroeconomic model-building structures based on the accounting system dynamics approach, because most models built in the book are constructed step by step by following the previous models. Your feedbacks are mostly appreciated by the author through his email at kaoru.yamaguchi@asbu.edu.tr or kaoru3-860@muratopia.net.

Part I Accounting System Dynamics

Chapter 1 introduces the author's way of understanding system dynamics from a dynamics viewpoint. Those who have its background may still find some useful features of system dynamics.

Chapter 2 compares general equilibrium price adjustment mechanism of demand and supply with off-equilibrium adjustment mechanism that is made possible by the system dynamics method of incorporating inventory. This off-equilibrium approach becomes a point of departure of our macroeconomic analysis from the neoclassical equilibrium analysis.

Chapter 3 combines the principles of system dynamics with those of accounting system. The unified principle is called the Principle of Accounting System Dynamics, which constitutes one of the most robust foundations for the analysis of macroeconomic dynamics.

Part II Debt Money System

Chapter 4 overviews macroeconomic system of debt money. This chapter investigates a simple capitalist market economy consisting of traditional budget equations by applying the principle of accounting system dynamics. The economy is constructed on the framework of monetary flow such that the so-called Say's law holds; that is, a well-known Goodwin Growth Cycle model. It is then applied to the monetary Goodwin model to find out if this integrated monetary economy with interest triggers business cycles into economic recessions.

Chapter 5 explores the nature of money with its classification table by two definitions of money, and explores its creation through a fractional reserve banking under current debt money system with flow and stock approaches. Then monetary theories are classified into four theories.

Chapter 6 comparatively investigates functional-money creation processes under both flow and stock approaches step by step from the case of the gold standard to the case of loan to banks, then loan to government. Then flow and stock approaches are shown to be identical.

Chapter 7 continues the analysis of money creation from the previous chapters, and discusses how money stock is endogenously determined by the demand for borrowing money by producers, households and government by running the ASD models of money creation in the previous chapter. Endogenous destruction and instability of money stock are explored.

Chapter 8 expands the analysis of money to interest and examines the equity distribution between non-financial sector and banks. These analyses are made under the following four cases: Gold standard, loans to banks, government debts and open market operations.

Part III IS-LM Models of Debt Money System

Chapter 9 discusses a typical Keynesian macroeconomic model of aggregate demand where Say's law no longer holds by applying system dynamics adjustment process. First, a Keynesian short-run IS-LM equilibrium model is explored by building its SD model, which is, then, extended to a case of flexible price. according to the double-entry bookkeeping accounting rules.

Chapter 10 The SD model is further expanded to the ASD model in which all macroeconomic sectors such as producers, households, government, banks and central bank make transactions with their budget equations. Then, loanable funds and endogenous model are constructed and compared.

Chapter 11 expands the ASD model of endogenous money short-run IS-LM to the long-run case in which production capacity is determined by the capital accumulation.

Part IV Macroeconomic Systems of Debt Money

Chapter 12 integrates the previous short-run and long-run analyses of IS-LM models and construct a standard macroeconomic model.

Chapter 13 incorporates population dynamics and labor market with the introduction of Cobb-Douglas production function. This chapter completes our comprehensive macroeconomic analysis under the debt money system. It reveals an inescapable accumulation of government debt even under an ideal equilibrium path in the real sector.

Part V Open Macroeconomic Systems of Debt Money

Chapter 14 sets off open macroeconomic analyses debt money system through chapter 15. This chapter explores a dynamic determination of foreign exchange rate in an open macro economy in which goods and services are freely traded and financial capital flows efficiently for higher returns.

Chapter 15 expands the comprehensive macroeconomic model in chapter 13 to the open macroeconomies on the basis of the framework developed in the previous chapter. It provides a complete generic macroeconomic model of open macroeconomies as a closed system of debt money.

Part VI Public Money System

Chapter 16 sets off our macroeconomic analyses of public money system through chapter 20. This chapter discusses how the government debt crisis is structurally built in the current macroeconomic system of debt money. Then it demonstrates how the government debt can be liquidated under an alternative macroeconomic system of public money, proposed by the American Monetary Act, by revisiting the integrated macroeconomic model developed in chapter 8.

Chapter 17 analyzes the workings of a public money system under the most comprehensive open macroeconomies developed in chapter 11. Then it is demonstrated that under the public money system government debt can be liquidated without triggering recession, unemployment and inflation both in domestic and foreign economies.

Chapter 18 explores monetary and financial stability under the public money system in comparison with the current debt money system by constructing a simplified macroeconomic model with a stock approach of credit creation presented in chapter 5.

Chapter 19 searches for a better design of our macroeconomic system for our sustainable futures. First, it examines the public money system in comparison with the current debt money system. Then, the MuRatopian economy that was introduced in 1988 is revisited as a complementary system. Finally, the integrated system of these two is proposed as the best design of macroeconomic system for our sustainable futures.

Chapter 20 proposes a transition process from the debt money system to the public money system by constructing a simple macroeconomic model based on the accounting system dynamics. The model briefly handles main features of the debt money system, in 8 steps, that cause "booms and depressions", debt accumulation and failures of recent quantitative easing financial policy. It then offers a transition process to the public money system in 6 steps.

Part VII Electronic Public Money

Chapter 21 explores a new public money system in the age of blokchain and crypto-money. Electronic Public Money (EPM) in the form of crypto-money is posed to be *money of the futures*. It proposes seven protocols for EPM to be the money of the futures.

ASD Models and Figures in the book

The reader is highly encouraged to confirm the simulation results in the book by running the companion models mentioned chapter by chapter. In this way, the reader may enjoy running simulations according to his or her own interest in macroeconomic behaviors.

All ASD models used in the book are freely available at

http://www.muratopia.org/Yamaguchi/MacroBook.html
http://www.muratopia.net/YamaguchiKaoru/Yamaguchi/MacroBook.html

Some Figures in thebook may be unfortunately too small to identify the details. Accordingly, they are also freely available for the convenience of the reader at the same Web sites as above.

Edition Notes

Edition 1.1 Figure 3.10 is revised. Minor type errors in Preface, Chapters 1, 9 and 15 are corrected.

Edition 2.0 Chapter 16 is newly added. Figure 11.6 is revised. Minor type errors are corrected.

Edition 3.0 Chapter 5 is fully revised with money creation models of both flow and stock approaches. Terminologies such as "money supply" and "monetary base" in the Chapter are replaced with "money stock" and "base money", respectively.

Edition 3.1 Chapter 3 is partly revised with revised definitions of Asset Management Ratios.

Edition 3.2 Classification of Money (Table 5.2 in Chapter 5) is slightly revised. Type errors in Bibliography are corrected.

Edition 4.0 Chapters 18 is newly added to the book as "Part V: Electronic Public Money". Preface to the edition 4.0 is newly written.

Edition 5.0 Subsection of Chapter 1 (Present Values) is added. Chapters 4, 5 and 7 are substantially revised. Chapter 6 is newly augmented. IS-LM analysis in Chapter 8 is expanded. Minor changes in Chapters 2, 3, 4, 9 and 16 are made.

Edition 5.1 Chapters 5, 6 and 18 are revised with new classification tables of money stock that include front face and back face of money definition. Chapter 2 is expanded with "Questions for Deeper Understanding".

Edition 5.2 Classification Table of Stock in Chapter 1 is expanded. Chapter 6 is expanded with Worksheet of Macroeconomy, and revised with linear regression equations in the section of "A Case in Japan". Chapter 7 is slightly revised.

Edition 5.3 Classification Tables of Money in Chapter 5 and 18 are slightly revised. Chapter 6 is slightly revised and its section of "A Case in Japan" is fully updated.

Edition 6.0 Chapter 5: Money and Its Creation is divided into two chapters; that is, Chapter 5: Money and Chapter 6: Creation of Money. In Chapter 6, loans to Government are divided into three parts: Government Debts by the Public, by Banks with Reserves and by Banks with Excess Reserves in the models: 3 Money(Flow-approach).vpmx, 3a Money(Stock-approach).vpmx and 4a Money(Stock-Instability).vpmx
Chapter 9 (previous Chapter 8) is completely revised and expanded into IS-LM trilogy chapters: that is, Chapter 9 (short-run IS-LM model), Chapter 10 (Endogenous Money IS-LM model), and Chapter 11 (long-run IS-LM model).

Postscript

Due to the budgetary constraint[2], the author was unable to get an editorial help in English. Accordingly, the reader would be kindly asked to accept the author's apologies for some clumsy writings that still remain in this book.

[2]This was caused by the sudden termination of the author's academic position, in March 2013, at the Graduate School of Business, Doshisha University, Kyoto, due to the use of system dynamics in his MBA lecture of Business Economics. Concerned researchers of system dynamics and economics overseas sent letters of petition to the president and dean of the university to stop the violation of academic freedom in vain.

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Part I

Accounting System Dynamics

Chapter 1

System Dynamics

This chapter[1] introduces system dynamics from a dynamics viewpoint for beginners who have no formal mathematical background. First, dynamics is dealt in terms of a stock-flow relation. Under this analysis, a concept of DT (delta time) and differential equation is introduced together with Runge-Kutta methods. Secondly, in relation with a stock-dependent flow, positive and negative feedbacks are discussed. Then, fundamental behaviors in system dynamics are introduced step by step with one stock and two stocks. Finally, chaotic behavior is explored with three stocks, followed by discrete chaos.

1.1 Language of System Dynamics

What is system dynamics? The method of system dynamics was first created by Prof. Jay Forrester, MIT, in 1950s to analyze complex behaviors in social sciences, specifically, in management, through computer simulations Forrester (1961). It literally means a methodology to analyze dynamic behaviors of system. What is system, then? According to Jay Forrester, a founder of this field, "A system means a grouping of parts that operate together for a common purpose Forrester (1971), page 1-1." For instance, following are examples of system he gave:

- An automobile is a system of components that work together to provide transportation.
- Management is a system of people for allocating resources and regulating the activity of a business.
- A family is a system for living and raising children.

[1]This chapter is based on the paper presented at the 17th International Conference of the System Dynamics Society: *Systems Thinking for the Next Millennium*, New Zealand, July 20 - 23 ,1999; specifically in the session L7: Teaching, Thursday, July 22, 1.30 pm - 3.00 pm, chaired by Peter Galbraith.

According to Edward Deming, a founder of quality control, " A system is a network of interdependent components that work together to try to accomplish the aim of the system Deming (1994), p. 50."

Both definitions share similar ideas whose keywords are: interdependent parts or components, and common purpose or aim.

To describe the dynamics of system thus defined, Forrester created a language of system dynamics consisting of four building blocks: Stock, Flow,Variable and information Arrow. They are illustrated in Figure 1.1. Flow is always connected to Stock. Arrow connects Variable, Flow and Stock.

This is a very genius idea. To describe a system, no matter how big it is, all we need is four building blocks (or letters) and their simple grammar. Compared with this, 26 letters in English and 55 phonetic letters in Japanese are required for writing a sentence, paper, or a book. As an analogy, let us consider our body as an example of system consisting of about 30 thousand genes. Yet they are created by four building blocks of DNA.

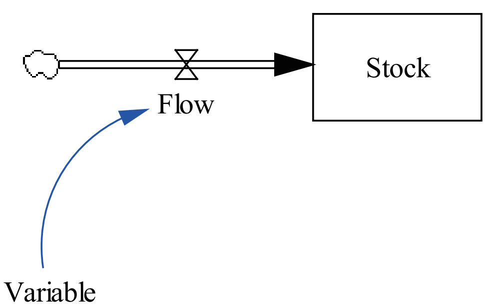


Figure 1.1: Language of System Dynamics

Textbooks and Softwares

Several textbooks are now available for learning how to build a system with the above four building blocks such as Sterman (2000) and Warren (2002) for business and management modeling, and Meadows et al. (1992) and Ford (1999) for sustainable environment. The reader is strongly recommended to learn system dynamics with these textbooks. I regularly use Sterman (2000), Warren (2002) and Meadows et al. (1992) in my MBA and policy classes.

Another way to learn quickly is start using SD softwares such as Stella, Vensim and PowerSim with manuals. For the modeling in this book, I have selected Vensim for two reasons; its graphical capability for creating a model and availability of its free version such as Vensim PLE and Vensim Model Reader. It is recommended that the reader runs the models attached to this book simultaneously.

Economics students might need a little bit more rigorous approach to modeling in relation with difference and differential equations, which is, however, not well covered in the above introductory textbooks, This is why I decided to add another introduction to system dynamics method in this chapter.

1.2 Dynamics

1.2.1 Time

For beginners system dynamics seems to be an analysis of systems in terms of feedback mechanisms and interdependent relations. In particular this is true when graphics-oriented softwares of system dynamics become available for PCs and Macs such as Stella, Vensim and PowerSim, enabling even introductory students to build a complicated dynamic model easily without knowing a mechanism of dynamics and differential equations behind the screen.

Accordingly, the analysis of dynamics itself has been de-emphasized in a learning process of system dynamics. Dynamic analysis, however, has to be a foundation of system dynamics, through which systems thinking will be more effectively learned. This is what I have experienced when I encountered system dynamics as a new research field.

Dynamic analysis needs to be dealt along with a flow of time; an irreversible flow of time. What is time, then? It is not an intention to answer this philosophically deep question. Instead, time is here simply represented as an one dimensional real number, with an origin as its initial starting point, that flows toward a positive direction of the coordinate.

In this representation of time, two different concepts can be considered. The first concept is to represent time as a moment of time or a point in time, denoted here as τ; that is, time is depicted as a real number such that τ= 1, 2, 3, $\ldots$. The second one is to represent it as a period of time or an interval of time, denoted here as t, such that t = 1st, 2nd, 3rd, $\ldots$, or more loosely t = 1, 2, 3, $\ldots$ (a source of confusion for beginners). Units of the period could be a second, a minute, an hour, a week, a month, a quarter, a year, a decade, a century, a millennium, etc., depending on the nature of the dynamics in question.

In system dynamics, these two concepts of time needs to be correctly distinguished, because stock and flow - the most fundamental concepts in system dynamics - need to be precisely defined in terms of either τ or t as discussed below.

1.2.2 Stock

Let us now consider four building blocks or letters of system dynamics language in detail. Among those letters, the most important letter is stock. In a sense, system could be described as a collection of stock. What is stock, then? It could be an object to be captured by freezing its movement imaginably by stopping a flow of time, or more symbolically by taking its still picture. The object that can be captured this way is termed as stock in system dynamics. That is, stock is the amount that exists at a specific point in time τ , or the amount that has been piled up or integrated up to that point in time.

Let x be such an amount of stock at a specific point in time τ . Then stock can be defined as $x(\tau)$ where τ can be any real number.

Stocks thus defined may be classified according to their different types of nature as follows.

Physical Stock	Non-Physical Stock
• Natural Stock • Capital Stock • Goods-in-Process and Use	• Information • Psychological Passion • Indexed Figures

Table 1.1: Classification of Stock

- Natural stock consists of those that exist in our natural environment such as the amount of water in a lake, number of trees and birds in a forest and wild animals on earth.
- Capital stock is a manufactured means of production such as buildings, factories and machines that have been used to produce final goods. In addition, world population and cattle in a ranch, etc. are also regarded as live capital stocks.
- Goods-in process are those that are in a process of production, which are sometimes called intermediate goods, and goods-in-use are final products that have been used by consumers such as cars and computers.
- Information (and knowledge) is non-physical stock that is stored in various forms of media such as papers, books, videos, tapes, diskettes, CD and DVDs, and memory cards. Money is stock of value information stored on banknotes and government coins.
- Psychological passion is emotional stock of human beings such as love, joy, happiness, hatred and anger that have been stored somewhere in our brain tissues.
- Indexed figures are specific forms of information stock that are (scientifically) defined to describe the nature of environment and human activities such as temperature, prices, deposits and sales values.

1.2.3 Stock-Flow Relation

Since Newton, it has been a challenge in classical mechanics to describe a change in stock. One of the methods widely employed is to capture the amount of stock at various discrete points in time, $\tau = 0, 1, 2, 3, \cdots$ and consider a change in stock at the next point as the amount of the stock at the present point and its increment between the present and next points; that is, τ and $\tau + 1$. Let us call such an interval of time between these two points a unit interval. The length of unit could be, as already mentioned above, a second, a minute, an hour, a day, a week, a month, a year, or whichever unit to be suitable for capturing the movement of the stock in question. Hence, a period of time t could be defined as a t-th unit interval or period, counting from the origin; that is, $\tau = 0$.

Flow is defined as an increment (or decrement) of stock during a unit interval, and denoted here by $f(t)$. Flow that can only be defined at each discrete period of time is called discrete flow.

It is important to note that flow defined in this way is the amount between two points in time or a unit interval, while stock is the amount at a specific point in time. In other words, τ which is used for defining stock implies a point in time and t which is used for defining flow means a t-th unit interval between a point in time τ and its next period $\tau + 1$.

In this way, any dynamic movement can be operatively understood in terms of stock and flow. This stock-flow relation becomes fundamental to a dynamic analysis. It is conceptually illustrated in Figure 1.2.

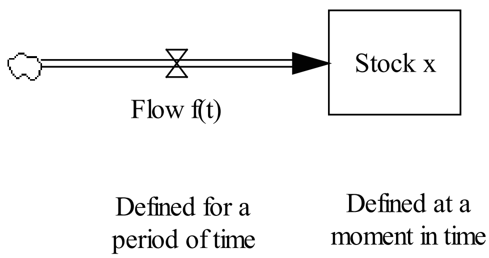


Figure 1.2: Stock-Flow Relation

It is essential to learn from the figure that flow is a part of stock, and in this sense physical or quantitative unit of flow and stock has to coincide. For instance, flow of oil cannot be added to the stock of water. As a system dynamics model becomes complicated, we tend to forget this essential fact.

Stock-flow relation can be formally written as

$$x(\tau + 1) = x(\tau) + f(t) \qquad \tau \text{ and } t = 0, 1, 2, 3, \cdots \tag{1.1}$$

To avoid a confusion derived from dual notations of time, τ and t, we need to describe stock-flow relation uniformly in terms of either one of these two concepts of time. Which one should, then, be adopted? A point in time τ could be interpreted as a limit point of an interval of time t. Hence, t can portray both concepts adequately, and can be chosen.

Since t represents a unit interval between τ and $\tau + 1$, the amount of stock at the t-th interval $x(t)$ could be defined as a balance at a beginning point τ of the period or an ending point $\tau + 1$ of the period; that is,

$$x(t) = x(\tau) : \text{ Beginning balance of stock} \tag{1.2}$$

or

$$x(t) = x(\tau + 1) : \text{ Ending balance of stock} \tag{1.3}$$

When the beginning balance of the stock equation (1.2) is applied, the stock-flow equation (1.1) becomes as follows:

$$x(t + 1) = x(t) + f(t) \qquad t = 0, 1, 2, 3, \cdots \tag{1.4}$$

In this formula, stock $x(t+1)$ is valued at the beginning of the period $t+1$; that is, flow $f(t)$ is added to the present stock value to give a stock value of the next period.

When the ending balance of the stock equation (1.3) is applied, the stock-flow equation (1.1) can be rewritten as

$$x(t) = x(t-1) + f(t) \qquad t = 1, 2, 3, \cdots \tag{1.5}$$

In this way, two different concepts of time - a point in time and a period of time - have been unified. It is very important for the beginners to understand that time in system dynamics always implies a period of time which has a unit interval. Of course, periods need not be discrete and can be continuous as well.

1.2.4 Integration of Flow

Discrete Sum

Without losing generality, let us assume from now on that $x(t)$ is an amount of stock at its beginning balance. If $f(t)$ is defined at a discrete time $t = 1, 2, 3, \ldots$, then the equation (1.4) is called a difference equation. In this case, the amount of stock at time t from the initial time 0 can be summed up or integrated in terms of discrete flow as follows:

$$x(t) = x(0) + \sum_{i=0}^{t-1} f(i) \tag{1.6}$$

This is a solution of the difference equation (1.4).

Continuous Sum

When flow is continuous and its measure at discrete periods does not precisely sum up the total amount of stock, a convention of approximation has been employed such that the amount of $f(t)$ is divided into n sub-periods (which is here defined as $\frac{1}{n} = \Delta t$) and n is extended to an infinity; that is, $\Delta t \to 0$. Then, the equation (1.4) can be rewritten as follows:

$$\begin{aligned} x(t) &= x\left(t - \frac{1}{n}\right) + \frac{f\left(t - \frac{1}{n}\right)}{n} \\ &= x(t - \Delta t) + f(t - \Delta t)\Delta t \end{aligned} \tag{1.7}$$

Let us further define

$$\lim_{\Delta t \to 0} \frac{x(t) - x(t - \Delta t)}{\Delta t} \equiv \frac{dx}{dt} \tag{1.8}$$

Then, for $\Delta t \to 0$ we have

$$\frac{dx}{dt} = f(t) \tag{1.9}$$

This formulation is nothing but a definition of differential equation. Continuous flow and stock are in this way transformed to differential equation, and the amount of stock at t is obtained by solving the differential equation. In other words, whenever a stock-flow diagram is drawn as in Figure 1.2, differential equation is constructed behind the screen in system dynamics.

The infinitesimal amount of flow that is added to stock at an instantaneously small period in time can be written as

$$dx = f(t)dt \tag{1.10}$$

Here, dt is technically called *delta time* or simply DT. Then an infinitesimal (or continuous) flow becomes a flow during a unit period t times DT.

Continuous sum is now written, in a similar fashion to a discrete sum in equation (1.6), as

$$x(t) = x(0) + \int_0^t f(u)du \tag{1.11}$$

This gives a general formula of a solution to the differential equation (1.9). The notational difference between continuous and discrete flow is that in a continuous case an integral sign is used instead of a summation sign. A continuous stock is, thus, alternatively called an integral function in mathematics.

In this way, stock can be described as a discrete or a continuous sum of flow[2]. This stock-flow relation becomes a foundation of dynamics (and, hence, system dynamics). It cannot be separable at all. Accordingly, among 4 letters of system dynamics language, stock-flow relation becomes an inseparable new building block or letter. Whenever stock is drawn, flows have to be connected to change the amount of stock. This is one of the most essential grammars in system dynamics.

1.3 Dynamics in Action

We are now in a position to analyze a dynamics of stock in terms of stock-flow relation. What we have to tackle here is how to find an efficient summation and integration method for different types of flow. Let us consider the most fundamental type of flow in the sense that it is not influenced (increased or decreased) by outside forces. In other words, this type of flow becomes autonomous and dependent only on time. Though this is the simplest type of flow, it is indeed worth being fully analyzed intensively by the beginners of system dynamics. Examples of this type to be considered here are the following:

[2] In Stella the amount of stock is described, similar to the equation (1.7), as

$$x(t) = x(t - dt) + f(t - dt) * dt,$$

while in Vensim it is denoted, similar to the equation (1.11), as

$$x(t) = INTEG(f(t),\ x(0)).$$

- constant flow
- linear flow of time
- non-linear flow of time squared
- random walk

Another examples would be trigonometric flow, present value, and time-series data, which are left uncovered in this book.

1.3.1 Constant Flow

The simplest example of this type of flow is a constant amount of flow through time. Let a be such a constant amount. Then the flow is written as

$$\boxed{f(t) = a} \tag{1.12}$$

This constant flow can be interpreted as discrete or continuous. A discrete interpretation of the stock-flow relation is described as

$$x(t+1) = x(t) + a \tag{1.13}$$

and a discrete sum of the stock at t is easily calculated as

$$x(t) = x(0) + at \tag{1.14}$$

On the other hand, a continuous interpretation of stock-flow relation is represented by the following differential equation:

$$\frac{dx}{dt} = a \tag{1.15}$$

and a continuous sum of the stock at t is obtained by solving the differential equation as

$$\begin{aligned} x(t) &= x(0) + \int_0^t a \; du \\ &= x(0) + at. \end{aligned} \tag{1.16}$$

From these results we can easily see that, if a flow is a constant amount through time, the amount of stock obtained either by discrete or continuous flow becomes the same.

1.3.2 Linear Flow of Time

We now consider autonomous flow that is linearly dependent on time. The simplest example of this type of flow is the following[3]:

$$\boxed{f(t) = t} \tag{1.17}$$

Let the initial value of the stock be $x(0) = 0$. Then the analytical solution becomes as follows:

$$x(t) = \int_0^t u\ du = \frac{t^2}{2} \tag{1.18}$$

At the period $t = 10$, we have $x(10) = 50$. This is a true value of the stock. Stock and flow relation of the solution for $dt = 1$ is shown in Figure 1.4. The amount of stock at a time t is depicted as a height in the figure, which is equal to the area surrounded by the flow curve and time-coordinate up to the period t.

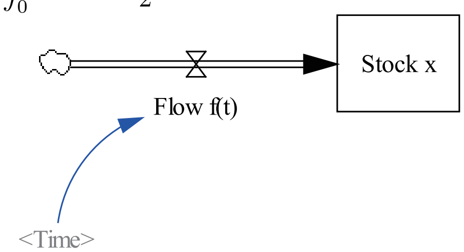


Figure 1.3: Linear Flow of Time

Discrete Approximation

In general, the analytical (integral) solution of differential equation is very hard, or impossible, to obtain. The above example is a lucky exception. In such a general case, a numerical approximation is the only way to obtain a solution. This is done by dividing a continuous flow into discrete series of flow. Let us try to solve the above equation in this way, assuming that no analytical solution is possible in this case. Then, a discrete solution is obtained as

$$x(t) = \sum_{i=0}^{t-1} i \tag{1.19}$$

and we have $x(10) = 45$ at $t = 10$ with a shortage of 5 being incurred compared with a true value of 50. Surely, the analytical solution is a true solution. Only when it is hard to obtain it, a discrete approximation has to be resorted as an

[3]When time unit is a week, $f(t))$ has a unit of (Stock unit/ week) . Accordingly, in order to have the same unit, the right hand side has to be multiplied by a unitary variable of unit converter which has a unit of (Stock unit / week / week).

$$f(t) = t * \text{unit converter}$$

This process is called "unit check", and system dynamics requires this unit check rigorously to obtain equation consistency. In what follows in this introductory chapter, however, this unit check is not applied.

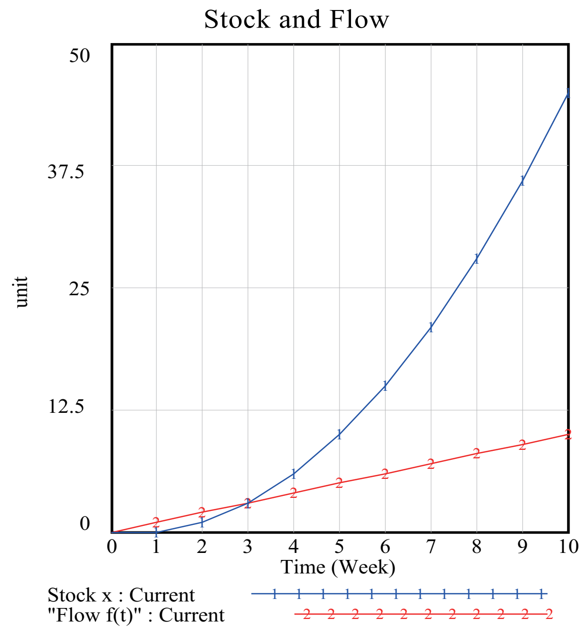


Figure 1.4: Linear Flow and Stock

alternative method for acquiring a solution. This approximation is, however, far from a true value as our calculation shows.

a) Continuous Flow $dt \to 0$

Two algorithms have been posed to overcome this discrepancy. First algorithm is to make a discrete period of flow smaller; that is, $dt \to 0$, so that discrete flow appears to be as close as to continuous flow. This is a method employed in equation (1.7), which is known as the Euler's method. Table 1.2 shows calculations by the method for $dt = 1$ and 0.5. In Figure 1.4 a true value at $t = 10$ is shown to be equal to a triangle area surrounded by a linear flow and time-coordinate lines; that is, $10 * 10 * 1/2 = 50$. The Euler's method is, graphically speaking, to sum the areas of all rectangles created at each discrete period of time. Surely, the finer the rectangles, the closer we get to a true area.

Table 1.3 shows that as $dt \to 0$, the amount of stock gets closer to a true value of $x(10) = 50$, but it never gets to the true value. Meanwhile, the number of calculations and, hence, the calculation time increase as dt gets finer.

Table 1.2: Linear Flow Calculation of $x(10)$ for dt=1 and 0.5

t	$x(t)$	dx
0	0	0
1	0	1
2	1	2
3	3	3
4	6	4
5	10	5
6	15	6
7	21	7
8	28	8
9	36	9
10	45	

where $dt = 1$ and $dx = f(t)dt = t$.

t	$x(t)$	dx	t	$x(t)$	dx
0.0	0.00	0.00	5.0	11.25	2.50
0.5	0.00	0.25	5.5	13.75	2.75
1.0	0.25	0.50	6.0	16.50	3.00
1.5	0.75	0.75	6.5	19.50	3.25
2.0	1.50	1.00	7.0	22.75	3.50
2.5	2.50	1.25	7.5	26.25	3.75
3.0	3.75	1.50	8.0	30.00	4.00
3.5	5.25	1.75	8.5	34.00	4.25
4.0	7.00	2.00	9.0	38.25	4.50
4.5	9.00	2.25	9.5	42.75	4.75
			10.0	47.50	

where $dt = 0.5$ and $dx = f(t)dt = 0.5t$.

Table 1.3: Discrete Approximation for $x(10)$

$f(t)\backslash dt$	1	1/2	1/4	1/8	1/16
Euler	45	47.5	48.75	49.375	49.6875
Runge-Kutta 2	50				

b) 2nd-Order Runge-Kutta Method

Second algorithm to approximate a true value is to obtain a better formula for calculating the amount of $f(t)$ over a period dt so that a rectangular area over the period dt becomes closer to a true area. The 2nd-order Runge-Kutta method is one such method. According to it, a value of $f(t)$ at the mid-point of dt is used.

$$x(t + dt) = x(t) + f(t + \frac{dt}{2})dt \tag{1.20}$$

In our simple linear example here, it is calculated as

$$f(t + \frac{dt}{2}) = t + \frac{dt}{2} \tag{1.21}$$

Applying the 2nd-order Runge-Kutta method, we can obtain a true value even for $dt = 1$ as shown in Table 1.3.

1.3.3 Nonlinear Flow of Time Squared

We now consider non-linear continuous flow that is dependent only on time. The simplest example is the following:

$$\boxed{f(t) = t^2} \tag{1.22}$$

Let the initial value of stock be $x(0) = 0$. Then the analytical solution is obtained as follows:

$$x(t) = \int_0^t u^2 du = \frac{t^3}{3} \tag{1.23}$$

At the period $t = 6$, a true value of the stock becomes $x(6) = 72$. Figure 1.5 illustrates a stock and flow relation for this solution. Stock is shown as a height at a time t, which is equal to an area surrounded by a nonlinear flow curve and a time-coordinate up to the period t.

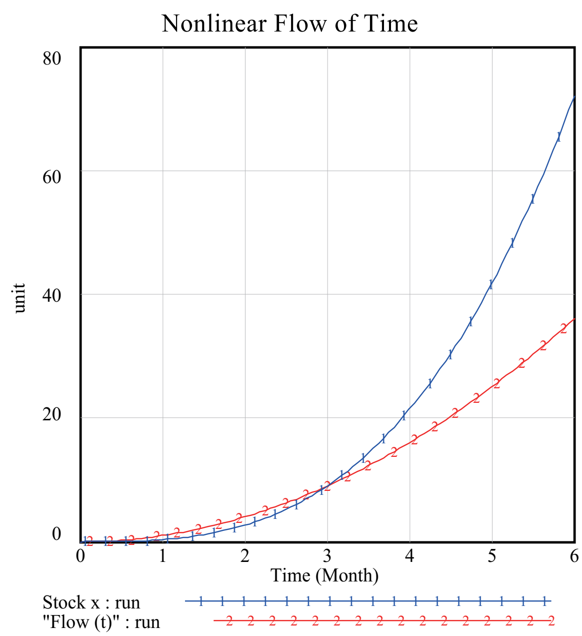


Figure 1.5: Nonlinear Flow and Stock

Discrete Approximation

A discrete approximation of this equation is obtained in terms of a stock-flow relation as follows:

$$x(t) = \sum_{i=0}^{t-1} i^2 \tag{1.24}$$

At the period $t = 6$, this approximation yields a value of 55, resulting in a large discrepancy of 17. In general, there exists no analytical solution for calculating a true value of the area surrounded by a nonlinear flow curve and a time-coordinate. Accordingly, two methods of approximation have been introduced; that is, the Euler's and 2nd-order Runge-Kutta methods. Table 1.4 shows such approximations by these methods for various values of dt. As shown in the table, both the Euler's and 2nd-order Runge-Kutta methods are not efficient to attain a true value for nonlinear flow even for smaller values of dt.

$$f(t + \frac{dt}{2}) = t^2 + tdt + \frac{dt^2}{4} \tag{1.25}$$

Clearly, in a case of nonlinear flow, the 2nd-order Runge-Kutta method, whether it be Stella or Madonna formula , fails to attain a true value at $t = 6$; that is, $x(6) = 72$.

Table 1.4: Discrete Approximation for $x(6)$

$f(t)\backslash dt$	1	1/2	1/4	1/8	1/16
Euler	55	63.25	67.5625	69.7656	70.8789
Runge-Kutta 2	71.5	71.875	71.9688	71.9922	71.998
Runge-Kutta 4	72.0				

4th-Order Runge-Kutta Method

The 4th-order Runge-Kutta method is a further revision to overcome the inefficiency of the 2nd-order Runge-Kutta method in a nonlinear case of flow as observed above. Its formula is given as[4]

$$x(t + dt) = x(t) + \frac{f(t) + 4f(t + \frac{dt}{2}) + f(t + dt)}{6} dt \tag{1.26}$$

Table 1.4 and 1.5 show that the 4th-order Runge-Kutta method are able to attain a true value even for $dt = 1$. The reader, however, should be reminded that this is not always the case as shown below.

1.3.4 Random Walk

Stochastic flow is created by probability distribution function. The simplest one is uniform random distribution in which random numbers are created between minimum and maximum. Let us consider the stock price whose initial value is \$ 10, and its price goes up and down randomly between the range of maximum \$1.00 and minimum - \$1.00.

[4]Fore detailed explanation, see Farlow (1994), section 2.8, pp.103 - 107 and 388 - 391.

Table 1.5: 2nd- and 4th-Order Runge-Kutta Method ($dt = 1$)

t	x(t)	Runge-Kutta 2	$x(t)$	Runge-Kutta 4
0	0	0.25	0	0.33
1	0.25	2.25	0.33	2.33
2	2.5	6.25	2.66	6.33
3	8.75	12.25	9	12.33
4	21	20.25	21.33	20.33
5	41.25	30.25	41.66	30.33
6	71.5		72	

$$\boxed{f(t) = \text{RANDOM UNIFORM (Minimum, Maximum)}} \quad (1.27)$$

Figure 1.6 is produced for a specific random walk. It is a surprise to see how a random price change daily produces a trend of stock price.

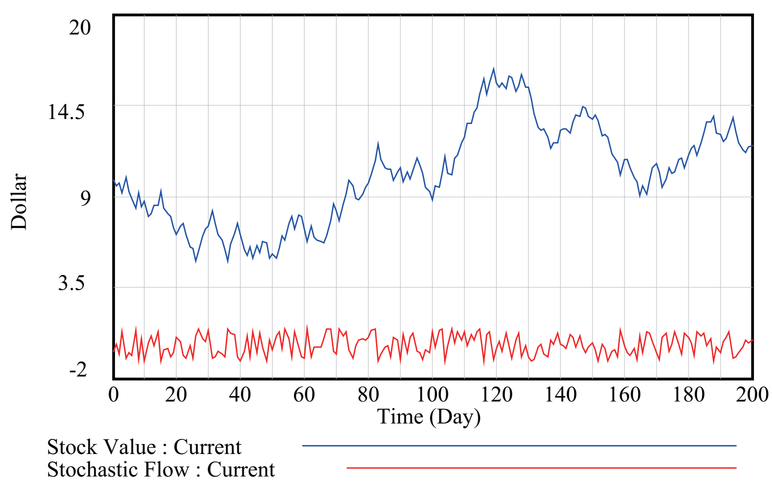


Figure 1.6: Random Walk

1.4 System Dynamics

1.4.1 Exponential Growth

So far the amount of flow is assumed to be created by autonomous outside forces at each period t. Next type of flow we now consider is the one caused by the amount of stock within the system. In other words, flow itself, being caused by the amount of stock, is causing a next amount of flow through a feedback process of stock: that is to say, flow becomes a function of stock. Whenever flow is affected by stock, dynamics becomes system dynamics.

When flow is discrete, a stock-flow relation of this feedback type is described as follows:

$$x(t+1) = x(t) + f(x(t)), \qquad t = 0, 1, 2, \cdots \tag{1.28}$$

In the case of a continuous flow, it is presented as a differential equation as follows.

$$\frac{dx}{dt} = f(x) \tag{1.29}$$

The simplest example of stock-dependent feedback flow is the following:

$$\boxed{f(x) = ax} \tag{1.30}$$

Figure 1.7 illustrates this stock-dependent feedback relation. Its continuous flow is depicted as an autonomous differential equation:

$$\frac{dx}{dt} = ax \tag{1.31}$$

From calculus, an analytical solution of this equation is known as the following exponential equation:

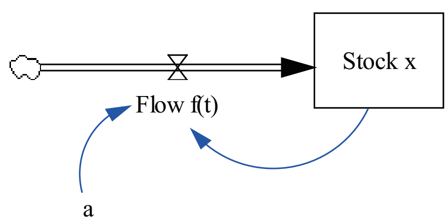


Figure 1.7: Stock-Dependent Feedback

$$x(t) = x(0)e^{at} \quad \text{where } e = 2.71828182845904523 54\cdots \tag{1.32}$$

It should be noted that the initial value of the stock $x(0)$ cannot be zero, since non-zero amount of stock is always needed as an initial capital to launch a growth of flow.

What happens if such an analytical solution cannot be obtained? Assuming that flow is only discretely defined, we can approximate the equation as a discrete difference equation:

$$x(t+1) = x(t) + ax(t), \ t = 0, 1, 2, \cdots \tag{1.33}$$

Then, a discrete solution for this equation is easily obtained as

$$x(t) = x(0)(1+a)^t \tag{1.34}$$

A true continuous solution of the equation could be obtained as an approximation from this discrete solution (1.34), first by dividing a constant amount of flow a into n sub-periods, and secondly by making n sub-periods into infinitely many finer periods so that each sub-period converges to a moment in time.

Table 1.6: Discrete Approximation

$f(t)\backslash dt$	1	1/2	1/4	1/8	1/16
Euler	259.374	265.33	268.506	270.148	270.984
Runge-Kutta 2	271.408	271.7191	271.8004	271.8212	271.8264
Runge-Kutta 4	271.8279	271.828169	271.828182	271.828182	271.828182

$$\begin{aligned} x(t) &= x(0)\left[\lim_{n\to\infty}\left(1+\frac{a}{n}\right)^n\right]^t \\ &= x(0)\left[\lim_{n\to\infty}\left(1+\frac{1}{\frac{n}{a}}\right)^{\frac{n}{a}}\right]^{at} \\ &= x(0)e^{at} \end{aligned} \tag{1.35}$$

Let an initial value of the stock be $x(0) = 100$ and $a = 0.1$. Then, a true value for the period $t = 10$ is $x(10) = 100e^{0.1*10} = 100e^1 = 271.8281828459\cdots$. This is to obtain a compounding increase in 10% for 10 periods. The amount of initial stock is shown to be increased by a factor of 2.7 when a growth rate is 10%. Table 1.6 shows numerical approximations by the Euler's, 2nd-order and 4th-order Runge-Kutta methods. It is observed from the table that even the 4th-order Runge-Kutta method cannot obtain a true value of the exponential e.

In Figure 1.7, the amount of flow is shown to be determined by its previous amount through the amount of stock. Structurally this relation is sketched as a following flow chart: an increase in flow↑ $\longrightarrow$ an increase in stock↑ $\longrightarrow$ an increase in flow↑ . At an annual growth rate of 10%, for instance, it takes only seven years for the initial amount of stock to double, and 11 years to triple, and 23 years to become 10 folds. In fifty years, it becomes about 150 times as large. This self-increasing relation is called a *reinforcing or positive feedback* (see Figure 1.7.) Left-hand diagram in Figure 1.16 illustrates such a positive feedback growth.

Constant Doubling Times

One of the astonishing features of exponential growth is that a doubling time of stock is always constant. Let $x(0) = 1$ and $x(t) = 2$ in the equation (1.32), then it is obtained as follows.

$$ln2 = at \implies t = \frac{0.693147}{a} \tag{1.36}$$

For instance, when $a = 0.02$, that is, an annual growth rate is 2%, then doubling time of the stock becomes about 35 years. That is to say, every 35 years the stock becomes twice as big. When $a = 0.07$, or an annual growth rate is 7%, stock becomes doubled about every 10 years. Consider an economy growing at 7% annually. its GDP becomes 8 folds in 30 years. This enormous power of exponential is usually overlooked or under estimated. See the section of "Misperception of Exponential Growth" on pages 269 - 272 in Sterman (2000).

Examples of Exponential Growth (Reinforcing Feedback)

In system dynamics, this exponential growth is called *positive* or *reinforcing* feedback. Figure 1.8 illustrates some examples of these reinforcing stock-dependent feedback relation. Left-hand diagram illustrates our financial system in which our bank deposits keeps increasing as long as positive interest rate is guaranteed by our banking system. This financial system creates the environment that "the rich becomes richer exponentially".

Figure 1.8: Examples of Exponential Feedback

1.4.2 Present Values

A frequently applied example of the exponential growth is observed in finance and economics to calculate present values of financial and real estate assets. From the equations (1.32) and (1.34), initial values of $x(0)$ increases exponentially to the values $x(t)$ at the period t. This implies that the initial values of $x(0)$ can be regarded as being equal to the intertemporal values $x(t)$. That is to say, future value of x(t) is only worth x(0) at the present (initial) time at $t = 0$.

More specifically, suppose $f(t)$ is an expected value of stream at the period t, $t = 0, 1, 2, \cdots$, and a is a discount rate of future, which can be represented by an interest rate or often referred to as marginal efficiency of capital in macroeconomics. Then, its present value $f(0)$ can be easily calculated from the equation (1.34) as

$$f(0) = \frac{f(t)}{(1+a)^t} \quad : \text{Present Value (Discrete)} \tag{1.37}$$

In the case of continuous time, its present value is calculated from the equation (1.32) as

$$f(0) = \frac{f(t)}{e^{at}} \quad : \text{Present Value (Continuous)} \tag{1.38}$$

Streams $f(t)$, $t = 0, 1, 2, \cdots$, are regarded as discount flows in system dynamics that constitute a stock of present values as illustrated in Figure 1.9. They could be payments of security interest, rentals from property and real estates, expected revenues of investment projects, and profits of corporate activities. Then, present values of securities, real estates, investment projects or corporations can be easily calculated, in the case of discrete time, as follows:

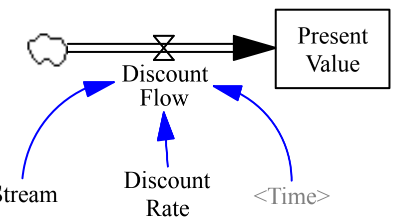


Figure 1.9: Present Value

$$\text{Present Value} = \sum_{t=0}^{\infty} \frac{f(t)}{(1+a)^t} \quad \text{(Discrete)}. \tag{1.39}$$

In the case of continuous time, they are obtained as

$$\text{Present Value} = \int_{t=0}^{\infty} \frac{f(t)}{e^{at}} dt \quad \text{(Continuous)}. \tag{1.40}$$

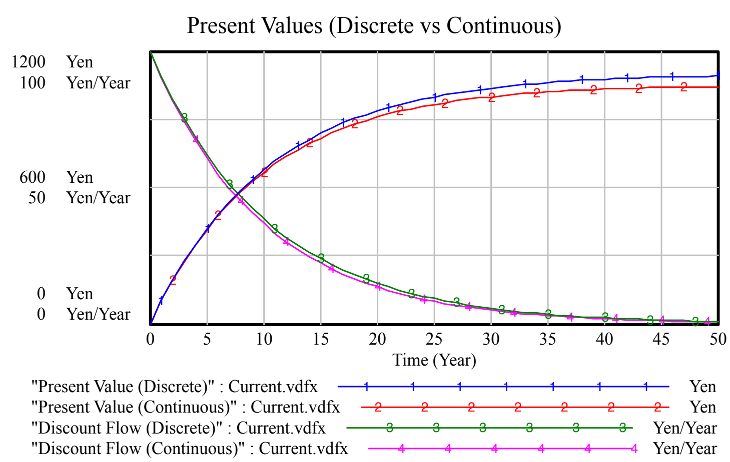


Figure 1.10: Present Values: Discrete vs Continuous

In this way, present value can be easily obtained, which is structurally the same as simple dynamics in Figure 1.3. Figure 1.10 compares two calculation of present values, discrete and continous. It is built with a constant value of stream (=100) and a discount rate of 10%. Line 3 and 4 indicates discrete and continuous discount flows, respectively, against which corresponding present values are calculated as line 1 and 2. Discrete present value slightly overestimates that of continuous value.

1.4.3 Balancing Feedback

If system consists of only exponential growth or reinforcing feedback behaviors, it will sooner or later explode. System has to have "a common purpose" or "the aim of the system" as already quoted in the beginning of this chapter. In other words, it has to be stabilized to accomplish its aim.

To attain a self-regulating stability of the system, another type of feedback is needed such that whenever a state of the system $x(t)$ is off the equilibrium x^*, it tries to come back to the equilibrium, as if it's being attracted to the equilibrium. If system has this feature, it will be stabilized at the equilibrium. In economics, it is called global stability. Free market economy has to have this price stability as a system to avoid unstable price fluctuations.

Structurally the stability is attained if stock-flow has a relation such that an increase in flow↑ ⟶ a decrease in stock↓ ⟶ a decrease in flow↓. This stabilizing relation is called a *balancing or negative feedback* in system dynamics. Figure 1.11 illustrates this balancing feedback stock-dependent relation.

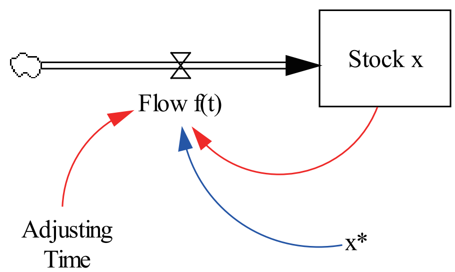


Figure 1.11: Balancing Feedback

Mathematically, this is to guarantee the stability of equilibrium. Let x^* be such an equilibrium point, or target or objective of the stock $x(t)$). Then stabilizing behavior is realized by the following flow

$$\boxed{f(x) = \frac{x^* - x(t)}{AT}} \tag{1.41}$$

where AT is the adjusting time of the gap between x^* and x.

Fortunately, this differential equation can be analytically solved as follows. First rewrite the equation (1.41) as

$$\frac{d(x(t) - x^*)}{x(t) - x^*} = -\frac{dt}{AT} \tag{1.42}$$

Then integrate both side to obtain

$$ln(x(t) - x^*) = -\frac{t}{AT} + C, \tag{1.43}$$

where ln denotes natural logarithm. This is further rewritten as

$$x(t) - x^* = e^{-\frac{t}{AT}} e^C \tag{1.44}$$

At the initial point in time, we have

$$e^C = x(0) - x^* \text{ at } t = 0 \tag{1.45}$$

Thus, the amount of stock at t is analytically obtained as

$$x(t) = x^* - (x^* - x(0))e^{-\frac{t}{AT}} \tag{1.46}$$

Examples of Balancing Feedback

Figure 1.12 illustrates some examples of these balancing stock-dependent feedback relation.

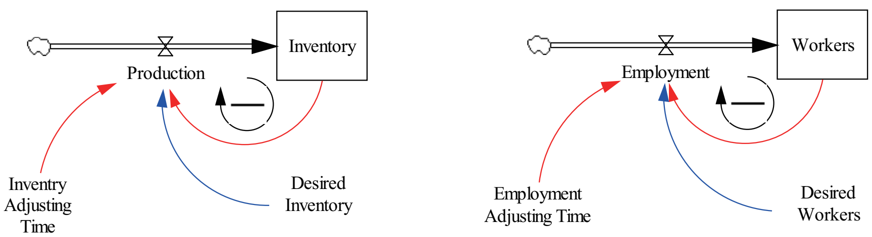


Figure 1.12: Examples of Balancing Feedback

Exponential Decay

When $x^* = 0$, system continues to decay or disappear. In other words, stock begins to decrease by the amount of its own divided by the adjusting time.

$$\boxed{f(x) = -\frac{x(t)}{AT}} \tag{1.47}$$

This decay process is called exponential decay. Whenever exponential decay appears, flow has only negative amount. In this case in system dynamics we draw flow out of stock so that it becomes more intuitive to understand the outflow of stock. Figure 1.13 illustrates such stock-outflow relation.

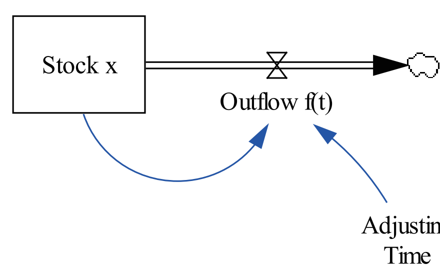


Figure 1.13: Exponential Decay

At an annual declining rate of 10%, for instance, the initial amount of stock decreases by half in seven years, by one third in 11 years, and by one tenth in 23 years, balancing to a zero level eventually. Right-hand diagram in Figure 1.16 illustrates such a negative feedback decay.

Examples of Exponential Decay

Figure 1.14 illustrates this stock-dependent feedback relation.

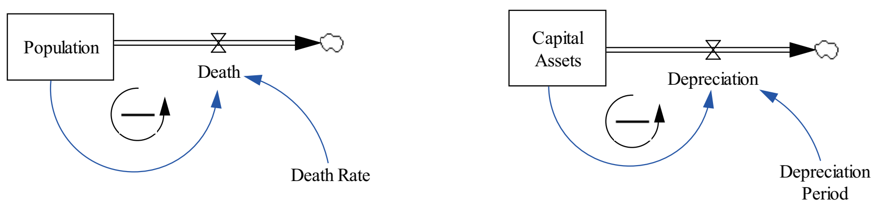


Figure 1.14: Examples of Exponential Decay

1.5 System Dynamics with One Stock

1.5.1 First-Order Linear Growth

We have now learned two fundamental feedbacks in system dynamics; reinforcing (exponential or positive) feedback and balancing (negative) feedback. Let us now consider the simplest system dynamics which have these two feedbacks simultaneously. It is called first-order linear growth system. "First-order" implies that the system has only one stock, while "linear" means that its inflow and outflow are linearly dependent on stock. Figure 1.15 illustrates our first system dynamics model which has both reinforcing and balancing feedback relations. Table 1.7 describes its equation.

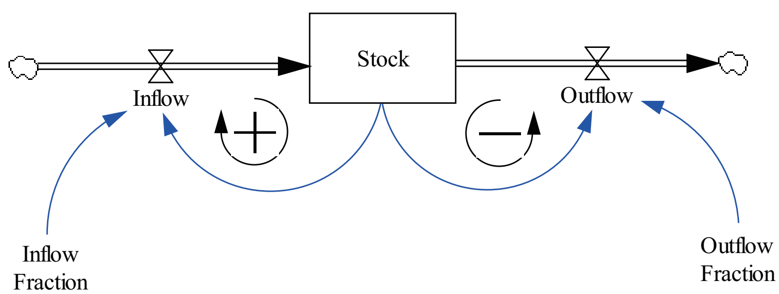


Figure 1.15: First-Order Linear Growth Model

Left-hand diagram of Figure 1.16 is produced for the inflow fraction value of 0.1 and outflow fraction value of zero, and has a feature of exponential growth. Right-hand diagram is produced by the opposite fractional values, and has a feature of exponential decay. It is easily confirmed that whenever inflow fraction is greater than outflow fraction, the system produces exponential growth behavior. When outflow fraction is greater than inflow fraction, it causes an

Table 1.7: Equations of the First-Order Growth Model

Inflow= Stock*Inflow Fraction
    Units: unit/Year
Inflow Fraction= 0.1
    Units: 1/Year [0,1,0.01]
Outflow= Stock*Outflow Fraction
    Units: unit/Year
Outflow Fraction= 0.04
    Units: 1/Year [0,1,0.01]
Stock= INTEG (Inflow-Outflow, 100)
    Units: unit

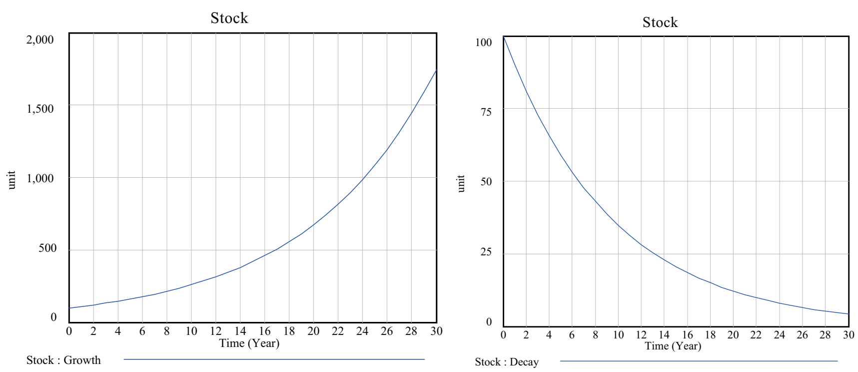


Figure 1.16: Exponential Growth and Decay

exponential decay behavior. In this way, the first-order linear system can only produces two types of behaviors: exponential growth or decay.

This model can best describe population dynamics. Suppose the world birth rate (inflow fraction) is 3.5%, while its death rate (outflow fraction) is 1.5%. This implies that world population grows exponentially at the net growth rate of 2%.

1.5.2 S-Shaped Limit to Growth

In the first-order linear model, the system may explode if inflow fraction is greater than outflow fraction. Population explosion is a good example. To stabilize the system, the exponential growth $ax(t)$ has to be curbed by bringing another balancing feedback which plays a role of a break in a car.

Specifically, whenever $x(t)$ grows to a limit x^*, it begins to be regulated as if population is controlled and speed of the car is reduced. This is a feedback mechanism to stabilize the system. It could be done by the following flow:

$$\boxed{f(x) = ax(t)b(t), \text{ where } b(t) = \frac{x^* - x(t)}{x^*}} \tag{1.48}$$

Apparently $b(t)$ is bounded by $0 \leq b(t) \leq 1$, and reduces to zero as $x(t)$ approached to its limit x^*. Figure 1.17 is such model in which both reinforcing (exponential) and balancing feedback are brought together. It is called S-shaped growth in system dynamics. Figure 1.18 illustrates its behaviors.

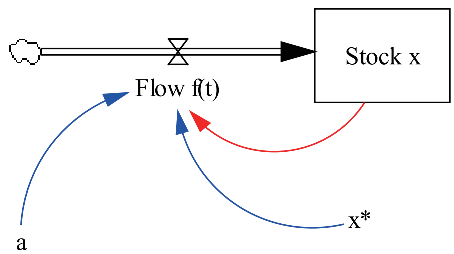


Figure 1.17: S-shaped Growth Model

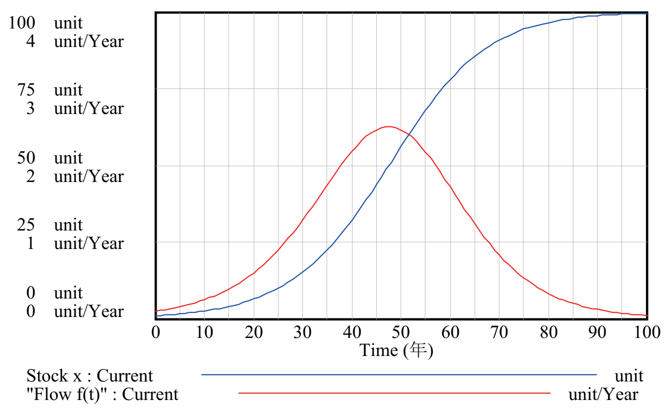


Figure 1.18: S-Shaped Limit to Growth 1

1.5.3 S-Shaped Limit to Growth with Table Function

Another way to regulate the growth of $x(t)$ is to increase $b(t)$ to the value of a as $x(t)$ grows to its limit x^* as shown below.

$$\boxed{f(x) = (a - b(t))x(t)} \tag{1.49}$$

Specifically, any functional relation that has a property such that $b(t)$ approaches a whenever $x(t)/x^*$ approaches 1 works for this purpose.

One of the simplest function is

$$b(t) = a\frac{x(t)}{x^*} \tag{1.50}$$

In this case the above function becomes

$$\boxed{f(x) = (a - b(t))x(t) = a\left(\frac{x^* - x(t)}{x^*}\right)x(t)} \tag{1.51}$$

which becomes the same as the above S-shaped limit to growth.

If mathematical function is not available, still we can produce S-shaped behavior by plotting the relation, which is called table function. One of such table function is shown in the right-hand diagram of Figure 1.19. Left-hand diagram illustrates S-shaped limit to growth model. Figure 1.20 illustrates its behaviors.

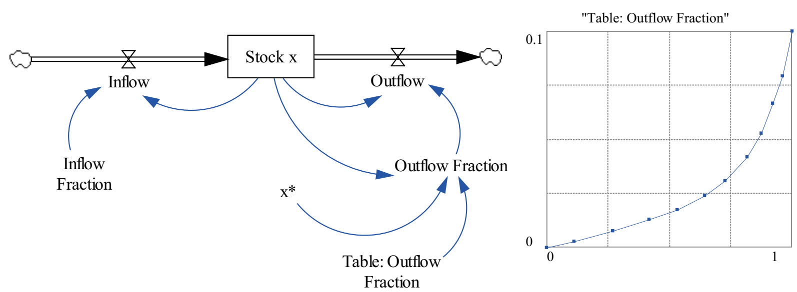


Figure 1.19: S-Shaped Limit to Growth Model with Table Function

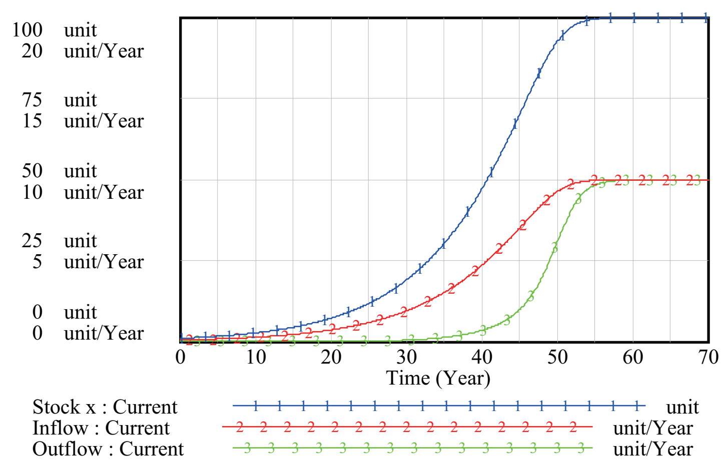


Figure 1.20: S-Shaped Limit to Growth 2 with Table Function

1.6 System Dynamics with Two Stocks

1.6.1 Feedback Loops in General

When there is only one stock, two feedback loops are at maximum produced as in first-order linear growth model. When the number of stocks becomes two, at maximum three feedback loops can be generated as illustrated in Figure 1.21

Mathematically, general feedback loop relation with two stocks can be represented by a following dynamical system in which each flow is a function of stocks x and y.

$$\frac{dx}{dt} = f(x, y) \tag{1.52}$$

$$\frac{dy}{dt} = g(x, y) \tag{1.53}$$

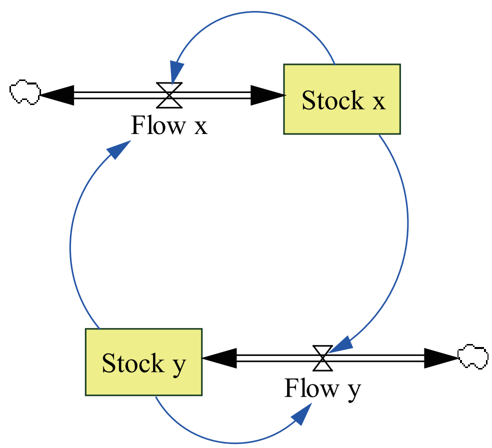


Figure 1.21: Feedback Loops in General

1.6.2 S-Shaped Limit to Growth with Two Stocks

Behaviors in system dynamics with one stock are limited to exponential growth and decay generated by the first-order linear growth model, and S-shaped limit to growth. To produce another fundamental behaviors such as overshoot and collapse, and oscillation, at least two stocks are needed. System dynamics with two stocks are called second-order system dynamics.

Let us begin with another type of S-shaped limit to growth behavior that can be generated with two stocks x and y. When the total amount of stock x and stock y is limited by the constant available resources such that $x + y = b$, and the amount of stock x flows into stock y as shown in Figure 1.22, stock y begins to create a S-shaped limit to growth behavior.

A typical system causing this behavior is described as follows.

$$\frac{dx}{dt} = -f(x,y) \qquad (1.54)$$

$$\begin{aligned}\frac{dy}{dt} &= f(x,y) \\ &= ax(t)y(t) \\ &= a(b-y(t))y(t) \qquad (1.55)\end{aligned}$$

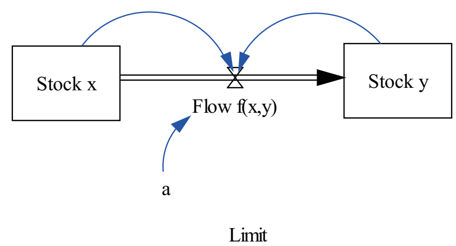


Figure 1.22: S-shaped Growth Model

Figure 1.23 illustrates its behaviors for the values $a = 0.001$ and $b = 100$.

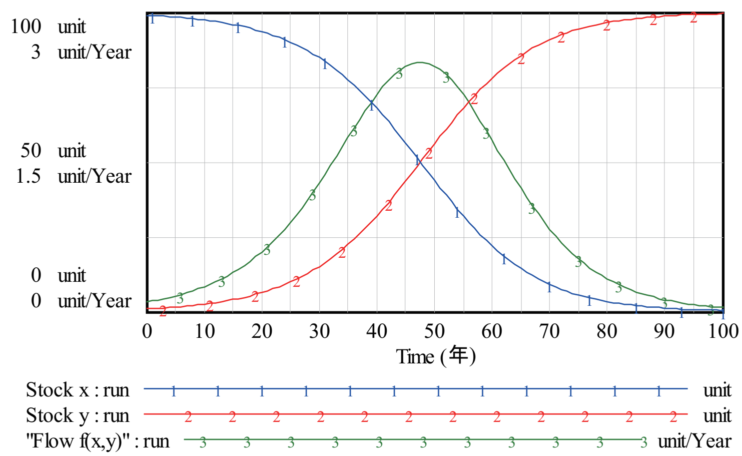


Figure 1.23: S-Shaped Limit to Growth 3

This relation is also reduced to

$$\frac{dx}{dt} + \frac{dy}{dt} = 0 \qquad (1.56)$$

Mathematically, the above equation (1.55) is similar to the S-shaped limit to growth equation (1.48). In other words, $x(t) = b - y(t)$ begins to diminish as $y(t)$ continues to grow. This is a requirement to generate S-shaped limit to growth.

Examples of this type of S-shaped limit to growth are abundant such as logistic model of innovation diffusion in marketing.

So far we have presented three different figures to illustrate S-shaped limit to growth. Mathematically, all of the S-shaped limits to growth turn out to have the same structure. The same structures can be built in three different models, depending on the issues we want to analyze. This indicates the richness of system dynamics approach.

1.6.3 Overshoot and Collapse

Next behavior to be generated with two stocks is a so-called overshoot and collapse. It is basically caused by the S-shaped limit to growth model with table function. However, coefficient $b(t)$ is this time affected by the stock y. Increasing stock x causes stock y to decrease, which in turn makes the availability of stock y smaller, which then increases outflow fraction. This relation is described by the table function in the right-hand diagram of Figure 1.24. Increasing fraction collapses stock x. The model is shown in the left-hand diagram. Behaviors of overshoot & collapse is shown in Figure 1.25.

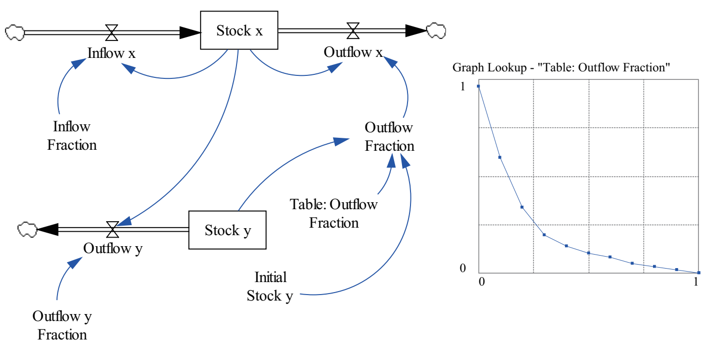


Figure 1.24: Overshoot & Collapse Model

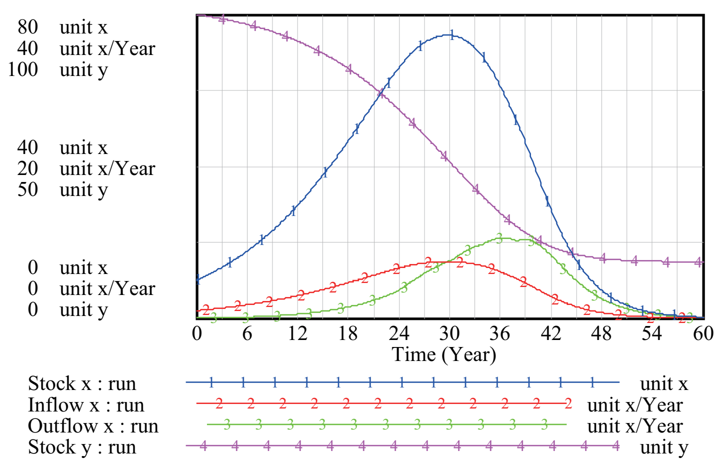


Figure 1.25: Overshoot & Collapse Behavior

Examples of Overshoot and Collapse

One of the favored examples of overshoot and collapse model is the decline of the Mayan empire in Breierova (1997).

1.6.4 Oscillation

Another behavior that can be created with two stocks is oscillation. A simple example of system dynamics with two stocks is illustrated in Figure 1.26.

It can be formally represented as follows:

$$\frac{dx}{dt} = ay, \; x(0) = 1, \; a = 1 \tag{1.57}$$

$$\frac{dy}{dt} = -bx, \; y(0) = 1, \; b = 1 \tag{1.58}$$

This is nothing but a system of differential equations, which is also called a dynamical system in mathematics. Its solution by Euler method is illustrated in Figure 1.27 in which DT is set to be $dt = 0.125$.

Movement of the stock y is illustrated on the y-axis against the x-axis of time (left figure) and against the stock of x (right figure). In this Euler's solution, the amount of stock keeps expanding even a unit period is divided into 8 sub-periods for better computations. In this continuous case of flow, errors at each stage of calculation continue to accumulate, causing a large deviation from a true value.

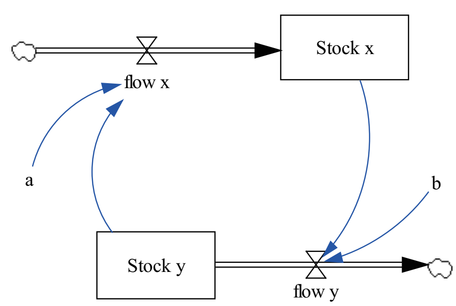


Figure 1.26: An Oscillation Model

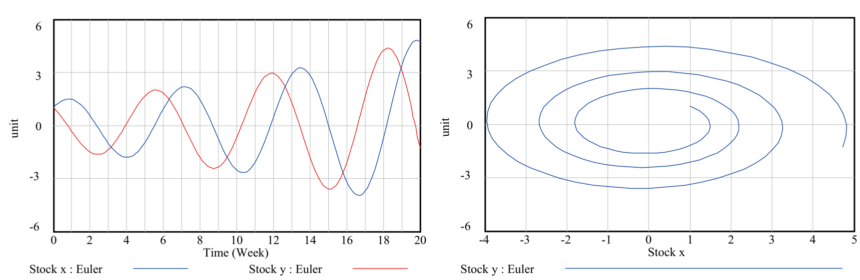


Figure 1.27: Oscillation under Euler Method

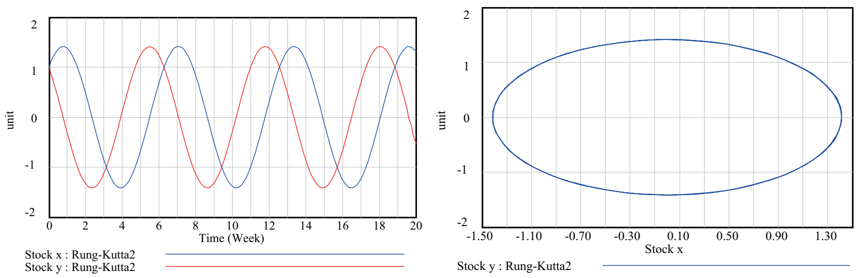


Figure 1.28: Oscillation under Runge-Kutta2 Method

On the other hand, the 2nd-order Runge-Kutta solution eliminates this deviation and yields a periodic or cyclical movement as illustrated in Figure 1.28. This gives us a caveat that setting a small number of dt in the Euler's method is not enough to approximate a true value in the case of continuous flow. It is expedient, therefore, to examine the computational results by both methods and see whether they are differentiated or not.

Examples of Oscillation

Pendulum movement is a typical example of oscillation. It is shown in Chung (1994) that employment instability behavior is produced by the same system structure which generates pendulum oscillation. Prey and predator model is another example of oscillation heavily used in ecology and economics. For instance, Goodwin's Growth Cycle model in Chapter 4 is a prey and predator model applied to economics (Goodwin, 1967, p.55, 1967).

1.7 Delays in System Dynamics

1.7.1 Material Delays

First-Order Material Delays

System dynamics consists of four building blocks or letters: stock, flow, variable and arrow, as already discussed in the beginning of this chapter. To generate fundamental behaviors, these letters have to be combined according to its grammatical rules: reinforcing (positive) and balancing (negative) feedback loops, and delays. So far reinforcing and balancing feedback loops have been explored. Yet delays have been already applied in our models above without focusing on them. Delays play an important role in model

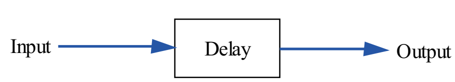


Figure 1.29: Structure of Delays

building. Accordingly, it is appropriate to examine the meaning of delays in system dynamics in this section.

Delays in system dynamics has a structure illustrated in Figure 1.29. That is, output always gets delayed when input goes through stocks. This is an inevitable feature in system dynamics. It is essential in system dynamics to distinguish two types of delays: material delays and information delays. Let us start with material delays first.

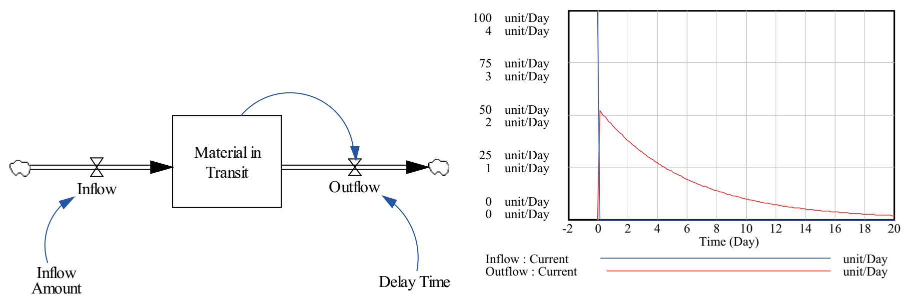
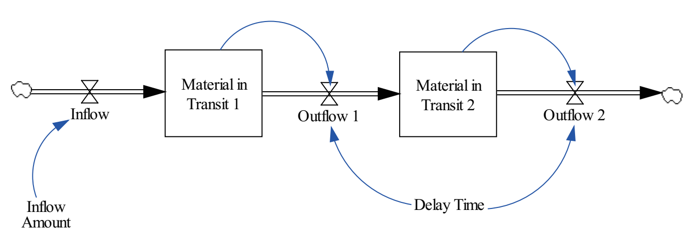


Figure 1.30: First-Order Material Delays

When there is only one stock, delays becomes similar to exponential decay for the one-time input, which is called *pulse*. In Figure 1.30, 100 units of material are input at time zero. This corresponds to the situation, for instance, in which 100 units of goods are purchased and stored in inventory, or 100 letters are dropped in the post office. Delay time is assumed to be 6 days in this example. In other words, one-sixth of goods are to be delivered daily as output.

Second-Order Material Delays

In the second-order material delays, materials are processed twice as illustrated in the top diagram of Figure 1.31. Total delay time is the same as 6 days. Accordingly, delay time for each process becomes 3 days. In this case, output distribution becomes bell-shaped. The reader can expand the delays to the n-th order and see what will happen to output.



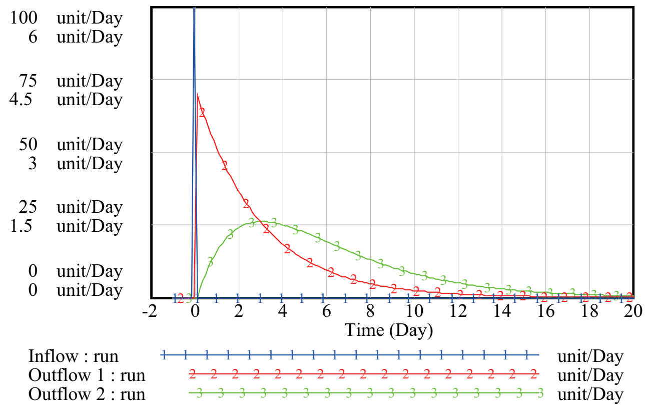


Figure 1.31: Second-Order Material Delays

1.7.2 Information Delays

First-Order Information Delays

Information delays occur because information as input has to be processed by human brains and implemented as action output. Information literally means in-form; that is, being input to brain which forms it for action. This is a process to adjust our perceived understanding in the brain to the actual situation outside the brain. Structurally this is the same as balancing feedback explained above to fill the gap between x^* and x, as illustrated in the left-hand diagram of Figure 1.32.

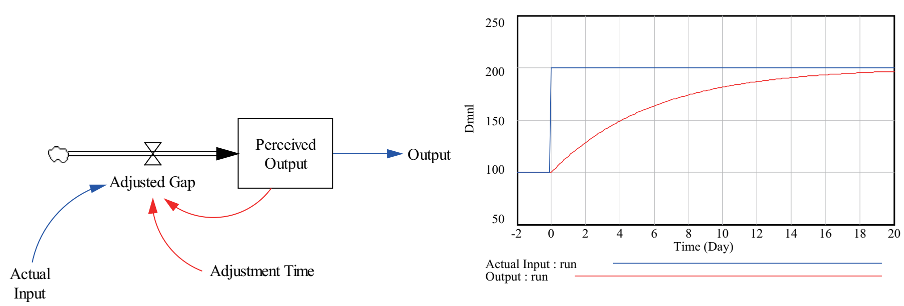


Figure 1.32: First-Order Information Delays

Our perceived understanding, say, on daily sales order, is assumed here to be 100 units, yet actual sales jumps to 200 at the time zero. Our suspicious brain hesitates to adjust to this new reality instantaneously. Instead, it slowly adapts to a new reality with the adjustment time of 6 days. This type of adjustment is explained as adaptive expectations and exponential smoothing in Sterman

(2000).

Second-Order Information Delays

Second-order information delays imply that information processing occurs through two brains. This is the same as re-thinking process for one person or a process in which information is being sent to another person. This structure is modeled in the top diagram of Figure 1.33. The adaptation process of the second-order information delays becomes slower than that of the first-order information delays as illustrated in the bottom diagram of the Figure.

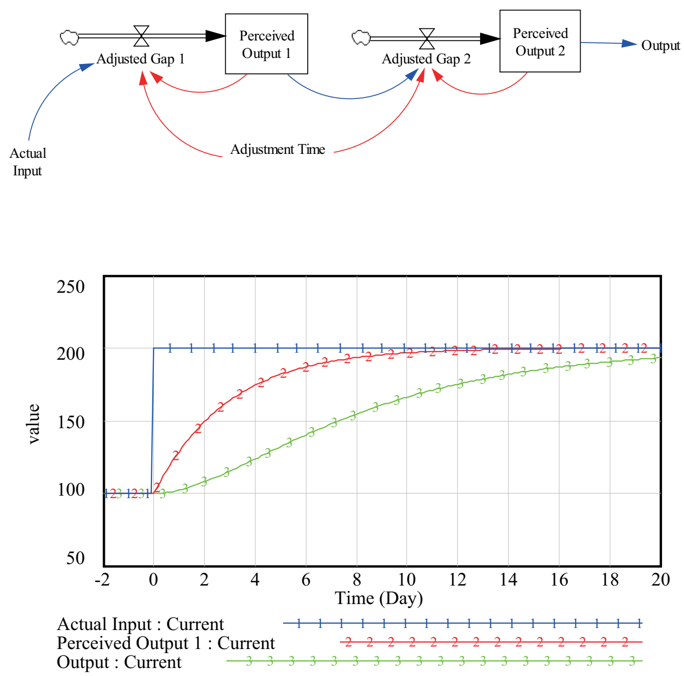


Figure 1.33: Second-Order Information Delays

Adaptive Expectations for Random Walk

First-order information delays are also called adaptive expectations or exponential smoothing because perceived output tries to adjust gradually to the actual input as illustrated in Figure 1.34.

This exponentially smoothing behaviors are illustrated in Figure 1.35. That is, random walk becomes actual input (line 2), then its gap with the Perceived Output is adjusted (smoothed) by the first-order information delays, which becomes output (line 1).

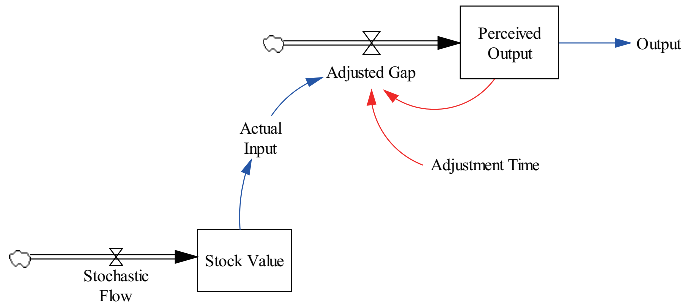


Figure 1.34: Adaptive Expectations Model for Random Walk

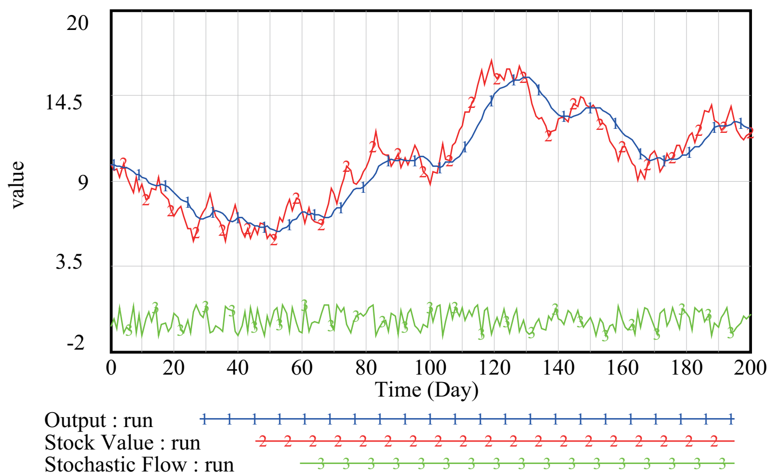


Figure 1.35: Adaptive Expectations Behaviors for Random Walk

1.8 System Dynamics with Three Stocks

1.8.1 Feedback Loops in General

It has been shown that system dynamics with two stocks can mostly produce all fundamental behavior patters such as exponential growth, exponential decay, S-shaped limit to growth, overshoot and collapse, and oscillation. Actual behaviors observed in complex system are combinations of these fundamental behaviors. We are now in a position to build system dynamics model based on these fundamental building blocks. And this introductory chapter on system dynamics seems appropriate to end at this point, and we should go to next chapter in which how system dynamics method can be applied to economics.

Yet, there exist another behaviors which can not be produced with two stocks; that is a chaotic behavior! Accordingly, we stay here for a while, and consider a general feedback relation for the case of three stock-flow relations. Figure 1.36 illustrates a general feedback loops.

Each stock-flow relation has its own feedback loop and two mutual feedback loops. In total, there are 6 feedback loops, excluding overlapping ones. As long as we observe *the parts* of mutual loop relations, that's all loops. However, if we observe *the whole*, we can find two more feedback loops: that is, a whole feedback loop of $x \to y \to z \to x$, and $x \to z \to y \to x$. Therefore, there are 8 feedback loops as a whole. The existence of these two whole feedback loops seems to me to symbolize a complex system in terms of loops; that is, *the whole is more than the sum of its parts.*

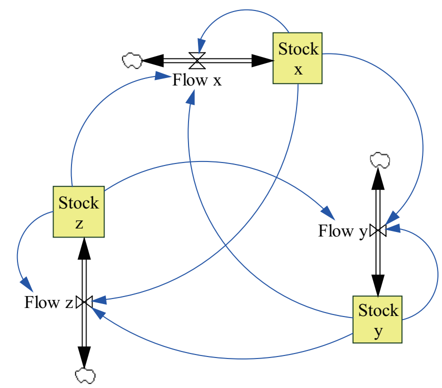


Figure 1.36: Feedback Loop in General

> A complex system is one whose component parts interact with sufficient intricacy that they cannot be predicted by standard linear equations; so many variables are at work in the system that its overall behavior can only be understood as an emergent consequence of the holistic sum of all the myriad behaviors embedded within. Reductionism does not work with complex systems, and it is now clear that a purely reductionist approach cannot be applied when studying life: in living systems, *the whole is more than the sum of its parts* (emphasis is made by the author) Levy (1992), pp. 7-8.

Mathematically, this general feedback loop relation can be represented by a following dynamical system in which each flow is a function of all stocks x, y and z.

$$\frac{dx}{dt} = f(x, y, z) \tag{1.59}$$

$$\frac{dy}{dt} = g(x, y, z) \tag{1.60}$$

$$\frac{dz}{dt} = h(x, y, z) \tag{1.61}$$

1.8.2 Lorenz Chaos

As a special example of the general feedback loops by three stock-flow relations, let us consider well-known Lorenz equations which yield a chaotic movement. Mathematical equations of the Lorenz chaos are written as

$$\frac{dx}{dt} = -a(x-y) \tag{1.62}$$

$$\frac{dy}{dt} = -xz + bx - y \tag{1.63}$$

$$\frac{dz}{dt} = xy - cz \tag{1.64}$$

Figure 1.37 illustrates feedback loops of the Lorenz equations. Compared with a general case of the above Figure 1.36, a link from the Stock z to the Flow x is missing. Accordingly, we have 6 feedback loops in total - a loss of two loops ! We are not sure if this loss of two loops is related with chaotic behaviors to be discussed below.

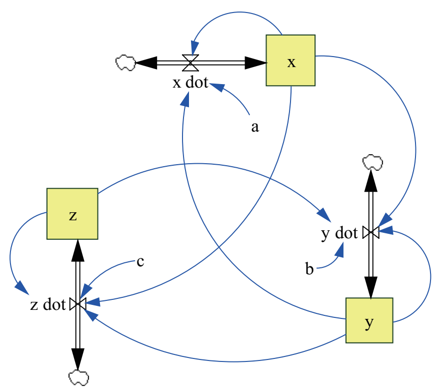


Figure 1.37: Lorenz Feedback Loop

Equilibrium of this Lorenz equations is obtained such that

$$x^* = \pm\sqrt{(b-1)c} \tag{1.65}$$

$$y^* = \pm\sqrt{(b-1)c} \tag{1.66}$$

$$z^* = b-1 \tag{1.67}$$

Parameter values of Lorenz equations are assigned as $a = 10,\ b = 28$ and $c = 8/3$. Hence, equilibrium values have to be $x^* = y^* = 3\sqrt{8}$ and $z^* = 27$. Initial values are instead set at off-equilibrium values such that $x(0) = 0,\ y(0) = 2$ and $z(0) = 0$. (See Chapter 14 The Lorenz System in Hirsh et al. (2004)).

Figure 1.38 illustrates two phase diagrams of stocks x - y and x - z, that is, movements of the stock y and z are illustrated on the y-axis against the stock x on the x-axis. Apparently, their off-equilibrium behaviors fail to restore

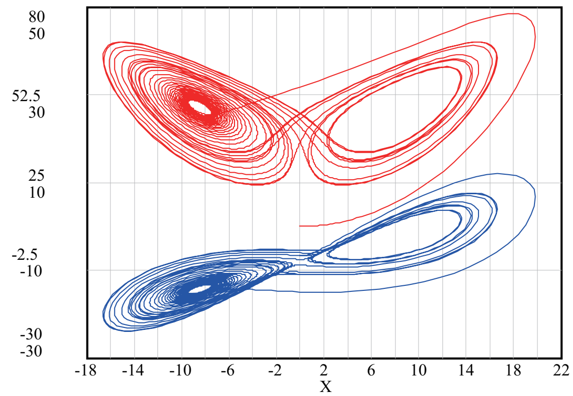


Figure 1.38: Lorenz Chaos

equilibrium, instead they begin to be attracted to a phase diagram, called *Lorenz attractor* of chaos, wherever they initially start. Calculations in the Figure are done by the 4th-order Runge-Kutta method at $dt = 0.0078125$; that is, at each of 128 sub-periods in a unit period. With such a small sub-period, computational errors may arise less likely as explained above.

Sensitive Dependence on Initial Conditions

In the above Lorenz phase diagram, movement of stocks does not converge to a fixed point or a limit cycle, or diverge to infinity. Instead, wherever it starts, it seems to be eventually attracted to a certain region and continue fluctuating in it, with the information of its start being lost eventually. That region is called *a strange attractor* or *chaos*. One of the main features of chaos is a sensitive dependence on initial conditions. This is numerically explained as follows. Suppose a true initial value of the stock y in the Lorenz equations is $y^*(0) = 2.0001$ instead of $y(0) = 2.0$, and denote its true value by y^*. At the period $t = 20$ those two values of the stock are calculated as $y(t) = 16.1513$, and $y^*(t) = 16.1453$. The difference is only 0.006 and they stay very close each other. This makes sense, because both started at the very close distance of 0.0001. To our surprise, however, at the period, say, $t = 26.5$, they are calculated as $y(t) = -2.25909$, and $y^*(t) = 9.9033$; a large difference of 12.16239 is made. Small amount of differences at an initial time eventually turns out to cause a big difference later. In other words, stock values sensitively depend on their initial conditions. Figure 1.39 illustrates how values of the stock y (line 1) begin to diverge from a true value y^* (line 2) around the period $t = 25.6$.

Why could it be possible? It is caused by the power of exponential magnification empowered by feedback loops. As illustrated in Figure 1.16, for instance, a simple calculation yields that an initial difference of 0.001 is exponentially magnified to 22.02 by the time $t = 100$, more than twenty-two thousand factors

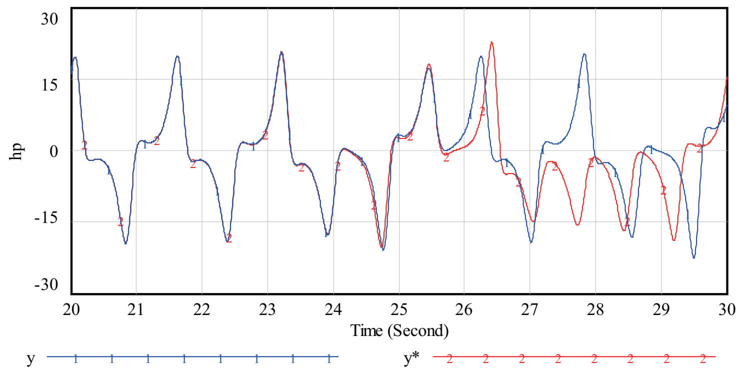


Figure 1.39: Sensitive Dependence on Initial Conditions

larger, because of a positive feedback loop. Chaos is a region called strange attractor to which infinitely many iterated and exponentially magnified values are confined. Hence, it is intuitively understood that exponentially magnified values in a chaos region sensitively depend on initial conditions; in other words, values whose initial conditions differ only very slightly cannot stay close and begin to diverge eventually.

This chaotic feature creates annoying problem in system dynamics: unpredictability in the future. It is almost impossible in reality to obtain true initial values due to some observation errors and round-off errors of measurement and computations. These errors are magnified in a chaotic system dynamics to a point where predictions of the future and forecasting become almost meaningless and misleading. If analytical solutions of differential equations could be found, this would never happen, because solutions are continuous function of time and we could easily predict or approximate the future behavior of the system even if initial conditions are missed slightly. Without the analytical solutions, the future has to be iterated step by step, causing an exponential magnification by feedback loop. Unfortunately as discussed above, it is almost impossible to find analytical solutions in a nonlinear dynamics and system dynamics. In such cases, if a true initial value fails to be specified, then we cannot predict the future at all, even if we try to make calculations as precise as possible by employing Runge-Kutta methods and making sub-periods smaller as discussed in the previous sections. Hence, system dynamics becomes inefficacious as a forecasting simulation method.

What's a good use of system dynamics, then? If a dynamic system is chaotic, all values of stocks are attracted to a region of strange attractor; in other words, information of initial conditions will be lost eventually and only patterns or structures of the system begin to reveal themselves. In system dynamics, these patterns and structures help us learn the behavior of the system we want to explore. System dynamics is a very effective learning method in that direction, not in the direction of futures prediction.

1.9 Chaos in Discrete Time

1.9.1 Logistic Chaos

Famous logistic function which produces chaos is the following:

$$x_{t+1} = ax_t(1 - x_t) \qquad t = 0, 1, 2, 3, \cdots \tag{1.68}$$

(See Chapter 15 Discrete Dynamical Systems in Hirsh et al. (2004))

To fit into our system dynamics presentation, its flow can be rewritten as follows:

$$\boxed{f(t) = ax_t(1 - x_t) - x_t} \tag{1.69}$$

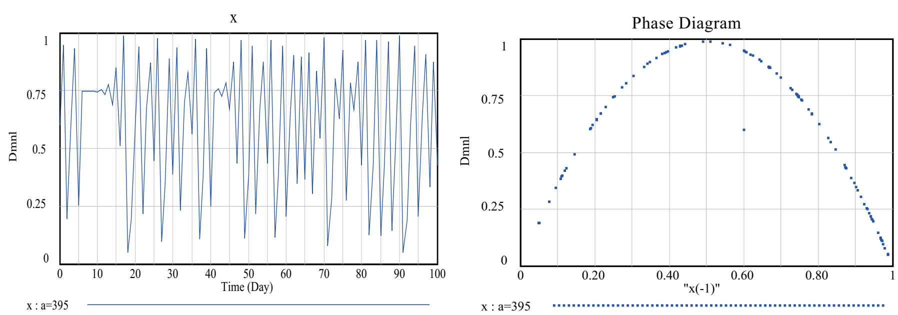


Figure 1.40: Chaos in Logistic Function

As coefficient a increases stock x produces n-period oscillations $n = 2, 4, 8, \cdots$, and eventually produces chaos. Left-hand diagram of Figure 1.40 shows an chaotic movement for $a = 3.95$ and right-hand diagram is its phase diagram. Chaotic movements do not fill in all space but fit into parabola shape as strange attractor.

This type of chaos in discrete time gradually disappears when DT(Delta Time) in simulation becomes smaller.

1.9.2 Discrete Chaos in S-shaped Limit to Growth

The equation (1.55) in the S-shaped limit to growth can be rewritten in a discrete format as

$$y_{t+1} = y_t + ay_t(b - y_t) \qquad t = 0, 1, 2, 3, \cdots \tag{1.70}$$

In other words, flow becomes

$$\boxed{f(t) = ay_t(b - y_t)}, \tag{1.71}$$

which also becomes the same as the right-hand side of the equation (1.68) for $b = 1$.

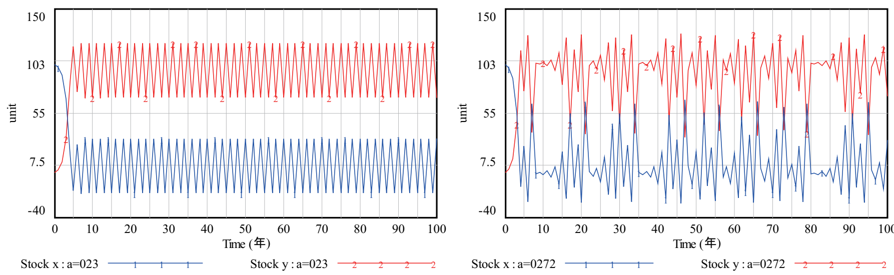


Figure 1.41: Chaos in S-shaped Limit to Growth

To our surprise, it turns out that the flow (1.71) can also produce chaos if $f(t)$ is allowed to take negative values. In other words, S-shaped limit to growth behavior turns out to be chaotic if flows move forward and backward between stocks x and y. Figure 1.41 illustrates such chaotic behaviors. Specifically, its left-hand diagram shows a two-period cycle of stocks x and y for $a = 0.023$ and its right-hand diagram shows chaotic movements for $a = 0.0272$.

Appendix: Runge-Kutta Methods in General

Flow in equation (1.29) can be more generally described as a function of time and stock; that is,

$$\frac{dx}{dt} = f(t, x) \tag{1.72}$$

Accordingly, the Runge-Kutta methods need to be more generally formulated as follows[5]

2nd-Order Runge-Kutta Method

$$dx_1 = f(t, x)dt \tag{1.73}$$

$$dx_2 = f(t + dt, x + dx_1)dt \tag{1.74}$$

$$\begin{aligned} dx &= \frac{dx_1 + dx_2}{2} \\ &= \frac{f(t, x) + f(t + dt, x + dx_1)}{2} dt \end{aligned} \tag{1.75}$$

4th-Order Runge-Kutta Method

$$dx_1 = f(t, x)dt \tag{1.76}$$

$$dx_2 = f(t + \frac{dt}{2}, x + \frac{dx_1}{2})dt \tag{1.77}$$

$$dx_3 = f(t + \frac{dt}{2}, x + \frac{dx_2}{2})dt \tag{1.78}$$

$$dx_4 = f(t + dt, x + dx_3)dt \tag{1.79}$$

$$dx = \frac{dx_1 + 2dx_2 + 2dx_3 + dx_4}{6} \tag{1.80}$$

Table 1.8: Same Number of Calculation

	dt	dt	dt
Euler	$\frac{1}{4}$	$\frac{1}{8}$	$\frac{1}{16}$
Runge-Kuttta 2	$\frac{1}{2}$	$\frac{1}{4}$	$\frac{1}{8}$
Runge-Kutta 4	1	$\frac{1}{2}$	$\frac{1}{4}$

Compared with the Euler's methods, the 2nd-order Runge-Kutta method requires twice as many calculations and the 4th-order Runge-Kutta method requires 4 times as many calculations. In other words, the number of calculation of the Euler's method for $dt = \frac{1}{4}$ is the same as the 2nd-order Runge-Kutta method for $dt = \frac{1}{2}$, which is also the same as the 4th-order Runge-Kutta method for $dt = 1$. Table 1.8 shows a combination of dt and three methods that induces the same number of calculations. Even so, from the results in Table 1.6, it can be easily verified that the Runge-Kutta methods produce better approximations for the same number of calculations.

[5] Technical Documentation, STELLA Software, High Performance Systems, Inc. pp. 13-6, 13-7, 1997.

Chapter 2

Demand and Supply

This chapter[1] first examines the neoclassical foundation of price adjustment mechanism built on Logical Time, using system dynamics modeling. Then it is argued that similar workings could be done in a real market economy running on Historical Time by the interplay of price, inventory and their interdependent feedback relations. This implies that off-equilibrium analysis built on historical time without neoclassical concept of Auctioneer is a better way of representing market activities. This approach can be one of the foundations of our macroeconomic modeling.

2.1 Adam Smith!

"There's a person who has influenced upon us more than Jesus Christ! Who's he?" The instructor of Economics 1, an introductory course for undergraduate students at the Univ. of California, Berkeley, challenged his students cheerfully. I was sitting in the classroom as a Teaching Assistant for the course. This was in early 80's when I was desperately struggling to unify three schools of economics in my dissertation; that is, neoclassical, Keynesian and Marxian schools of economics.

"He's the author of the Wealth of Nations written in 1776; his name is Adam Smith!", claimed the instructor. Adam Smith's idea of free market economy has been a core doctrine throughout the so-called Industrial Age which started in the middle of the eighteenth century. It has kept influencing our economic life even today with a simple diagram such as Figure 2.1.

Those who have studied economics are very familiar with this diagram of demand and supply, which intuitively illustrates a market mechanism of price

[1]This chapter is based on the paper: Logical vs Historical Time in A Price Adjustment Mechanism in "Proceedings of the 27th International Conference of the System Dynamics Society", Albuquerque, New Mexico, USA, July 26-30, 2009. ISBN 978-1-935056-03-4. It is written during my short-term sabbatical leave at the Victoria Management School, Victoria University of Wellington, New Zealand in March 2009.

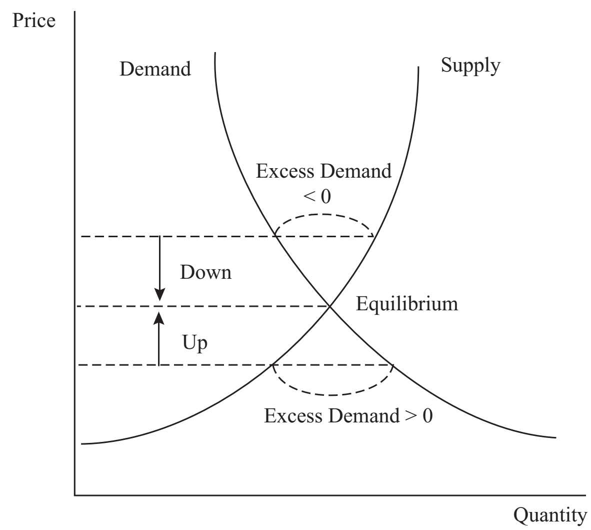


Figure 2.1: Price Mechanism of Demand and Supply

adjustment processes. Price is taken on vertical axis and quantity is taken on horizontal axis. Demand is illustrated as a downward sloping curve, indicating the attitude of consumers that their demand decreases for higher prices and increases for lower prices. This relation is theoretically derived from a utility maximization principle of consumers. Supply is illustrated as an upward sloping curve which exhibits the behavior of producers that their supply increases for higher prices and decreases for lower prices. This relation results from a principle of profit maximizing behavior by producers. Market equilibrium, in which the amount of demand is equal to the amount of supply and market clears, is shown to exist at a point where demand and supply curves intersect in the diagram.

When price is higher than the equilibrium, there exists an excess supply or unsold and increased amount of inventory (which is also called a negative excess demand), and price is eventually forced to go down to attract more consumers to buy the product. On the other hand, if price is lower, there exists an excess demand or the shortage of product which eventually pushes up the price. In either case, price tends to converge to an equilibrium price. This adjusting market force is provided by an *invisible hand*, Adam Smith believed. It is called a price adjustment mechanism, or tâtonnement process, in modern microeconomics.

This price adjustment mechanism works not only in commodity markets but also in labor markets as well as financial capital markets. For instance, let us consider a labor market by taking a wage rate on the vertical axis and the quantity of labor on the horizontal axis. Then, demand curve is interpreted as the demand for labor by producers and supply curve represents the attitude of workers to work. Producers do not employ as many workers as before if wage rate increases, while more workers want to work or they want to work longer hours if their wage rate is higher, and vice versa. Market equilibrium in the labor market denotes full employment. If wage rate is higher than the equilibrium, unemployment comes off and eventually workers are forced to accept a wage cut. In the case of lower wage rate, labor shortage develops and eventually wage rate is pushed up. In this way, price adjustment mechanism works similarly in the labor market.

In a financial capital market, price on the vertical axis becomes an interest rate, and it become a foreign exchange rate in a case of a foreign exchange market. Price mechanism works in a similar fashion in those markets.

In this way, workings of a price adjustment mechanism could be explicated uniformly in all markets by the same framework. Our daily economic activities are mostly related with these market mechanisms governed by the *invisible hand*. This is why the instructor at the UC Berkeley amused his students, saying that Adam Smith has been more influential than Jesus Christ!

Unfortunately, however, this doctrine of *invisible hand*, or neoclassical school of economic thought has failed to obtain unanimous acceptance among economists, and two opposing schools of economics eventually have been struggling to fight against the workings of market price mechanism depicted by Figure 2.1. They are Keynesian and Marxian schools. Mutually-antagonistic dissents of these school created the East-West conflicts, Cold War since the World War II, and domestic right-left wing battle till late 80's when these battles of ideas finally seemed to have ended with a victory of neoclassical school. Since then, the age of the so-called privatization (of public sectors), and globalization with the help of IT technologies have started as if the doctrine of the *invisible hand* has been the robust foundation of free market fundamentalism similar to religious fundamentalisms.

Accordingly most of us believed there would be no longer conflicts in economic thoughts as well as in our real economic life until recently when we were suddenly hit by severe financial crises in 2008; the worst recession ever since the Great Depression in 1929. The battle of ideas seems to be re-kindled against the doctrine of the *invisible hand*. Indeed, the instructor at the UC Berkeley was right. Today Adam Smith seems to be getting more influential globally, not because his doctrine is comprehensive enough to accomplish a consensus on the workings of a market economy, but because it caused many serious socio-economic conflicts and wars instead.

2.2 Unifying Three Schools in Economics

As a graduate student in economics in late 70's and early 80's, I was struggling to answer the question: Why did three schools disagree? As a proponent of Adam Smith's doctrine, neoclassical school believes in a price adjusting mechanism in the market. As shown above, however, this price mechanism only works so long as prices and wages move up and down flexibly in order to attain an equilibrium. Therefore, if disequilibria such as recession, economic crisis and unemployment happen to occur, they believe, it's because economic agents such as monopoly, government and trade unions refuse to accept price and wage flexibility and distort the workings of market mechanism.

Keynesian school considers that market has no self-restoring forces to establish an equilibrium once economic recessions and unemployment occur, because prices and wages are no longer flexible in a modern capitalist market economy. To attain an equilibrium, therefore, government has to stimulate the economy through fiscal and monetary policies. In Figure 2.1 these policies imply to shift the demand curve to the right so that excess supply (and negative excess demand) will be eliminated.

Marxian school believed that market disequilibria such as economic crisis and unemployment are inevitable in a capitalist market economy, and proposed a planned economy as an alternative system. After the collapse of the Soviet Union in 1989, Marxian school ceased to exercise its influence because the experiments of a planned economy in the former socialist countries turned out to be a failure. Even so, they manage to survive under the names of post-Keynesian, environmental economics and institutional economics, etc.

Accordingly, only neoclassical and Keynesian schools remain to continue influencing today's economic policies. In the United States, Republican policies are deeply affected by the doctrine of neoclassical school such as free market economy and small government through deregulation. Meanwhile, Democrats favor for Keynesian viewpoint of public policies such as regulations by wise (not small) government. Current financial crises may reinforce the trend of regulation against hand-free financial and off-balance transactions.

Why do we need three different glasses to look at the same economic reality? Why do we need three opposing tools to analyze the same economic phenomena? These were naive questions I posed when I started studying economics as my profession. In those days I strongly believed that a synthesis of three schools in economics is the only way to overcome Cold War, East-West conflicts and domestic right-left wing battles. By synthesis it was meant to build a unified general equilibrium framework from which neoclassical, Keynesian and Marxian theories can be derived respectively as a special case. My intention was to show that different world views were nothing but a special case of a unified economic paradigm.

While continuing my research toward the synthesis, I was suddenly encountered by a futuristic viewpoint of *The Third Wave* by Alvin Toffler Toffler (1981). It was on December 23, 1982, when I happened to pick up the book which was piled up in a sociology section at the Berkeley campus bookstore. The most unimaginable idea to me in the book was the one that both capitalism and socialism were the two sides of the same coin in the industrial age against the leftist doctrine that socialism is an advanced stage of economic development following capitalism. What's an economic system of the Third Wave, then? Can a new economic system in the information age comply with either neoclassical or Keynesian school of economics developed in the industrial age? I kept asking these questions many times in vain, because Toffler failed to present his economic system of the information age in a formal and theoretical fashion.

Being convinced by Toffler's basic idea, however, I immediately decided to develop a simple economic model which could be a foundation of a new economic framework for the information age. In this way, the Third Wave became a turning point of my academic research in economics, and since then my work has been focused on a new economic system of the information age. My effort of synthesizing three schools in economics and creating a future vision of a new economic system fortunately resulted in a publication of the book Yamaguchi (1988). Its main message was that three schools in economics are effete in a coming information age, and a new economic paradigm suitable for the new age has to be established.

My idea of economic synthesis was to distinguish Logical Time on which neoclassical school's way of thinking is based, from Historical Time on which Keynesian and Marxist schools of economic thought are based. Yet, the working tools available in those days are paper and pencil. Under such circumstances I was fortunate to encounter by chance system dynamics in middle 90's through the activities of futures studies. Since then, system dynamics modeling gradually started to re-kindle my interest in economics. This chapter examines a true mechanism of the working of market economy, which is made possible by the application of system dynamics modeling.

2.3 Tâtonnement Adjustment by Auctioneer

Let us now construct a simple SD model to examine how a market economy of demand and supply works. In this simple economy buyers and sellers have demand and supply schedules of shirts per week as shown in Table 2.1. These figures are taken from a paper in Whelan and Msefer (1994) under the supervision of Professor Jay W. Forrester[2]. The reader can easily replace them with his or her own demand and supply schedules.

Price	Quantity Demanded $D = D(p)$	Quantity Supplied $S = S(p)$
\$ 5	100	0
\$ 10	73	40
\$ 15	57	57
\$ 20	45	68
\$ 25	35	77
\$ 30	28	84
\$ 35	22	89
\$ 40	18	94
\$ 45	14	97
\$ 50	10	100

Table 2.1: Demand and Supply Schedules in Whelan and Msefer (1994)

[2]MIT System Dynamics in Education Project (http://sysdyn.clexchange.org/sdep.htm) offers a collection of SD models and papers called Road Maps for self-taught learning of system dynamics. The reader is encouraged to explore these profound resources of SD modeling.

In microeconomics these schedules are called demand and supply functions of market prices and derived rigorously from the axiomatic assumptions of consumers and producers. Demand and supply schedules (or functions $D = D(p)$ and $S = S(p)$) are illustrated in Figure 2.2 in which price is taken on horizontal axis while demand and supply are plotted on vertical axis. This is a standard presentation of functions in mathematics. On the other hand, in standard textbooks of economics price has been traditionally taken on vertical axis as illustrated in Figure 2.1.

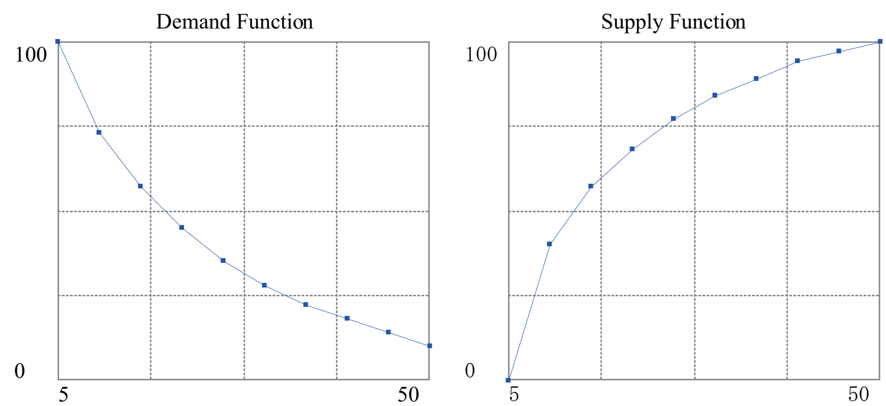


Figure 2.2: Demand and Supply Functions

Now buyers and sellers meet in the market to buy and sell their products according to their schedules of demand and supply. In order to make this market economy work, we need the third player called *Auctioneer* who quotes a price. His role is to raise a price if demand is greater than supply, and lower it if demand is less than supply. His bids continue until the equilibrium is attained where demand is simply equal to supply. This process is called Walrasian or neoclassical price adjustment mechanism or tâtonnement.

The important rule of this market game is that no deal is made until market equilibrium is attained and buyers and sellers can make contracts of transactions. In this sense, time for adjustment is not a real time in which economic activities such as production and transactions take place, but the one needed for calculation. The time of having this nature is called *Logical Time* in Yamaguchi (1988). In reality, there are very few markets that could be represented by this market except such as stock and auction markets. Even so, neoclassical school seems to cling to this framework as if it represents many real market transactions.

Equilibrium

Does this market economy work? This question includes two different inquiries: an existence of equilibrium and its stability. If equilibrium does not exist, the Auctioneer cannot finish his work. If the equilibrium is not stable, it's impossible to attain it. Let us consider the existence problem first.

The Auctioneer's job is to find an equilibrium price at which demand is equal to supply through a process of the above-mentioned tâtonnement or groping process. Mathematically this is to find the price p^* such that

$$D(p^*) = S(p^*) \tag{2.1}$$

In our simple demand and supply schedules in Table 2.1, the equilibrium price is easily found at \$ 15. The existence proof of general equilibrium in a market economy has annoyed economists over a century since Walras. It was finally proved by the so-called Arrow-Debreu model in 1950's. For detailed references, see Yamaguchi Yamaguchi (1988). Arrow received Nobel prize in economics in 1972 for his contribution to "general economic equilibrium and welfare theory". He was a regular participant from Stanford University to the Debreu's seminar on mathematical economics when I was in Berkley. Debreu received Nobel prize in economics in 1983 for his contribution to "new analytical methods into economic theory and for his rigorous reformulation of the theory of general equilibrium". I used to attend his seminar on mathematical economics in early 80's, and still vividly remember the day of his winning the prize, followed by a wine party spontaneously organized by faculty members and graduate students.

Stability

The second question is how to find or attain the equilibrium. From the demand and supply schedules given above, there seems to be no difficulty of finding the equilibrium. In reality, however, the Auctioneer has no way of obtaining these schedules. Accordingly, he has to grope them by quoting different prices. To describing this groping process, a simple SD model is built as in Figure 2.3 [Companion model: 1 Auctioneer.vpmx].

Mathematically, the model is formulated as follows:

$$\frac{dp(t)}{dt} = f(D(p) - S(p), \lambda) \tag{2.2}$$

where f is excess demand function and λ is a price adjustment coefficient. In the model f is further specified as

$$f = \lambda \ \frac{D(p) - S(p)}{D(p) + S(p)} \ p \tag{2.3}$$

From the simulations in our simple model the idea of tâtonnement seems to be working well as illustrated in Figure 2.4. The left-hand diagram shows that the initial price of \$10 tends to converge to an equilibrium price of \$15.

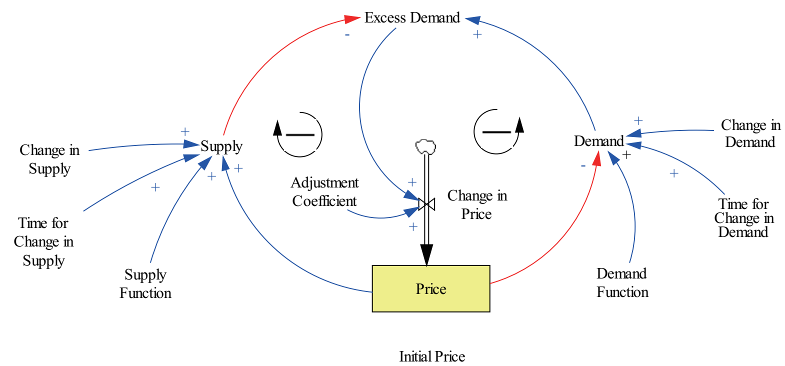


Figure 2.3: Auctioneer's Tâtonnement Model

Whatever values of initial price are taken, the convergence can be similarly shown to be attained. In this sense, the market economy can be said to be globally stable. With this global stability, the Auctioneer can start with any quotation of initial price to arrive at the equilibrium successfully.

In the right-hand diagram, demand schedule is suddenly increased by capricious buyers by 20 units at the week of 15, followed by the reactive increase of the sellers in the same amount of supply at the week of 30, restoring the original equilibrium. In this way, the Auctioneer can easily respond to any changes or outside shocks and attain new equilibrium states. These shifts of demand and supply curves are well known in microeconomics as comparative static analysis.

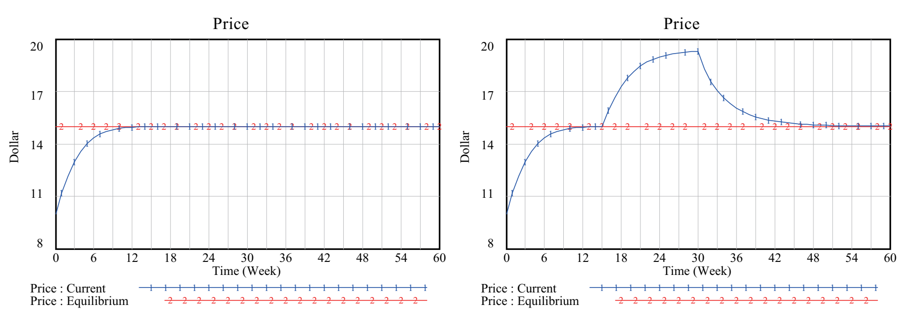


Figure 2.4: Stability of Equilibrium

Chaos

So far, neoclassical price mechanism seems to be working well. To attain the equilibrium in our model, a price adjustment coefficient is set to be 0.4. What will happen if the Auctioneer happens to increase the adjustment coefficient from 0.4 to 3 in order to speed up his tâtonnement process? Surprisingly this has caused a period 2 cycle of price movement with alternating prices between 10.14 and 18.77 for the initial price of p=10, as illustrated in the left-hand diagram of Figure 2.5. When the coefficient is increased a little bit further to 3.16, price behavior suddenly becomes very chaotic as the right-hand diagram illustrates. I encountered this chaotic price behavior unexpectedly when I was constructing a pure exchange economic model using S language under UNIX environment in Yamaguchi (1993).

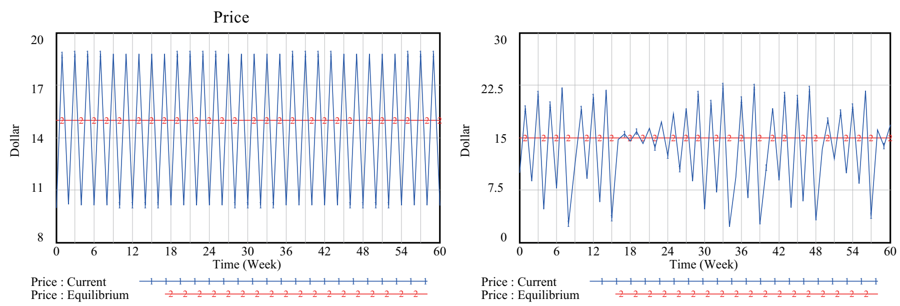


Figure 2.5: Chaotic Price Behavior

Under such a chaotic price behavior, it is obvious that the Auctioneer fails to attain an equilibrium price. Accordingly, under the failure of finding the equilibrium, market transactions can never take place according to the neoclassical rule of the market game. This indicates a fundamental defect in neoclassical framework of market economy based on the idea of *logical* time.

Short-side Transactions

Tired with an endless struggle by the Auctioneer to attain an equilibrium in a chaotic price behavior, buyers and sellers may force their actual transactions to resume at a short-side of demand and supply. In other words, if demand is greater than supply, the amount supplied at that price is traded, while the amount demanded is purchased if supply is greater than demand.

To allow this off-equilibrium transactions, the Auctioneer has to have enough amount of inventory at hand before the market starts. To calculate the enough amount of inventory, a slightly revised model is built as shown in the left-hand diagram of Figure 2.6 [Companion model: 2 Auctioneer(Inventory).vpmx].

When the Auctioneer quotes an initial price below equilibrium at $5, allowing the short-side trade, unrealized excess demand keeps piling up as backlog due to an inventory shortage and the amount accumulates up to 325.30 shirts. When market price is initially quoted above equilibrium at $25, excess supply causes the inventory of unsold shirts to pile up to 137.86 shirts, as illustrated in the right-hand diagram of Figure 2.6. If the Auctioneer is allowed to have these amount of inventories from the beginning, he could find an equilibrium price even by allowing these inter-auction transactions. Since no shirts are made

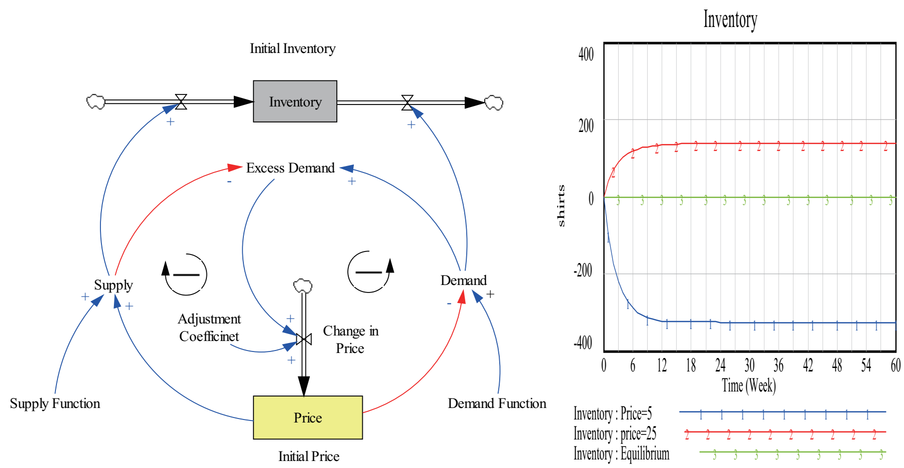


Figure 2.6: Short-side Transaction Model and Inventory

available until the equilibrium contract is made and production activities start under the neoclassical rule of market game, this short-side off-equilibrium deal is logically impossible. In other words, no feedback loop is made available without inventory from the viewpoint of system dynamics. In conclusion, the existence of chaotic price behavior and neoclassical assumption of market economy are inconsistent.

2.4 Price Adjustment with Inventory

The above analysis indicates it's time to abandon the neoclassical framework based on Logical Time. In reality, production and transaction activities take place week by week, and month by month at short-side of product availability, accompanied by piled-up inventory or backlog. Time flow on which these activities keep going is called *Historical Time* in Yamaguchi (1988). In system dynamics, demand and supply are regarded as the amount of flow per week, and flow eventually requires its stock as inventory to store products. Thanks to the inventory stock, transactions now need not be waited until the Auctioneer finishes his endless search for an equilibrium. This is a common sense, and even kids understand this logic. In other words, a price adjustment process turns out to require inventory from the beginning of its analysis, which in turn makes off-equilibrium transactions possible on a flow of Historical Time.

This disequilibrium approach is the only realistic method of analyzing market economy, and system dynamics modeling makes it possible. The model running on Historical Time for simulations, which is based on Whelan and Msefer (1994), is drawn in Figure 2.7 [Companion model: 3 Inventory.vpmx].

Price no longer need to respond to the excess demand, instead it tries to adjust to the gap between inventory and desired inventory. To avoid a shortage

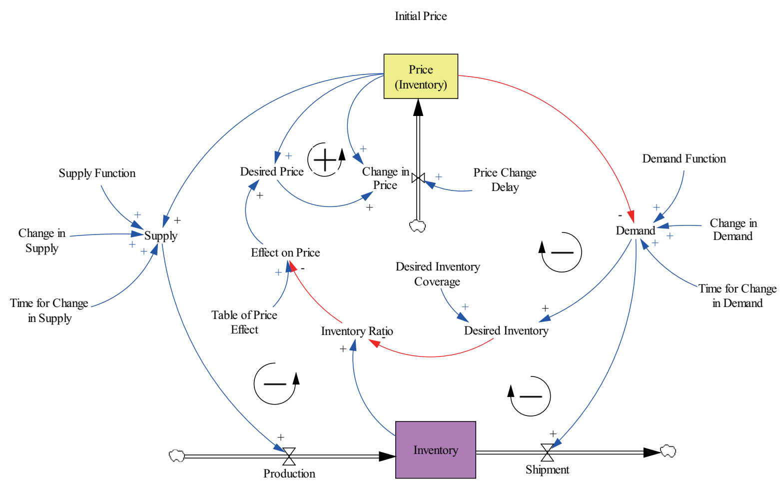


Figure 2.7: Price Adjustment Model with Inventory

under off-equilibrium transactions, producers usually try to keep several weeks of the demanded amount as inventory. This amount is called desired inventory. An inventory ratio is thus calculated as the inventory divided by the desired inventory. And market prices are assumed to respond to this ratio. Table 2.2 specifies the effect of the ratio on price. For instance, if the actual inventory is 20% larger than the desired inventory, price is assumed to be lowered by 25%. Vice versa, if it's 20% smaller, then price is assumed to be raised by 35%.

Inventory Ratio	0.6	0.7	0.8	0.9	1	1.1	1.2	1.3	1.4
Effect on Price	1.8	1.55	1.35	1.15	1	0.875	0.75	0.65	0.55

Table 2.2: Effect of Inventory Ratio on Price

Mathematically, the model is formulated as follows:

$$\frac{dp(t)}{dt} = \frac{p^* - p(t)}{PCD} \tag{2.4}$$

where PCD is a parameter of price change delay, and p^* is a desired price such that

$$p^* = p(t)g(\theta) \tag{2.5}$$

Function $g(\theta)$ is a formal presentation of "Effect on Price", and θ is "Inventory Ratio in Table 2.2 such that $\theta = x(t)/x^*$. $x(t)$ and x^* denote inventory and desired inventory, respectively, such that

$$\frac{dx(t)}{dt} = S(p) - D(p) \tag{2.6}$$

$$x^* = \alpha D(p) \tag{2.7}$$

where α is a parameter of desired inventory coverage as illustrated in Figure 2.7.

To apply this idea of price adjustment mechanism with inventory more uniformly in this book, let us define $g(\theta)$ specifically as

$$g(\theta) = \frac{1}{\theta^e}, \text{ (where } \theta = \frac{x(t)}{x^*} \text{ in this section)} \tag{2.8}$$

e in the equation can be interpreted as an elasticity of the function $g(\theta)$.[3]

Desired price p^* in equation(2.5) can be now rewritten as

$$p^* = p(t)g(\theta) = p(t)\frac{1}{\theta^e} = \frac{p(t)}{(\frac{x(t)}{x^*})^e} \tag{2.9}$$

This is our unified modeling method of price adjustment processes in our macroeconomic models throughout this book. For instance, for the modeling of wage rate adjustment, $g(\theta)$ becomes effect on wage rate and θ is obtained as a ratio of labor supply and demand. For interest rate adjustment, $g(\theta)$ becomes effect on interest rate and θ is calculated as a ratio of money stock and demand.

Under such circumstances, the initial price is set here at \$10 as in the case of the Auctioneer's tâtonnement. Price (line 5) now fluctuates around the equilibrium price of \$15 by overshooting and undershooting alternatively, then tends to converge to the equilibrium as illustrated in Figure 2.8. Inventory gap (= desired inventory - inventory) is the gap between line 4 and 3, and price responds to this gap rather than the excess demand (the gap between line 1 and 2). The reader can easily confirm that price tends to rise as long as the inventory gap is positive, or inventory ratio is lower than one, and vice versa.

In the left-hand diagram of Figure 2.9, demand is increased by 20 units at the week of 15, followed by the increase in the same amount of supply at the week of 30, restoring the original equilibrium as in the case of the Auctioneer's tâtonnement, though overshooting this time. These shifts of demand and supply curves, however, may no longer be appropriate to be called comparative static analysis method in microeconomics, because we are no longer comparing two different states of equilibrium points. Right-hand diagram illustrates how price cycle is triggered by reducing the original inventory coverage of 4 weeks to 2.3 weeks. In conclusion, system dynamics modeling makes it possible to describe the actual off-equilibrium transactions and price behaviors along the Historical Time.

2.5 Logical vs Historical Time

A combined model is created in Figure 2.10 to compare how the above two price adjustment processes behave differently; one is running on Logical Time and the

[3] Elasticity of the function g can be easily calculated as

$$\text{Elasticity} \equiv -\frac{dg}{g}/\frac{d\theta}{\theta} = -\frac{dg}{d\theta}\frac{\theta}{g} = -\left(-\frac{e}{\theta^{e+1}}\right)\frac{\theta}{g} = e$$

The function $g(\theta)$ is, thus, shown to have a uniform elasticity e over its entire range.

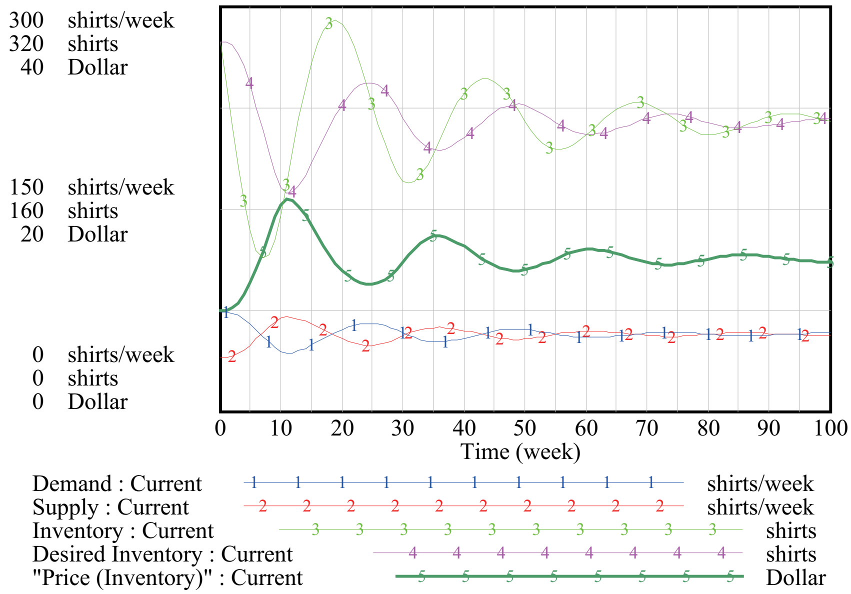


Figure 2.8: Price Adjustment with Inventory

other on historical time [Companion model: 4 Comparison.vpmx].

Left-hand diagram of Figure 2.11 is produced to show similar patterns by setting the Auctioneer's adjustment coefficient to be 2.7. In both cases it takes about 100 weeks to attain the equilibrium. The difference is that under logical time production and transactions never take place until the equilibrium is attained around the Logical Time of 100 weeks, while a real economy running on the Historical Time is suffering from the fluctuation of inventory business cycles for 100 weeks until a real equilibrium price is attained.

What will happen if the demand suddenly increases by 20 at week 50. Right-hand diagram illustrates the real economy can no longer attain the equilibrium in 100 weeks. In this way the market economy is forced to be fluctuating around off-equilibrium points forever in face of continued outside shocks, compared with a quick realization of the equilibrium by the Auctioneer around the Logical Time of week 70.

The meaning of logical and Historical Times is now clear. Microeconomic textbooks are full of Logical Time analyses when dynamics of price movements are discussed. The reader now has the right to ask if the time in textbooks is logical or historical. If historical, price has to be always accompanied by the inventory on Historical Time.

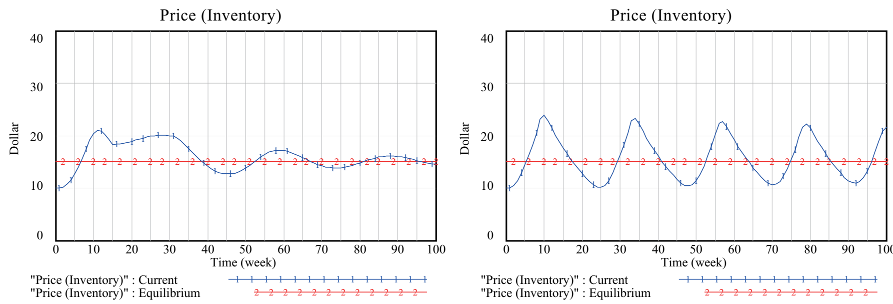


Figure 2.9: Effects of the Changes in Demand, Supply and Inventory Coverage

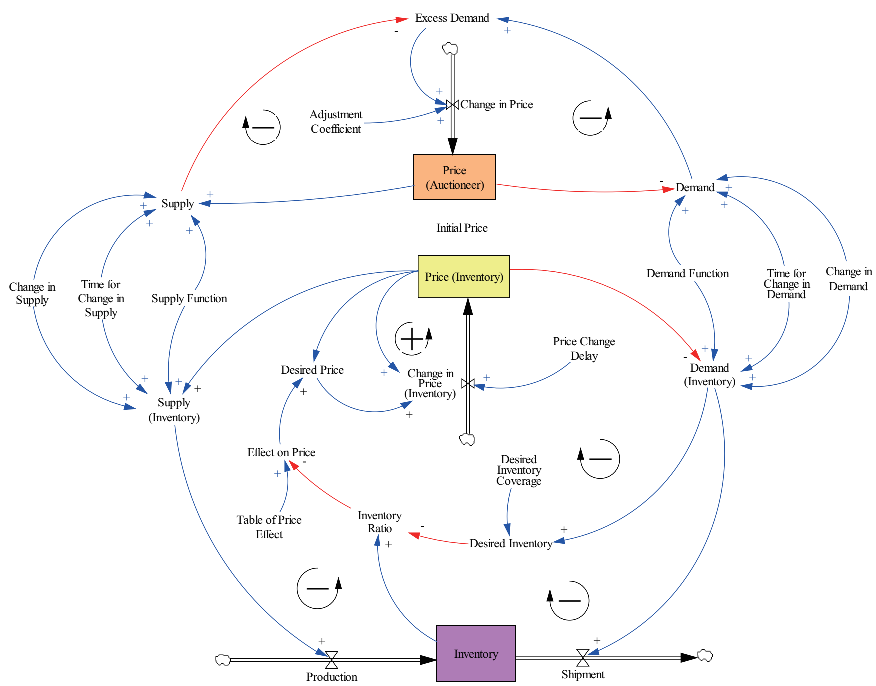


Figure 2.10: Auctioneer vs Inventory Price Mechanism Compared

2.6 Stability on A Historical Time

Which path, then, should we follow to analyze free market economic activities? Neoclassical analysis of Logical Time is mathematically rigorous, yet free price behavior is no longer stable, as preached by market fundamentalists, due to the appearance of Chaos as shown above. In other words, market economy could be chaotic even on the basis of neoclassical doctrine.

On the other hand, analysis running on historical time is off-equilibrium and

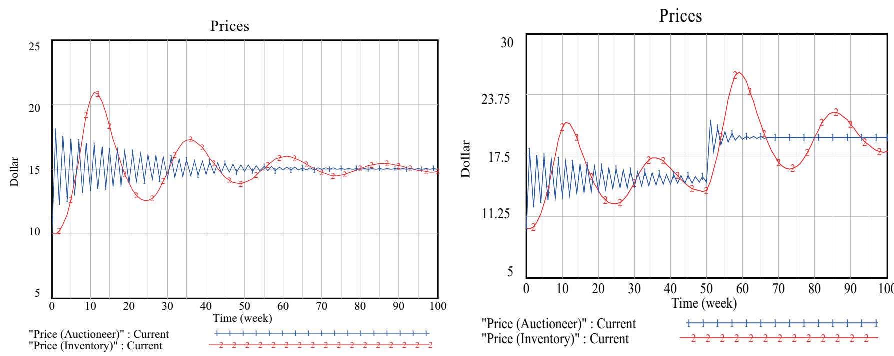


Figure 2.11: Auctioneer vs Inventory Price Behaviors

looks unstable, full of business cycles; that is, chaotic as well. Yet, there's a way to make the historical time analysis stable and free from business cycles. To do so, let us now change the seller's supply (production) schedule so that it can reflect the inventory gap as follows:

$$\text{Supply (Inventory)} = \text{Supply Function (Price (Inventory))} \\ + \text{Inventory Gap / Inventory Adjustment Time} \quad (2.10)$$

Mathematically, equation (2.6) is replaced with the following:

$$\frac{dx(t)}{dt} = S^*(p) - D(p) \quad (2.11)$$

$$S^*(p) = S(p) + \frac{x^* - x(t)}{IAT} \quad (2.12)$$

where IAT is inventory adjustment time.

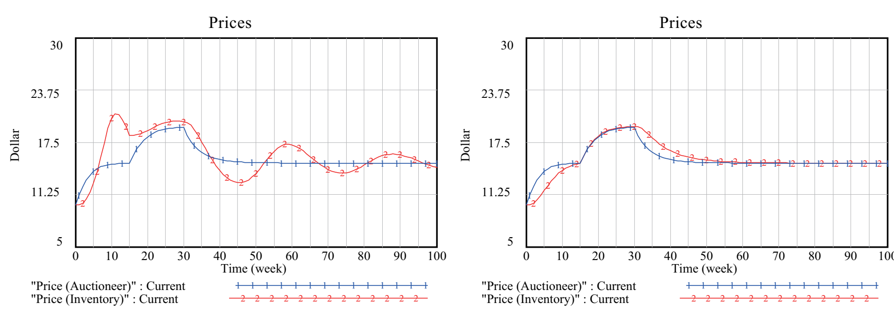


Figure 2.12: Historical Price Stability with Adjusted Supply Schedule (1)

Left-hand diagram of Figure 2.12 illustrates how price behaviors are different between Logical Time (line 1) and historical time (line 2) when demand is increased by 20 units at the week of 15, followed by the increase in the same amount of supply at the week of 30 [Companion model: 5 Comparison(Supply).vpmx)]. In both cases prices try to restore the original equilibria, though their speed and meaning are different. In the right-hand diagram, newly adjusted supply schedule is now applied with the inventory adjustment time of 3 weeks. To our surprise, almost the same price behavior is obtained as the one on Logical Time.

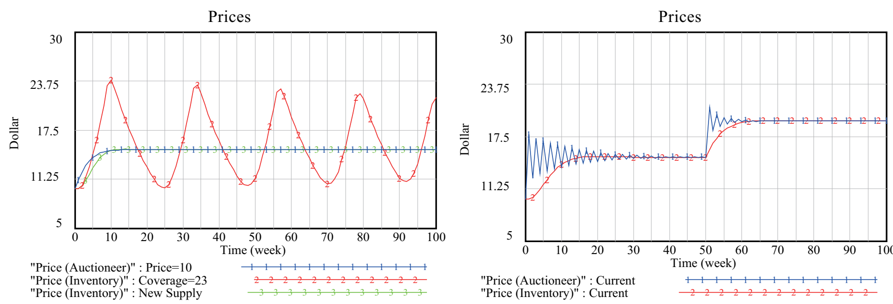


Figure 2.13: Historical Price Stability with Adjusted Supply Schedule (2)

In the left-hand diagram of Figure 2.13, price behavior on the Logical Time is illustrated as line 1 for the initial price at $10, while the same price behavior on the Historical Time is illustrated as line 2 for the inventory coverage of 2.3 weeks, similar to the right-hand diagram of Figure 2.9. Now the new supply schedule is applied to the same situation, which results in line 3. Again, the line 3 becomes very similar to the price behavior (line 1) on the Logical Time.

Finally let us apply the new supply schedule to the right-hand diagram of Figure 2.11, that is previously explained as the case in which "the real economy can no longer attain the equilibrium in 100 weeks." Right-hand diagram of Figure 2.13 is the result obtained by newly adjusted supply with the inventory adjustment time of 3 weeks. Again almost similar price behavior is restored as the one on the Logical Time.

These simulation results may indicate that our market economy could behave as close as the one predicted by neoclassical equilibrium analysis on Logical Time so long as economic agents behave appropriately on the historical off-equilibrium time. In other words, we no longer need a help from Auctioneer running on logical time to attain an equilibrium in a market economy. Price, inventory and their interdependent feedback relations can do the same job in a real market economy.

2.7 A Pure Exchange Economy

2.7.1 A Simple Model

Chaotic price behavior observed in tâtonnement adjustment is not specific to a partial or single market. To show a Chaos in a general equilibrium framework, let us consider a pure exchange economy: the most favored economy used by neoclassical economists in textbooks. A pure exchange economy is a kind of game without production in which initially endowed goods are exchanged on the basis of traders' own preferences such that their utilities are maximized. Such an exchange economy is profoundly criticized by Joan Robinson Robinson (1971) as an irrelevant game in a prison camp in which prisoners are given fairly equal amounts of commodities irrespective of their personal tastes so that an exchange game based on their tastes can easily proceed. I have also criticized its appropriateness as a capitalist economic model (Yamaguchi, 1988, Chapter 7), and posed a more comprehensive model comprising the analysis of both logical and Historical Time for a better understanding of the functioning of a capitalist market economy(Yamaguchi, 1988, Chap.3-6).

Yet, the exchange model is still used in most textbooks on microeconomics as a first approximation to a market mechanism. If there still exists something that we can learn from a pure exchange model, it is the functioning of a tâtonnement price adjustment mechanism. The structure of the price mechanism is basically the same for a more general economy with production. Thus, Hildenbrand and Kirman justify the analysis of a pure exchange economy as saying "if we cannot solve, in a reasonably satisfactory way, the exchange problem, then there is not much hope for the solution of the more general one (Hildenbrand and Kirman, 1988, pp.51-51)." I have indicated Yamaguchi (1988) that this justification is only applicable to the analysis of *logical* time, but not to that of *historical* time. A pure exchange model should, therefore, be confined to a heuristic use for understanding a price mechanism of Logical Time.

Understanding the exchange economy this way, do we still have unanswered problems? The answer seemed to me to be negative at first, since the economy has been comprehensively studied in the literature, for instance, Hildenbrand and Kirman (1988) and Smale (1981). However, there still exist some interesting questions in the area of numerical computations and simulations of price adjustment mechanisms using system dynamics modeling.

The economy is explained as follows. It consists of at least two traders (and consumers simultaneously) who bring their products to the market for exchange. Their products are called *initial endowment* in economics, which becomes the source of supply in the market. We assume following endowment for consumer 1 and 2.

$$\begin{cases} \text{Consumer 1} & = (10,\ 6) \\ \text{Consumer 2} & = (\ 6, 15) \end{cases} \tag{2.13}$$

The economy can thus evade the analysis of production. That's why it is called a pure exchange economy.

In the pure exchange economy only relative prices matter due to the Walras

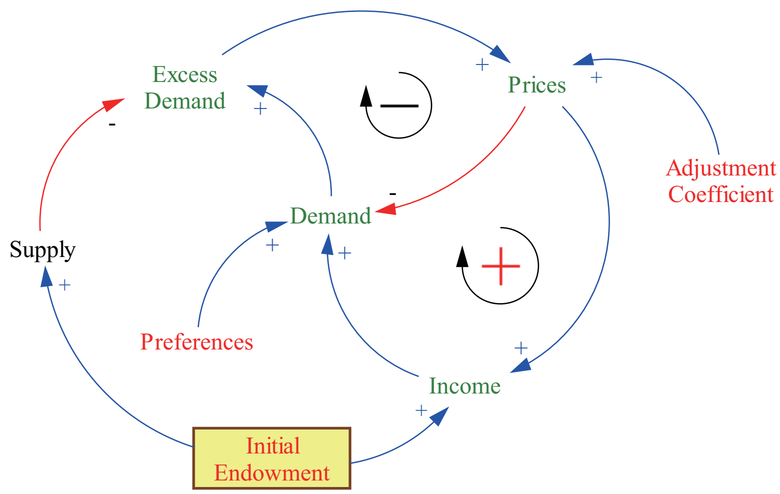


Figure 2.14: A Causal Loop of A Pure Exchange Economy

law[4]. Let us assume that commodity 1 becomes a numeráire, that is, its price is unitary: $p_1 = 1$, $p_2 = p$ be a relative price of commodity 2.

When the price is quoted in the economy, traders evaluate a market value of their products as a source of their income for further exchange or purchase of the products in the market. Then as consumers, they try to maximize their utility (which is derived from the consumption of the products purchased in the market) according to their own preferences subject to their income constraint. In this way their demand for products are calculated as a function of prices, income (which in turn is a function of prices) and preferences. Total demand is obtained as a sum of these individual consumer's demand, which is then compared with the total supply. Excess demand is defined as the difference between total demand and total supply, and becomes a function of prices and preferences. Figure 2.14 illustrates a causal loop diagram of the pure exchange economy.

Market prices have two causal loops; one positive and one negative feedback loops. In the figure they are indicated by plus and minus signs. Positive loop in general tries to reinforce the original move stronger, while negative loop tries to counterbalance it. Thus, a moving direction of market prices depends on which loop is dominating: positive or negative? When a positive feedback loop dominates, prices tend to diverge, while a negative feedback loop reverses the direction of the price movement. These opposite and complicated movements are caused by the values of two parameters: adjustment coefficient and preferences. Pure exchange model is illustrated in Figure 2.15 [Companion model: 6 PureExchange.vpmx].

[4]See the appendix for detail.

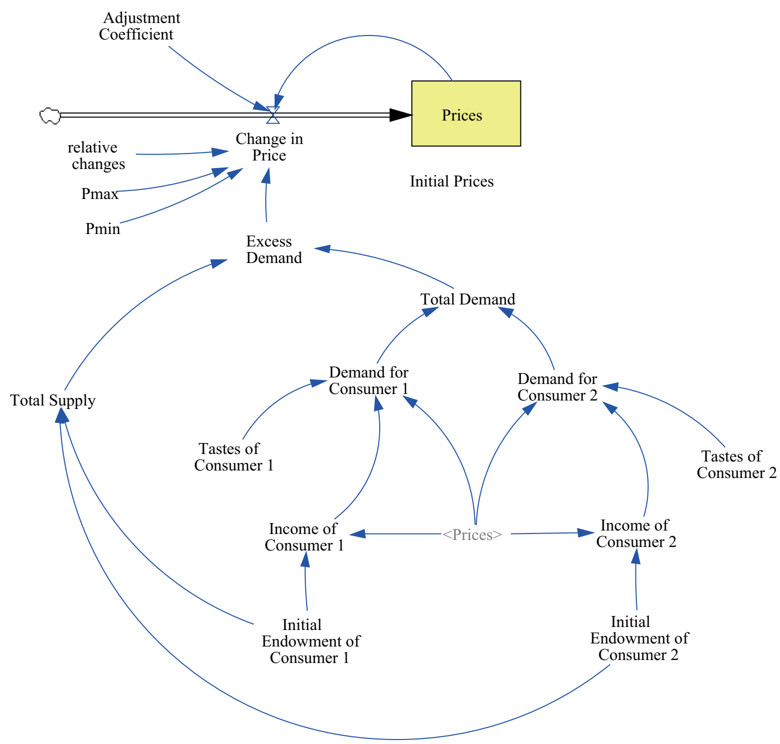


Figure 2.15: A Pure Exchange Economy Model

2.7.2 Tâtonnement Processes on Logical Time

A step-by-step calculation process of price adjustment is depicted in Figure 2.16, where P_t denotes prices at the period t, a function f denotes the amount of

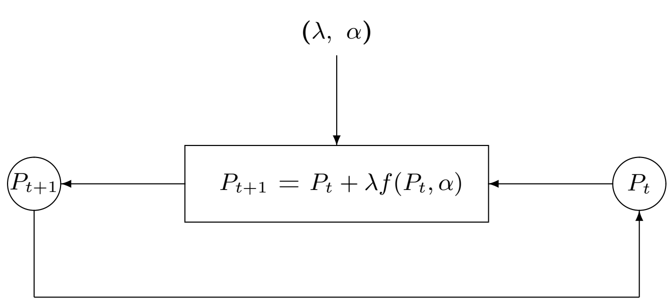


Figure 2.16: Tâtonnement Adjustment Process

excess demand, and α, λ denotes preferences and price adjustment coefficient, respectively. Preferences and adjustment coefficient are the only parameters in the economy which have to be exogenously determined. Once these are given and present prices are quoted, excess demand can be calculated. If it is positive, prices at the next period are increased by the amount of the excess demand multiplied by the adjustment coefficient. Hence, adjustment coefficient determines the degree of a price increase in the next period. When excess demand is negative, prices at the next period are decreased by the amount of the excess demand multiplied by the adjustment coefficient.

As illustrated in Figure 2.1, a convergence of prices to the equilibrium is expected where demand and supply curves intersect. Indeed, they did for a very small value of adjustment coefficient; that is, prices are shown to be globally stable.

To our surprise, however, something strange happened as the value of the coefficient increased. As Figure 2.17 indicates, the adjustment process begins to produce a clear bifurcation, or an oscillation of prices in period 2 when price adjustment coefficient is $\lambda = 0.148$. Furthermore, an increasing adjustment coefficient continues to create new bifurcations or price oscillations of period $2n$, $n = 1, 2, \ldots$ until it became totally chaotic. In other words, instead of converging to an equilibrium or diverging to infinity, market prices seemed to be eventually attracted to a certain region and continue fluctuating in it, with the information of initial values being lost shortly.

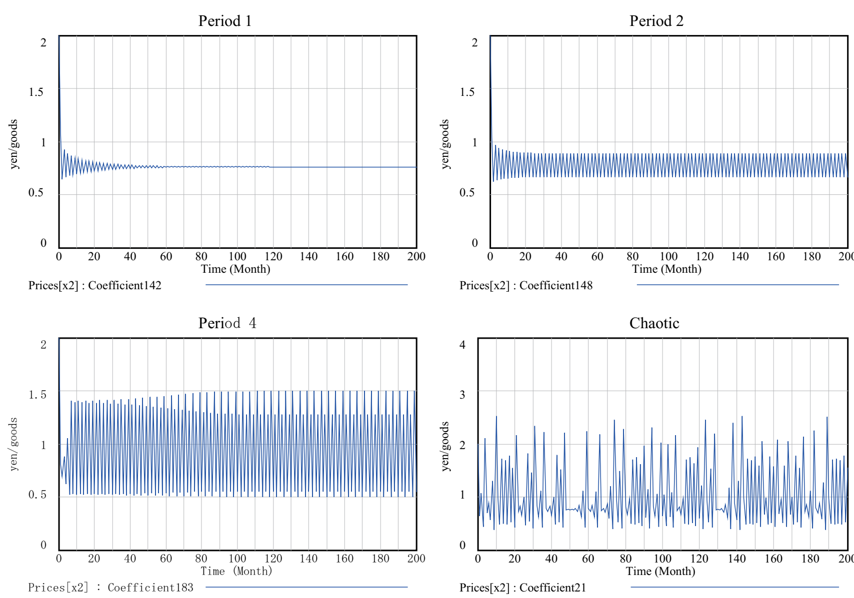


Figure 2.17: Price Movement of Period 1, 2, 4 and Chaos

Figure 2.18 illustrates the bifurcation of prices as the adjustment coefficient increases. The region is called *a strange attractor* or *Chaos*. Hence, a price mechanism in a market economy turned out to be chaotic! In such a chaotic region, market economy becomes far from the equilibrium and globally unstable, and economic disequilibria such as recession and unemployment become dominant.

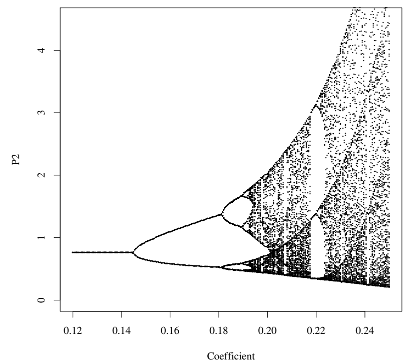


Figure 2.18: Chaotic Price for λ

One of the main features of Chaos is a sensitive dependence on initial conditions. This means that a very small difference of initial values will create a big difference later on and a long run prediction of the movement will become eventually impossible. This is confirmed by plotting prices as time-series data. In Figure 2.19 two lines represent time-series behaviors of two prices whose initial values only differ by 0.00001. Line 1 is obtained at $\lambda = 0.21001$, while line 2 is obtained at $\lambda = 0.21002$. Evidently two lines begin to diverge as time passes around month 20, which proves that prices are indeed chaotic (See Yamaguchi (1993) for details).

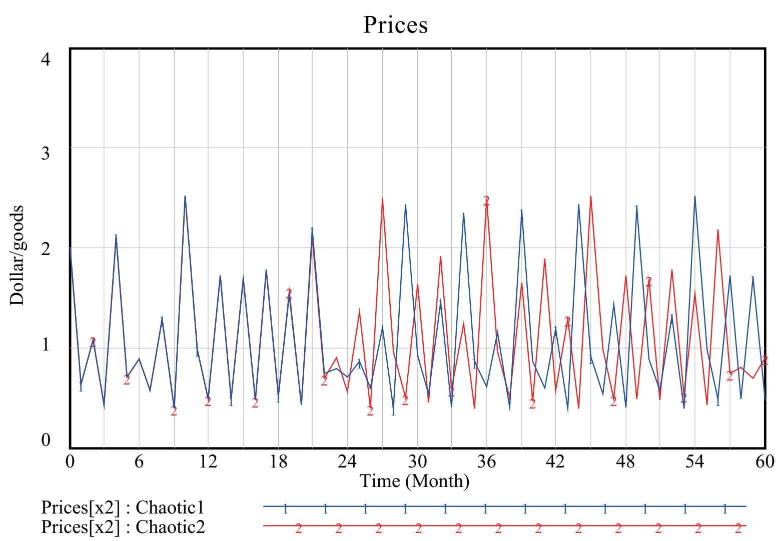


Figure 2.19: Sensitive Dependence on Initial Conditions

It is almost impossible in reality to obtain a true initial value due to some observation errors and round-off errors of measurement and computations. These errors are exponentially magnified in a chaotic market to a point where predictions of future prices and forecasting are almost meaningless and even misleading.

This is a wholly unexpected feature for a neoclassical doctrine of market stability originated by Adam Smith's idea of *invisible hand.* Even so, this chaotic situation could be harnessed so long as the value of adjustment coefficient is small enough; in other words, prices are regulated to fluctuate only within a small range so that no violent jumps of prices are allowed - a relief to the neoclassical school.

2.7.3 Chaos Triggered by Preferences

What will happen, then, if preferences, an another parameter in the economy, vary? Can whimsical preferences of consumers are also powerful enough to drive a stable economy into chaos? To examine this, I started with a globally stable situation in which a price, wherever its initial position is, converges to

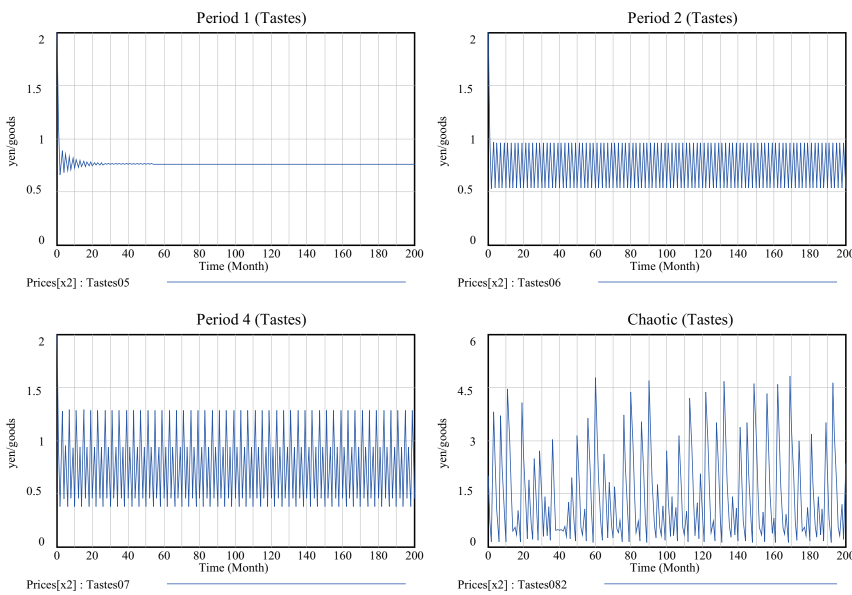


Figure 2.20: Price Movement of Period 1, 2, 4 and Chaos Caused by Tastes

an equilibrium price; specifically at the adjustment coefficient of $\lambda = 0.138$. Then tastes of goods 1 for consumer 1 is increased from 0.5 slightly up. Figure 2.20 illustrates periodic behavior of price caused by the changes in consumer 1's tastes.

Figure 2.21 is produced by changing the values of preferences α. It indicates that as the values of α increase an equilibrium price tends to be going down up to a bifurcation point. Except this decreasing equilibrium price, to our surprise, both diagrams in Figures 2.18 and 2.21 turned out to be structurally similar; that is, Chaos is similarly caused by the changes in preferences (Fore details see Yamaguchi (1993) and Yamaguchi (1994)).

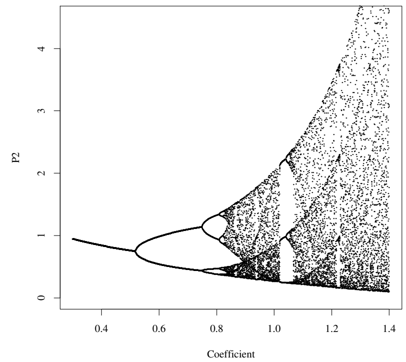


Figure 2.21: Chaotic Price for α

This seems to be a serious challenge against a neoclassical doctrine of price stability. Market equilibrium can no longer be restored even by a small value of adjustment coefficient. That is to say, price regulations suggested above are no longer effective to harness a Chaos in the market. The price stability attained by a small value of adjustment coefficient can be easily driven into a chaos by whimsical preferences of consumers. Capricious behaviors of consumers themselves are the cause of chaos and, to be worse, no regulations are possible to control consumers' preferences. It is concluded, therefore, that Chaos is inherent in the market, to be precise, of Logical Time.

2.7.4 Off-Equilibrium Transactions on Historical Time

What is an economic implication of this chaotic price adjustment, then? Pure exchange economy works only when its Auctioneer can find equilibrium prices at which traders and consumers make their transactions. If the Auctioneer cannot find the equilibrium, market failure arises according to neoclassical framework of market economy. The Auctioneer could become totally helpless in the face of an unpredictability of market prices and the existence of Chaos itself in the market economy.

Chaos is caused by the values of two parameters; adjustment coefficient and preferences. The Auctioneer could find the coefficient value which attains price stability and eventually equilibrium. This could be done by harnessing a chaotic movement of prices, as mentioned above, by imposing a price regulation directly or setting a market rule for price changes. These policies of the Auctioneer inevitably begin to justify a Keynesian school's idea of utilizing public policies by wise government.

Yet, Chaos is triggered by another parameter of consumers' preferences. This time the Auctioneer has no direct or indirect control over preferences and tastes of consumers. This means consumers' whimsical preferences have a chance to nullify price adjustment stabilization and drive a stable economy into Chaos again.

Accordingly, it has to be concluded that in a pure exchange market economy there is no way to avoid a chaotic price movement and a global instability. We will be all of a sudden thrown into a chaotic world against a neoclassical world of a stable price mechanism. From the simulation results above, it could be even concluded that disequilibrium states are normal in a market economy! In other words, a stable price adjustment mechanism propounded by neoclassical school is rather exceptional in a market economy that is prevalently chaotic.

No one could deny this conclusion, because it is drawn from a most fundamental exchange model of a market economy. This conclusion forces us to drastically change our vision on a classical doctrine of *invisible hand* that has been believed for more than 200 years since Adam Smith.

Traditional classical and neoclassical doctrine of economics has been constructed on a linear framework of a classical Newtonian mechanics. Modern neoclassical theory of price adjustment mechanism is nothing but an application of such a classical mechanics to economics. Keynes once warned that our economic thoughts are easily enslaved by those of professional economists. It turned out that economists themselves were enslaved by classical physicists.

Modern economic theory has not only failed to provide remedies for overcoming these disequilibria caused by a chaotic market, but also has stubbornly clung, to be worse, to a traditional belief in a globally stable market economy.

Market economic analysis now has to be based on off-equilibrium transactions on Historical Time. Once economic analysis is freed from the control of *invisible hand*, market disequilibria such as recession and unemployment can be better handled on Historical Time with system dynamics method.

The MuRatopian Economy

After the collapse of the former Soviet Union in 1989, a capitalist market economy has become the only remaining alternative, no matter how violent and chaotic it is. Accordingly, free market principles are enforced globally such as market and financial deregulations, restructuring and re-engineering by business corporations, resulting in recessions and higher unemployment rates. And government tries repeatedly to exercise traditional fiscal and financial policies in vain.

In the book Yamaguchi (1988), information age is shown to be incompatible with a capitalist market economy and a mixed economy of welfare state. It then poses a necessity of new economic paradigm suitable for the information age. As one such new paradigm, I have proposed an economic system called MuRatopian economy. Interested readers are referred to "Sustainability and MuRatopian Economy" (Yamaguchi, 1997, Chapter 5) and "Toward A New Social Design" (Yamaguchi, 1988, Chapter 8).

Now that disequilibria on Historical Time are shown to be normal states in a capitalist market economy, the doctrine of Adam Smith should not be influential anymore in the information age of the 21st century. We need to change the way we think about a market economy. We have to create a new economic system that is beyond a chaotic capitalist market economy and is preferable in the new information age. This will be challenged in Part IV of chapters 12, 13, 14 and 15; that is, Macroeconomic Systems of Public Money. Specifically, chapter 15 revisits the MuRatopian economy, and incorporates it with the public money system we propose in this book as our best social design of macroeconomy for sustainable futures.

Before going so far, we have to explore how market economies and macroeconomies running on Historical Time work.

2.8 Co-Flows of Goods with Money

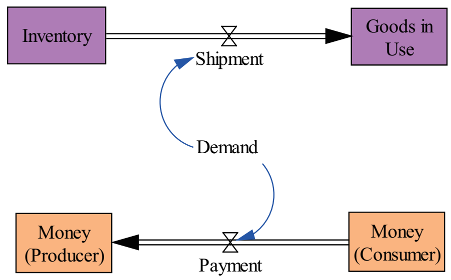


Figure 2.22: Co-flows of Goods and Money

So far, we have focused on the attainment of the equilibrium in a market economy through price adjustment. In a market economy, however, attainment of equilibrium is necessary, but not sufficient to make transactions possible if the economy is not a so-called pure exchange economy, and it is running on historical time.

Whenever transactions are allowed at off-equilibrium prices, money as a medium of exchange has to be introduced. This is what human history tells us, as explored in Zarlenga (2002). In other words, goods and money flows simultaneously as illustrated in Figure 2.22.

Accordingly, we have to explore how to model such co-flow transactions. It will be done in the next chapter by examining accounting system.

Appendix: A Pure Exchange Economy

A Model

A pure exchange model can be represented as constituting n commodities and H consumers who own the initial endowments:

$$\bar{x}^h = (\bar{x}_1^h, \bar{x}_2^h, \ldots, \bar{x}_n^h), \quad h \in H. \tag{2.14}$$

Total supply of commodities in the economy is obtained as

$$\bar{x}_i = \sum_{h \in H} \bar{x}_i^h, \quad i = 1, 2, \ldots, n. \tag{2.15}$$

Moreover, for a given price vector $p = (p_1, p_2, \ldots, p_n)$, a consumer h's notional income is calculated as

$$I_h(p) = p\bar{x}^h = \sum_{i=1}^{n} p_i \bar{x}_i^h, \quad h \in H. \tag{2.16}$$

As a consumer h's preferences, let me assume a following Cobb-Douglas utility function in a logarithmic form where $\alpha^h > 0$:

$$u^h(x^h, \alpha^h) = \sum_{i=1}^{n} \alpha_i^h \log x_i^h. \tag{2.17}$$

It is well known that a utility function thus defined is strongly quasi-concave.

The consumer h is now assumed to seek to maximize $u^h(x^h, \alpha^h)$ subject to his budget constraint $px^h \leq I_h(p)$. Then, by a simple calculation his demand functions are obtained as

$$x_i^h(p) = \hat{\alpha}_i^h \frac{I_h(p)}{p_i}, \quad i = 1, 2, \ldots, n, \tag{2.18}$$

$$\text{where } \hat{\alpha}_i^h = \frac{\alpha_i^h}{\sum_{i=1}^{n} \alpha_i^h} \text{ and } \sum_{i=1}^{n} \hat{\alpha}_i^h = 1. \tag{2.19}$$

These non-linear demand functions are shown to be homogeneous of degree zero in price p.

Total demand for commodities is defined as

$$x_i(p) = \sum_{h \in H} x_i^h(p), \quad i = 1, 2, \ldots, n. \tag{2.20}$$

Then, excess demand functions are calculated as

$$\zeta_i(p) = \frac{1}{p_i} \sum_{h \in H} \hat{\alpha}_i^h I_h(p) - \bar{x}_i, \quad i = 1, 2, \ldots, n. \tag{2.21}$$

An equilibrium of the economy is defined to be a situation in which all markets clear for some price p^*, that is,

$$\zeta(p^*) = \{\zeta_1(p^*), \zeta_2(p^*), \ldots, \zeta_n(p^*)\} = 0. \tag{2.22}$$

The existence of such an equilibrium price is reduced to find a solution in the following linear system:

$$\begin{bmatrix} a_{11} - \bar{x}_1 & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} - \bar{x}_2 & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} - \bar{x}_n \end{bmatrix} \begin{bmatrix} p_1 \\ p_2 \\ \vdots \\ p_n \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ \vdots \\ 0 \end{bmatrix}. \tag{2.23}$$

where $a_{ij} = \sum_{h \in H} \hat{\alpha}_i^h \bar{x}_j^h$.

It is shown in (Hildenbrand and Kirman, 1988, p.100) that there exists a non-trivial positive equilibrium price $p^* \gg 0$. The existence of equilibria in an exchange economy is more generally shown by SmaleSmale (1981). Such an equilibrium price is known to be unique up to n-1 prices. This can be easily confirmed by the fact that the column sums of the above matrix are zero, or from the Walras' law: $p\zeta(p) \equiv 0$. That is to say, only relative prices are determined in the equilibrium.

Two commodities and two consumers

Let us simplify the exchange economy as consisting of two commodities and two consumers. In this simplified economy, excess demand functions are calculated as

$$\zeta_1(p) = \hat{\alpha}_1^1 \frac{I_1(p)}{p_1} + \hat{\alpha}_1^2 \frac{I_2(p)}{p_1} - \bar{x}_1, \tag{2.24}$$

$$\zeta_2(p) = \hat{\alpha}_2^1 \frac{I_1(p)}{p_2} + \hat{\alpha}_2^2 \frac{I_2(p)}{p_2} - \bar{x}_2. \tag{2.25}$$

These excess demand functions are obviously homogeneous of degree zero, and Walras' law in this economy is shown to be

$$p_1\zeta_1(p) + p_2\zeta_2(p) \equiv 0. \tag{2.26}$$

Therefore, a relative equilibrium price $p^* = (p_1^*, p_2^*)$ satisfying $\zeta_i(p^*) = 0,\ i = 1, 2$, is calculated as follows.

$$\frac{p_1^*}{p_2^*}_{|\zeta_1=0} = \frac{\hat{\alpha}_1^1 \bar{x}_2^1 + \hat{\alpha}_1^2 \bar{x}_2^2}{(1-\hat{\alpha}_1^1)\bar{x}_1^1 + (1-\hat{\alpha}_1^2)\bar{x}_1^2}. \tag{2.27}$$

$$\frac{p_1^*}{p_2^*}_{|\zeta_2=0} = \frac{(1-\hat{\alpha}_2^1)\bar{x}_2^1 + (1-\hat{\alpha}_2^2)\bar{x}_2^2}{\hat{\alpha}_2^1 \bar{x}_1^1 + \hat{\alpha}_2^2 \bar{x}_1^2}. \tag{2.28}$$

From a relation: $1 - \hat{\alpha}_1^i = \hat{\alpha}_2^i, \ i = 1, 2$, it can be shown that these two relative equilibrium prices are equal, that is,

$$\frac{p_1^*}{p_2^*}_{|\zeta_1=0} = \frac{p_1^*}{p_2^*}_{|\zeta_2=0} \tag{2.29}$$

In sum, it is demonstrated that in this simplified economy an equilibrium price exists, and only a relative price is determined, as expected from the analysis of the general model above.

Constructing Tâtonnement Processes

How can we attain an equilibrium price when it cannot be directly computed? In such a case, a tâtonnement price adjustment process is the only available method to determine an equilibrium price or even estimate it. A standard adjustment process that is often used in the literature is the following in which an adjustment coefficient λ is given exogenously.

$$p_i(t+1) = \text{Max } \{p_i(t) + \lambda\zeta_i(p(t)), 0\}, \quad i = 1, 2. \tag{2.30}$$

As an alternative tâtonnement adjustment (a), the following process is also employed:

$$p_i(t+1) = p_i(t) + \lambda \text{Max } \{\zeta_i(p(t)), 0\}, \quad i = 1, 2. \tag{2.31}$$

When prices are bounded by some minimum and maximum values, the following minmax tâtonnement adjustment (m) is occasionally applied:

$$p_i(t+1) = \text{Min } \{\bar{p}_i, \text{Max } \{p_i(t) + \lambda\zeta_i(p(t)), \underline{p}_i\}\}, \quad i = 1, 2. \tag{2.32}$$

This process is a generalization of the above standard tâtonnement adjustment process whose maximum price is assumed to be infinite.

In these processes the adjustment coefficient λ has to be arbitrarily chosen by an Auctioneer. To avoid this arbitrariness, let us construct another processes in which an adjustment coefficient λ is determined by a relative weight of prices at the iteration period t such that

$$\lambda_i(t) = \frac{p_i(t)}{\sum_{i=1}^{2} p_i(t)}, \quad i = 1, 2, \tag{2.33}$$

and call these revised coefficients composite coefficients. Thus, these composite coefficients are applied to the above three adjustment processes respectively as follows.

Standard composite tâtonnement adjustment (c)

$$p_i(t+1) = \text{Max } \{p_i(t) + \lambda_i(t)\zeta_i(p(t)), 0\}, \quad i = 1, 2. \tag{2.34}$$

Alternative composite tâtonnement adjustment (ac)

$$p_i(t+1) = p_i(t) + \lambda_i(t) \text{Max } \{\zeta_i(p(t)), 0\}, \quad i = 1, 2. \tag{2.35}$$

Minmax composite tâtonnement adjustment (mc)

$$p_i(t+1) = \text{Min}\ \{\bar{p}_i, \text{Max}\ \{p_i(t) + \lambda_i(t)\zeta_i(p(t)), \underline{p}_i\}\}, \quad i = 1, 2. \tag{2.36}$$

In this way six different tâtonnement price adjustment processes can be constructed.

Global Stability

Can any arbitrarily-chosen initial price attain an equilibrium in an exchange economy? If it can, the economy is called globally stable. Arrow, Block and Hurwicz Arrow et al. (1959) proved such a global stability under the assumptions of Walras' law, homogeneity of excess demand function and gross substitutability. Since then it has been generally adopted in the literature on microeconomics and mathematical economics, for instance (Takayama, 1985, pp.321-329). Walras' law and homogeneity are already shown to hold in the exchange economy. It is also shown here that for $(p_1,\ p_2) > 0$ a gross substitutability holds in the simplified economy as follows.

$$\frac{\partial \zeta_1(p)}{\partial p_2} = \frac{1}{p_1}(\hat{\alpha}_1^1 \bar{x}_2^1 + \hat{\alpha}_1^2 \bar{x}_2^2) > 0. \tag{2.37}$$

$$\frac{\partial \zeta_2(p)}{\partial p_1} = \frac{1}{p_2}(\hat{\alpha}_2^1 \bar{x}_1^1 + \hat{\alpha}_2^2 \bar{x}_1^2) > 0. \tag{2.38}$$

Equilibrium prices are attained under a condition that *an adjustment coefficient λ is fixed at its original default value.* Hence, the simplified exchange economy turned out to be globally stable.

Questions for Deeper Understanding

1. As a typical *Auctioneer Price Adjustment Model* "1 Auctioneer.vpmx" model" was built in this chapter. Assume that the auctioneer in the model quotes the initial price at p=20. Due to this higher price against the equilibrium price of p=15, consumers' demand drops by 10 shirts/Week at the week of 15. Then, discouraged producers reduce their supply by 15 shirts/Week at the week of 25. What will be a a new equilibrium price under these circumstances and how can the auctioneer attain it?

2. Now set up the initial price at P = 8 in the "1 Auctioneer.vpmx" model". Discuss how does a parameter value of "Auctioneer Coefficient" affect price adjustment processes by selecting three different parameter values. Compare price behaviors caused by them by illustrating an integrated comparative diagram.

3. When the adjustment coefficient is set to be 3.16 in the "1 Auctioneer.vpmx" model", the price begins to show chaotic behaviors as explained in the subsection of Chaos in section 2.3.. Confirm these chaotic price behaviors for the initial price levels such as 7.00001 and 7.00002. In these cases, the initial price difference is almost negligible: that is, 0.00001, and, consequently, prices of both cases are expected to behavior similarly. Discuss if this negligible difference of initial price values affect price behaviors? If so, how?

   (Remark: Chaos is one of the greatest scientific discoveries in the last decade of the last century. Accordingly, most traditional dynamic economic models failed to integrate the chaotic phenomena into the models.)

4. As a typical *Inventory Price Adjustment Model* "3 Inventory.vpmx" was built in this chapter. Set up the initial price at p=20 in this model. You may notice that price adjustment process is heavily affected by the parameter values of "Desired Inventory Coverage". Discuss how price behaviors are affected when these values are set to be 2, 3, and 4 weeks. Then discuss how you can avoids such market price fluctuations.

5. *Price Adjustment Mechanisms: Battle of Economic Ideas*
   You have now examined two different SD models of price adjustment mechanism: 1 Auctioneer.vpmx and 3 Inventory. vpmx. Discuss how are they different? Where do such differences come from? Which modeling method, do you think, is more appropriate to analyze market price behaviors?

   Tips: Your discussions may include basic concepts of system dynamics methodology: logical vs historical time, stock and flow, number of stocks, delays, adjustment time, etc.

Chapter 3

Accounting System Dynamics

Understanding financial statements is imperative for better management of corporations, while system dynamics (SD) offers dynamic modeling and simulation skills for better strategies of management. This chapter[1] tries to present a consolidated principle of accounting system dynamics on the basis of simple principles from SD and accounting system. It is, then, specifically applied to model corporate financial statements (income statement, balance sheet and cash flow statement) described in the book Ittelson (1998). It is shown that cash flow statement is indispensable for modeling financial statements. At the same time, a limitation of the current accounting system as a dynamic guidance for management strategies is pointed out. This demonstrates the importance of SD modeling in the field of accounting system.

3.1 Introduction

Business accounting system consists of three financial statements such as income statement, balance sheet and cash flow statement. Success or failure of corporations has been measured by these financial statements. In this sense, accounting system has been and will be a foundation for our business activities, on which macroeconomic activities are further built.

Accounting system is recently undergoing radical reforms in Japan in order to catch up with its global de facto standard of the American accounting system. The so-called Japanese version of financial Big Bang began to be implemented in March 2000. One of its major reforms is a legal requirement of cash flow statement which had been neglected in the Japanese accounting system until recently. Since then many introductory accounting books focusing on cash flows have been lined up in many bookstores, attracting attention to many business people in Japan.

[1] This chapter is based on the paper: Principle of Accounting System Dynamics – Modeling Corporate Financial Statements – in "Proceedings of the 21st International Conference of the System Dynamics Society", New York City, USA, July 20-24, 2003, ISBN 0-9672914-9-6.

Under such circumstances, recent financial scandals such as Enron and WorldCom were a surprise to most Japanese who have been trying to introduce the American accounting system as the most trustworthy system. What went wrong with them? One of the reflecting arguments was that the practice of the current accounting system is heavily dependent on professional accountants and specialized accounting software. If current accounting system were more friendly to managers and employees, then abnormal behaviors of financial practices such as mentioned above would have been avoided at its earlier stage, I thought.

It occurred to me then that SD approach to the accounting system could make it more friendly. Furthermore, it would be more practical, I thought, if corporate SD models could incorporate financial statements directly or indirectly, since model performances are better evaluated in terms of financial statements as done in the real world of business.

With these beliefs in mind, I began to search for references on a system dynamics method of modeling corporate financial statements. My search has been unsuccessful except the book Lyneis (1998) which was by chance suggested in the discussions among SD mailing community. It took more than a year to obtain the book through the Amazon on-line search for used books. It turned out, however, that the book was written with DYNAMO, and accordingly has been left unnoticed in my bookshelf.

Failure of the search gave me an incentive to develop a SD method of modeling financial statements from a scratch. I started working in the summer of 2001 when I was spending relatively a quiet time on a daily rehabilitation exercise in order to recover from the physical operation on my shoulder in June of the same year. This environment gave me a good chance for reading books on accounting. My readings mainly consisted of the introductory books such as Franklin J. Plewa and Friedlob (1995), Ittelson (1998), Kremer and Case (2009), Tracy (1996), Tracy (1999), since my knowledge of accounting was limited[2]. Through such readings, I have been convinced that system dynamics approach is very effective for understanding the accounting system.

The purpose of this chapter is, therefore, to understand the accounting system in terms of system dynamics. A consolidated principle of accounting system dynamics will be constructed for this purpose. It is then applied to model corporate financial statements exemplified in Ittelson (1998). In the due course, it will be shown how cash flow statement plays an indispensable role in modeling corporate financial systems, contrary to the practice that it has not been required in the Japanese financial statements. I wondered why such an essential cash flow statement has been neglected until recently in Japan. System dynamics approach indeed sheds light on the wholeness of the current accounting system.

On the other hand, SD business models seem to have also neglected the importance of incorporating financial statements for better evaluation of model performances. Business models without such financial statements, whether they

[2]In addition to these books, a paper dealing with corporate financial statements Bianchi (2002) is recently published. However, current research for modeling financial statements is independently carried out here with a heuristic objective in mind.

are explicitly or implicitly built in them, would be indeed incomplete, because they fail to reflect the wholeness of dynamic business activities. In this sense, a corporate financial model that will be suggested at the end of this chapter would provide a kind of pecuniary archetype for corporate financial modeling.

3.2 Principles of System Dynamics

System is a self-functioning whole consisting of interdependent parts that are interacting with one another with some influence from its outside world. Examples of systems are abundant such as our bodies, communities, corporations, and public organizations as well as subsystems within these systems. System dynamics is a discipline that tries to describe dynamic movements of these systems. For the understanding of financial accounting system, which is a main purpose of this chapter, it would be enough to consider the following three principles of system dynamics.

Principle 1 (System as a collection of stocks) System can be described by a collection of state variables, called *stocks* in system dynamics, whose levels or volumes are measured at a *moment in time*.

In other words, state variables (stocks) of the system are the entity that can be pictured or recorded for its description.

Principle 2 (Stock-flow relation) Levels of a stock can only be changed by the amount of *flows* measured for a *period of time*. The amount of flow that increases the stock is called inflow, while the one that decreases it is called outflow.

In this way, stock and flow constitute an inseparable relational unit in system dynamics Yamaguchi (2000). Stock-flow relation is illustrated in Figure 3.1.

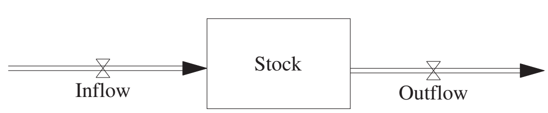


Figure 3.1: Stock-Flow Relation

Principle 3 (Information feedback) The amount of inflows and outflows is directly or indirectly determined either by the information obtained from the stocks through their feedback loops, or parameters obtained outside the system such that the system pursues its purpose.

As will be clarified below, modeling dynamic accounting system mostly depends on the parameters of transaction data obtained outside the system.

3.3 Principles of Accounting System

Accounting system of modern corporations consists of three financial statements such as balance sheet, income statement and cash flow statement. Examples of these statements used in this chapter are replicated from the book Ittelson (1998).

Balance Sheet

A	Cash
B	Accounts Receivable
C	Inventories
D	Prepaid Expenses
A + B + C + D = E	Current Assets
F	Other Assets
G	Fixed Assets @ Cost
H	Accumulated Depreciation
G - H = I	Net Fixed Assets
E + F + I = J	Total Assets
K	Accounts Payable
L	Accrued Expenses
M	Current Portion of Debt
N	Income Taxes Payable
K + L + M + N = O	Current Liabilities
P	Long-Term Debt
Q	Capital Stock
R	Retained Earnings
Q + R = S	Shareholders' Equity
O + P + S = T	Total Liabilities & Equity

Table 3.1: Balance Sheet in Ittelson (1998)

How are these three statements related one another, then? Their relationships are best described as follows:

> The balance sheet reports the aggregate effect of transactions at a **point in time**, whereas the income statement, statement of retained earnings, and statement of cash flows report the effect of transactions over a **period of time**. (Delaney et al., 2002, page 35).

The relationship of three financial statements thus can be best understood in terms of the above stock-flow relation of system dynamics as follows:

Principle 4 (Stock-flow relation of financial statements) Balance sheet is a collection of stocks only, while income statement and cash flow statement consist of inflows and outflows of the stocks in balance sheet.

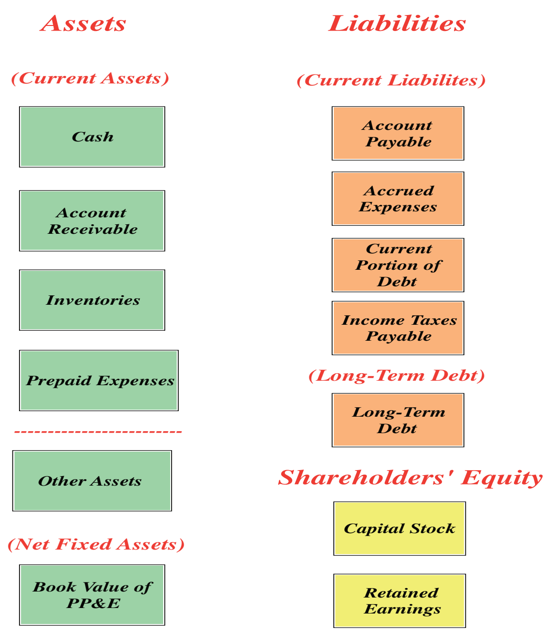


Figure 3.2: Balance Sheet in Ittelson (1998) as a Collection of Stocks

Balance sheet in Table 3.1 is now best illustrated as a collection of stocks as in Figure 3.2. One remark may be needed on Net Fixed Assets. It is defined in Table 3.1 as Fixed Assets @ Cost less Accumulated Depreciation. In Figure 3.2, it is renamed as Book Value of PP&E (Property, Plant and Equipment) and illustrated as the only stock for the net fixed assets. This is because, with the introduction of stock-flow relation, net fixed assets can be better represented as a book value relation as illustrated in Figure 3.3.

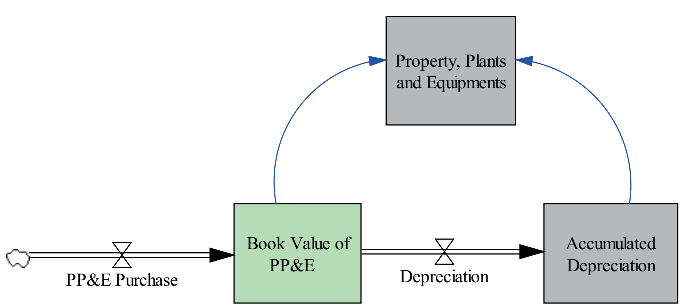


Figure 3.3: Net Fixed Assets (Book Value) Relation

There are 13 stocks in the balance sheet of Figure 3.2. From the Principle 2, they all need to be illustrated together with inflows and outflows. However, from the Principle 4, only inflows and outflows of Retained Earnings and Cash can be illustrated from the figures in Income and Cash Flow Statements. Specifically, inflows and outflows of Retained Earnings are obtained from the Income Statement in Table 3.2. That is, its inflow is revenues or net sales, while its outflows consist of costs of goods sold, operating expenses, net interest income[3], and income taxes. These stock-flow relations are illustrated in Figure 3.4.

Income Statement

1	Net Sales
2	Cost of Goods Sold
1 -2 = 3	Gross Margin
4	Sales & Marketing
5	Research & Development
6	General & Administrative
4+5+6=7	Operating Expenses
3-7=8	Income From Operations
9	Net Interest Income
10	Income Taxes
8+9-10=11	Net Income

Table 3.2: Income Statement in Ittelson (1998)

On the other hand, inflows and outflows of Cash could also be illustrated from Cash Flow Statement in Table 3.3. Its inflow is basically cash receipts and its outflow is cash disbursements. Cash flows, however, are better classified in detail into three activities; that is, operating activities, investing activities and financing activities, and accordingly stock-flow relations of Cash are usually described with additional inflows and outflows. They will be, thus, more concretely illustrated in Figure 3.15 after cash-related transactions are examined in Section 3.6.

To illustrate stock-flow relations of the remaining 11 stocks, we need to add inflows and outflows to them by newly defining their names. A generic naming rule is employed here to define them as long as no other appropriate names are found in the existing accounting system. For instance, inflow and outflow of Accounts Payable are named *Accounts Payable Incurred* and *Accounts Payable Paid*. In this way, stock-flow relations of all stocks in the balance sheet are constructed.

How can the levels of these 13 stocks in the balance sheet be changed, then, by the changes in inflows and outflows? In the accounting system, they are changed by a so-called bookkeeping rule of *double entry*. Accounting system has

[3] In this figure it is modeled such that net interest income = interest payment - interest income. Moreover, interest payment and income are modeled as a part of non-operating expenses and revenues.

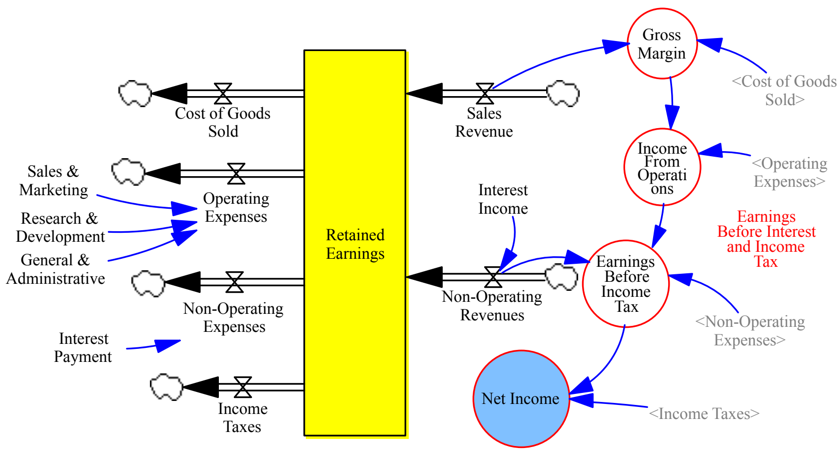


Figure 3.4: Income Statement as Stock-Flow Relation

Cash Flow Statement

a	Beginning Cash Balance
b	Cash Receipts
c	Cash Disbursements
b-c=d	Cash Flow From Operations
e	PP&E Purchase
f	Net Borrowings
g	Income Taxes Paid
h	Sale of Capital Stock
a+d-e+f-g+h=i	Ending Cash Balance

Table 3.3: Cash Flow Statement in Ittelson (1998)

a long history of more than several hundred years, and become a well-established and complete system. Its success has been attained by the introduction of this *double entry* principle. The double entry rule, however, has also been a major source of confusions for the students of accounting.

With the introduction of stock-flow relation, the double entry principle is now very intuitively illustrated as in Figure 3.5, in which all stocks in the Balance Sheet are collectively described as Assets and Liabilities, while Shareholders' Equity is described with its original stock names of Capital Stock and Retained Earnings. All inflows to Assets and all outflows from Liabilities and Equity are booked on the left side of debit, while all outflows from Assets and all inflows to Liabilities and Equity are booked on the right side of credit. That is to say, each transaction has to be booked simultaneously on both sides of debit and credit to keep the balance sheet in balance – a very simple rule!. It is formally

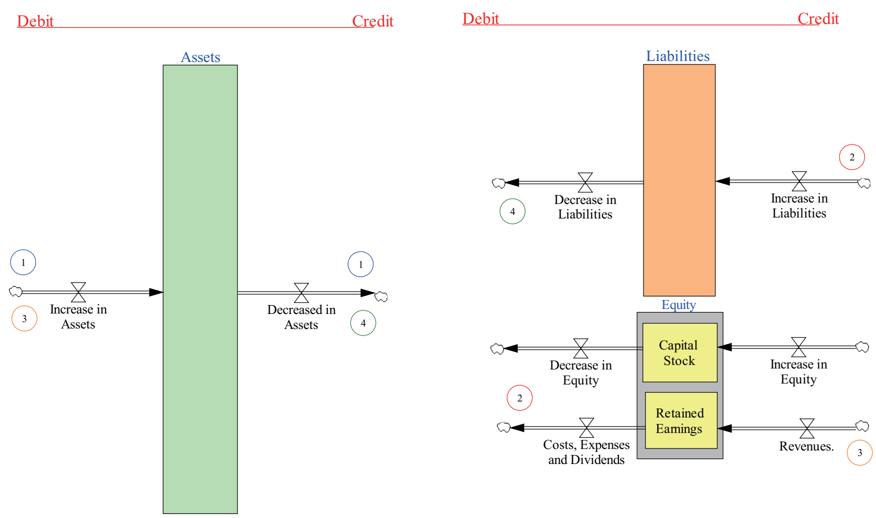


Figure 3.5: Double Entry Rule of Bookkeeping as Debit and Credit

summarized as follows:

Principle 5 (Double entry rule of bookkeeping) All transactions in the accounting system are recorded as inflows and/or outflows of stocks in the balance sheet so that each transaction causes two corresponding stocks to change simultaneously in balance. For this purpose, each transaction is booked twice on both debit and credit sides. Inflows of assets and outflows of liabilities and shareholders' equity are booked on the debit side, while outflows of assets and inflows of liabilities and shareholders' equity are booked on the credit side.

3.4 Principle of Accounting System Dynamics

We have now obtained five principles from system dynamics and accounting system. Let us call them collectively Principle of Accounting System Dynamics (PASD).

Principle of Accounting System Dynamics Principles 1 through 5 obtained from system dynamics and accounting system constitutes the Principle of Accounting System Dynamics.

From the principle, four major categories of bookkeeping practices are easily classified as follows:

(1) Debit:inflow ↔ Credit:outflow Transactions within assets are classified in this category. For example, an increase in Fixed Assets by the purchase of PP&E is balanced by the decrease in Cash by its payment.

Figure 3.6 illustrates the example of bookkeeping (1). Right-hand diagram is the combined way to describe the left-hand diagram.

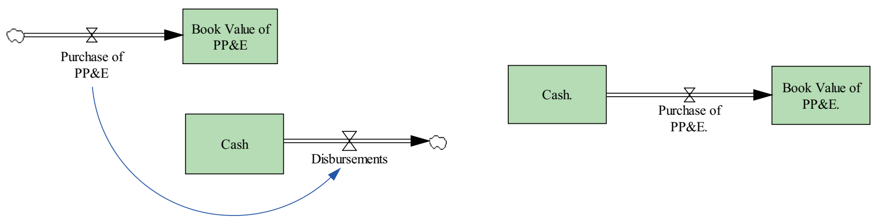


Figure 3.6: Double Entry Rule of Bookkeeping (1)

(2) Debit:outflow ↔ Credit:inflow Transactions within liabilities and equity are classified here. For example, a decrease in Retained Earnings caused by an increase in operating expenses such as sales & marketing expenses is balanced by the increase in Accrued Expenses.

Figure 3.7 illustrates the example of bookkeeping (2).

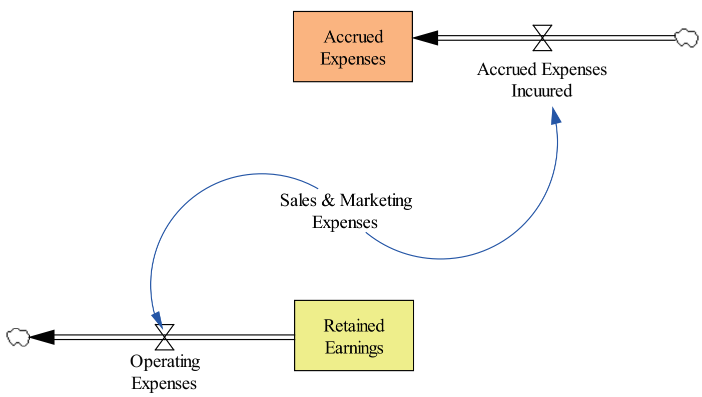


Figure 3.7: Double Entry Rule of Bookkeeping (2)

(3) Debit:inflow ↔ Credit:inflow Transactions in this category cause both Assets and Liabilities/Equity to increase. For instance, an increase in net sales causes both Accounts Receivable and Retained Earnings to increase.

Figure 3.8 illustrates the example of bookkeeping (3).

(4) Debit:outflow ↔ Credit:outflow Transactions here cause both Assets and Liabilities/Equity to decrease. For instance, payment of Accounts Payable causes both Cash and Accounts Payable to decrease.

Figure 3.9 illustrates the example of bookkeeping (4).

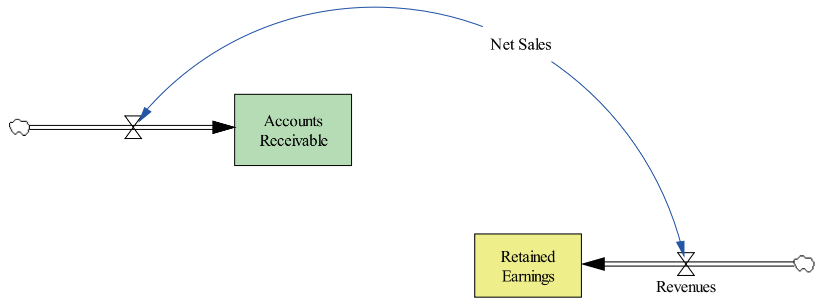


Figure 3.8: Double Entry Rule of Bookkeeping (3)

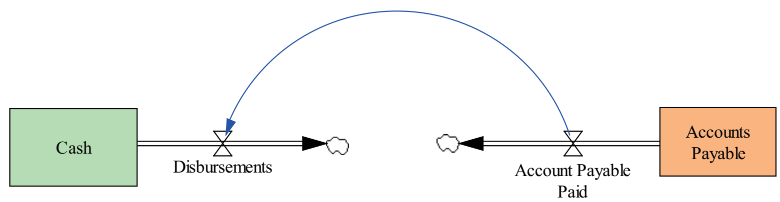


Figure 3.9: Double Entry Rule of Bookkeeping (4))

3.5 Accounting System Dynamics Simplified

According to PASD, all transactions have to be booked on both debit and credit sides simultaneously. This bookkeeping rule is formally described here as follows:

$\Rightarrow$ Transaction
 $\Rightarrow$ [Stock 1 $\pm$] $\leftrightarrow$ [Stock 2 $\pm$]

Stock 1 is a primary stock that is changed by the inflow or outflow of a transaction, and Stock 2 is its corresponding stock to be changed simultaneously for keeping the balance sheet in balance. For example, if an item in the accrued expenses is paid in cash, this transaction decreases both Accrued Expenses and Cash, and it is described as follows:

$\Rightarrow$ T: Accrued Expenses Paid
 $\Rightarrow$ [Accrued Expenses -] $\leftrightarrow$ [Cash -]

This formula implies that payment of accrued expenses lowers both the levels of accrued expenses and cash. Such an identifications of a primary stock affected by the transaction and its corresponding stock is essential for modeling financial statements.

Now we are ready to apply PASD to the construction of a simplified business transaction model illustrated in Figure 3.10 [Companion model: ASD Simplified.vpmx]. This simplified ASD model provides a fundamental framework not only for modeling our macroeconomic activities, but also for building financial business activities. Let us start with sales revenues. When Sales Revenues are realized, they are modeled as increased inflows to the stocks of Retained Earnings and Accounts Receivable as follows:

⇒ T: Sales Revenues
⇒ [Retained Earnings +] ↔ [Accounts Receivable +]

Simultaneously, corresponding Cost of Goods Sold to the sales revenues has to be subtracted from the Retained Earnings and Inventories as follows:

⇒ T: Cost of Goods Sold
⇒ [Retained Earnings -] ↔ [Inventories -: Shipment]

Non-Operating Revenues such as interest and dividend income are booked as increased inflows to the stocks of Retained Earnings and Accounts Receivable as follows:

⇒ T: Non-Operating Revenues
⇒ [Retained Earnings +] ↔ [Accounts Receivable +]

Accounts Receivable thus received is paid in due course to the Cash/Deposits as follows:

⇒ T: Receipts
⇒ [Accounts Receivable -] ↔ [Cash/Deposits +]

Operating Expenses consist of Sales & Marketing, Research & Development and General & Administrative Expenses. When they are paid out of Cash/Deposits, they are also deducted from the Retained Earnings as follows:

⇒ T: Operating Expenses
⇒ [Retained Earnings -] ↔ [Cash/Deposits -: Payments]

Non-Operating Expenses such as interest payment are also paid out of Cash/Deposits, and simultaneously deducted from the Retained Earnings as follows:

⇒ T: Non-Operating Expenses
⇒ [Retained Earnings -] ↔ [Cash/Deposits -: Payments]

When Income Taxes are paid out of Cash/Deposits, they are simultaneously deducted from the Retained Earnings as follows:

⇒ T: Income Taxes
⇒ [Retained Earnings -] ↔ [Cash/Deposits -: Payments]

Production activities incurs purchases of Raw Materials and employment of workers. These input values are treated as an increase in Inventories. Raw materials are usually paid in due course, causing a temporary increase in liabilities of Accounts Payable; meanwhile Wages are paid out of Cash/Deposits as follows:

⇒ T: Raw Materials
⇒ [Inventories +: Production] ↔ [Accounts Payable +]

⇒ T: Raw Materials Payments Dues
⇒ [Accounts Payable -] ↔ [Cash/Deposits -: Payments]

⇒ T: Wages
⇒ [Inventories +: Production] ↔ [Cash/Deposits -: Payment]

PP&E Purchase as new investment adds to Fixed Assets, while its payment is done out of Cash/Deposits as follows:

⇒ T: PP&E Purchase
⇒ [Fixed Assets +] ↔ [Cash/Deposits -]

Depreciation of Fixed Assets has to be handled in two ways, depending on the kind of Fixed Assets. If Fixed assets are not directly used in production, their depreciation incurs an increase in operating expenses (whose case is not considered here). Meanwhile Fixed Assets contributing directly to the production process is treated as follows:

⇒ T: Depreciation
⇒ [Fixed Assets -] ↔ [Inventory +: Production]

Short Term and Long Term Loans are made as an increase in Debts/Deposits, while its Reimbursements are paid out of Cash/Deposits as follows:

⇒ T: Loans
⇒ [Debt +] ↔ [Cash/Deposits +]

⇒ T: Reimbursements
⇒ [Debt -] ↔ [Cash/Deposits -: Payments]

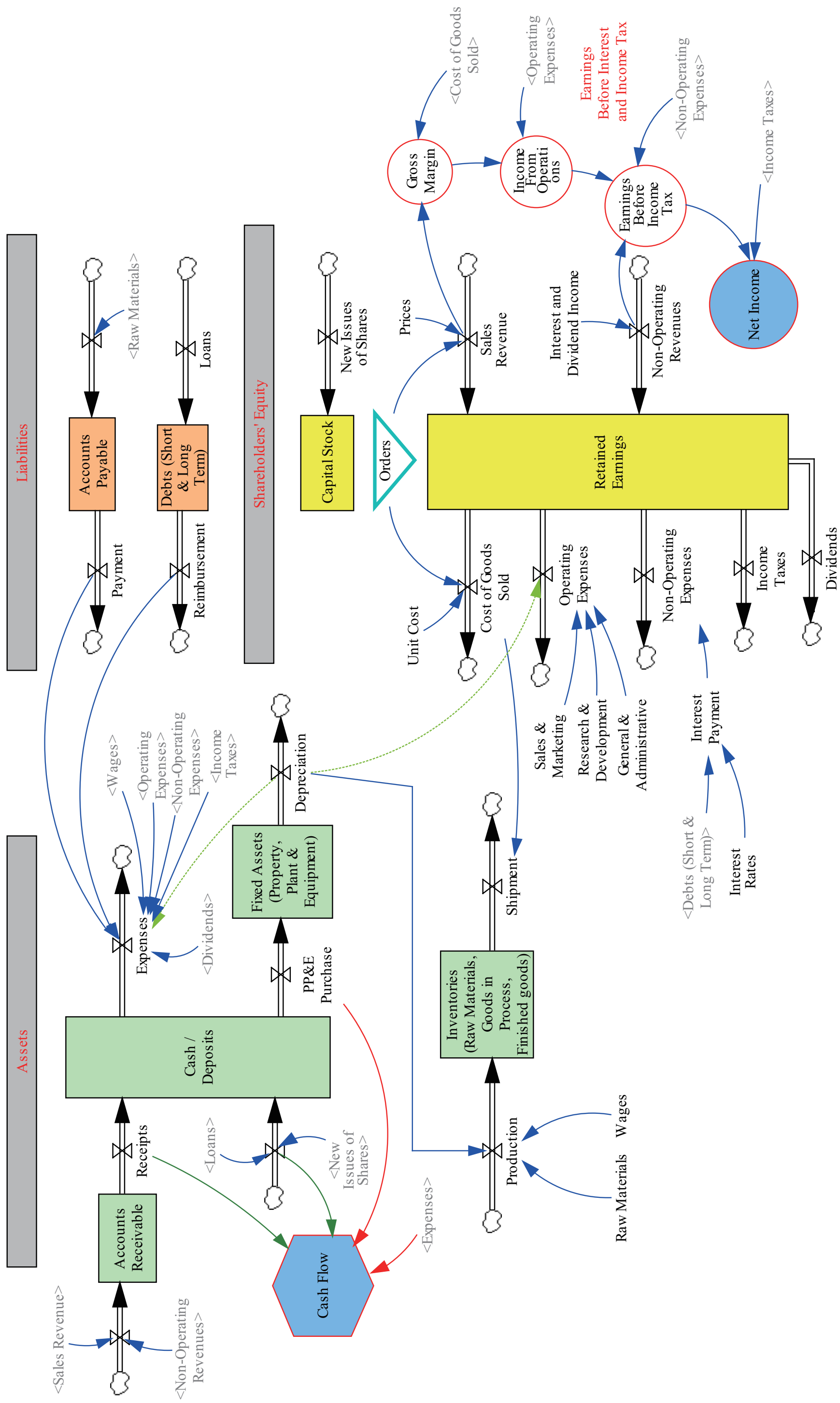


Figure 3.10: Accounting System Dynamics Simplified

3.6 Accounting System Dynamics in Action

On the basis of the PASD, we are now in a position to model real corporate financial statements in detail. For this purpose, examples of transactions are taken from the book Ittelson (1998). That is, all transactions described below are quoted from the book. Accordingly, this section can be better followed with the book at hand and our simplified ASD model in mind simultaneously [Companion model: Accounting.vpmx].

In the book 31 transactions are explained to describe the start-up business activities of AppleSeed Enterprises, Inc. In our modeling here each transaction is assumed to be taken in a week without losing generality, so that 31 transactions are done in 31 weeks. There are 28 transaction items, starting with suffix T:, that are used as model parameters.

Transaction 1 A group of investors is willing to exchange their $1.5 million in cash for stock certificates representing 150,000 common shares of AppleSeed Enterprises, Inc.
Note: When you formed the company you bought 50,000 shares of "founder's stock" at $1 per share for a total investment of $50,000 in cash. Thus after this sale to the investor group there will be 200,000 shares outstanding. They will own 75% of AppleSeed and you will own the rest.

⇒ T:New Issue of Shares (= 150,000 common shares)
⇒ [Capital Stock +] ↔ [Cash +]

Transaction 2 Book all payroll-associated company expenses totaling $6,230 including salary, employer's contribution to FICA (Social Security)[4] and various insurance expenses. Issue yourself a payroll check for $3,370 (your $5,000 monthly salary minus $1,250 in federal and state withholding tax and $380 for your own contribution to FICA).

⇒ T: General & Administrative (= $6,230)
⇒ [Accrued Expenses +] ↔ [Retained Earnings - : Operating Expenses]

⇒ T: Accrued Expenses Paid (= $3,370)
⇒ [Accrued Expenses -] ↔ [Cash -]

Transaction 3 Borrow $1 million to purchase an all-purpose building. This term note will run for 10 years, calling for yearly principal payments of $100,000 plus interest at a rate of 10% per annum.

[4] The Federal Insurance Contributions Act (FICA) of 1937 is the U.S. law that mandates a payroll tax on the paychecks of employees, as well as contributions from employers, to fund the Social Security and Medicare programs.

Transactions	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15	T16	T17	T18	T19	T20	T21	T22	T23	T24	T25	T26	T27	T28	T29	T30	T31
Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
T: Account Receivable Paid																							234,900							1,404,000	
T: Long-Term Borrowing			1,000,000																												
T: New Issue of Shares	150,000																														
T: Wages												9,020						9,020													
T: PP&E Purchase				1,500,000																											
T: Other Assets Purchase							125,000	125,000																							
T: Account Payable Paid														20,000			150,000											150,000	82,907		
T: Accrued Expenses Paid		3,370			7,960	9,690			2,720														4,698				18,480				
T: Current Debt Paid																										25,000					
T: Income Taxes Paid																															
T: Insurance Premium																									26,000						
T: Interest Expenses																										25,000			75,000		
T: Write-off Cost																								15,900							
T: Scrapped Cases																500		150													
T: Insurance Premium Paid																									6,500						
T: Raw Material Purchase										20,000	332,400							166,200													
T: All Other Overhead													8,677					8,677													
T: Sales & Marketing (AP)																			103,250												
T: Researh & Development																													26,000		
T: Payroll-associated fringes and taxes												8,160						8,160											26,435		
T: Sales & Marketing (AE)					7,680															318		4,698		-318					212,895		
T: General & Administrative (AE)		6,230			7,110				4,880																				162,900		
T: Production												20,000						20,000											20,000	20,000	20,000
T: Completion															19,500			19,000											19,500	19,500	19,500
T: Depreciation													7,143					7,143											64,287		
T: Principal Payments			100,000																							25,000			75,000	75,000	
T: Par Share Dividend																															0.375
T: Customer Order																				1,000		15,000							176,400		
Data: Price Change																					-0.24							0.24			

Table 3.4: All Transaction Data

⇒ T: Long-Term Borrowing (= $1 million)
⇒ [Long-Term Debt +] ↔ [Cash +]

⇒ T: Principal Payments (= $100,000)
⇒ [Long-Term Debt -] ↔ [Current Portion of Debt +]

Transaction 4 Purchase 100,000 square foot building and land for $1.5 million in cash. This facility will serve as AppleSeed Enterprises' headquarters, manufacturing facility and warehouse.

⇒ T: Property, Plant & Equipment Purchase (= $ 1.5 million)
⇒ [Book Value of PP & E +] ↔ [Cash -]

Transaction 5 Book this month's payroll-associated expenses of $14,790, (that is, $7,680 for Sales & Marketing and $7,110 for General & Administrative). These expenses include salaries, wages, insurance and other fringe benefits. Issue payroll checks totaling $7,960 to SG & A (sales, general and administrative) employees.

⇒ T: Sales and Marketing (AE)) (= $ 7,680)
⇒ [Retained Earnings -] ↔ [Accrued Expenses +]

⇒ T: General & Administrative (= $ 7,110)
⇒ [Retained Earnings -] ↔ [Accrued Expenses +]

⇒ T: Accrued Expenses Paid ((= $7,960)
⇒ [Accrued Expenses -] ↔ [Cash -]

Transaction 6 Pay all the payroll-associated expenses that were accrued in Transaction 2 and Transaction 5, including FICA, withholding tax and unemployment insurance due the government. Also pay to private insurance companies the workmen's compensation and health and life insurance premiums.

⇒ T: Accrued Expenses Paid (= $9,690)
⇒ [Accrued Expenses -] ↔ [Cash -]

Transaction 7 Place an order for $250,000 worth of applesauce-making machinery. Make a prepayment of $125,000 with the balance due upon successful installation.

⇒ T: Other Assets Purchase (= $125,000)
⇒ [Other Assets +] ↔ [Cash -]

Transaction 8 Make final payment of $125,000, the balance due on the applesauce-making machinery.

⇒ T: Other Assets Purchase (= $125,000)
⇒ [Other Assets +] ↔ [Cash -]

After the completion of payment and the delivery of machinery, it is now recorded as PP&E. It may be written in our transaction format as follows.

⇒ Installation (= $250,000)
⇒ [Book Value of PP&E +] ↔ [Other Assets -]

Transaction 9 Book supervisor's salary and associated payroll expenses as a General & Administrative expense since we have not yet started production. Issue first month's salary check. Make no entries for hourly workers since they have not yet reported for work.

⇒ T: General & Administrative (= $4,880)
⇒ [Retained Earnings -] ↔ [Accrued Expenses +]

⇒ T: Accrued Expenses Paid (= $2,720)
⇒ [Accrued Expenses -] ↔ [Cash -]

Transaction 10 Order and receive 1 million applesauce jar labels at a cost of $0.02 each for a total of $20,000 to be paid 30 days after delivery.

⇒ T: Raw Material Purchase (= $20,000)
⇒ [Raw Material Inventory +] ↔ [Accounts Payable+]

From this transaction on, production activities are booked under the stock account of inventory, which is, accordingly, separated from the balance sheet of assets here, though it is still its part. Moreover, inventories are further broken down as illustrated in Figure 3.11.

Transaction 11 Receive a two months' supply of all raw materials (apples, sugar, cinnamon, jars, caps, boxes) worth $332,400 in total. (That is, $8.55 total materials per case less $0.24 for the already received labels times 40,000 cases.)

⇒ T: Raw Material Purchase (= \$332,400)
⇒ [Raw Material Inventory +] ↔ [Accounts Payable+]

Transaction 12 Pay production workers' wages and supervisor's salary for the month. Book associated fringe benefits and payroll taxes. (Now that we are manufacturing product, these salary and wages are costs that increase the value of our product, and are shown as an increase in inventory.)

⇒ T(Cash-): Wages (= \$9,020)
⇒ [Work in Process Inventory +] ↔ [Cash -]

⇒ T: Payroll-associated Fringes and Taxes (= \$8,160)
⇒ [Work in Process Inventory +] ↔ [Accrued Expenses +]

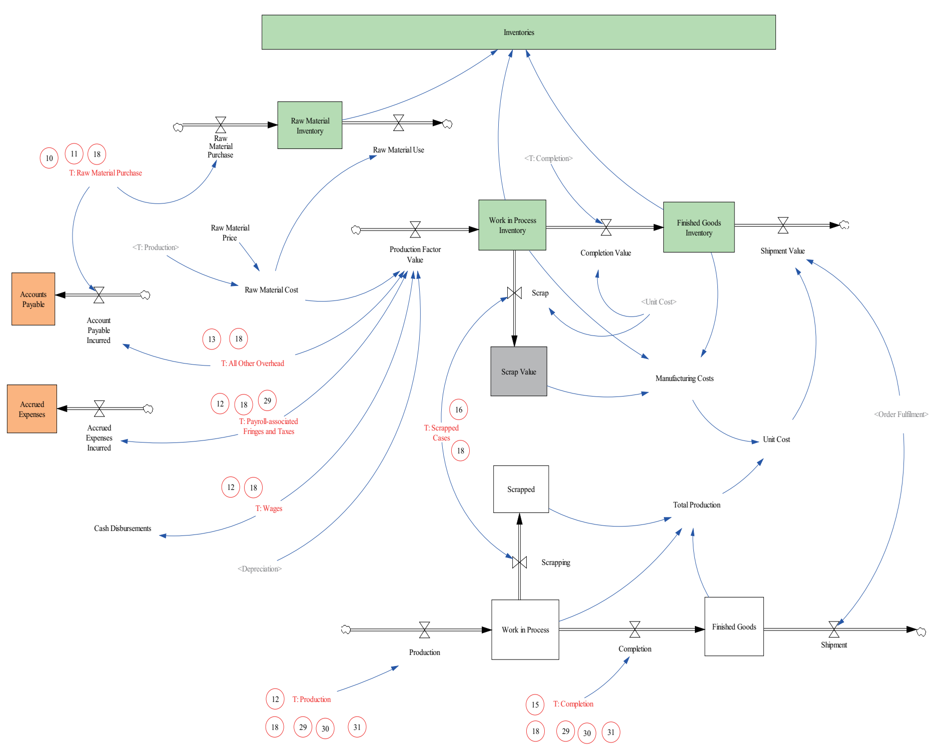


Figure 3.11: Inventories with Production

As production starts, raw material use may be written as follows.

⇒ T: Production (= 20,000 cases)
(⇒ Raw Material Use (= 20,000 * $8.55 = $171,000))
⇒ [Raw Material Inventory -] ↔ [Work in Process Inventory +]

Transaction 13 Book this month's manufacturing depreciation of $7,143 and $8,677 covering "all other" overhead costs. Note that depreciation is not a cash expense and will not lower our cash balance. But, the "all other" overhead we will eventually have to pay with cash.

⇒ T: Depreciation (= $7,143)
⇒ [Work in Process Inventories +] ↔ [Book Value of PP&E -]

⇒ T: All Other Overhead (= $8,677)
⇒ [Work in Process Inventories +] ↔ [Account Payable]

Transaction 14 Pay for 1 million labels received in Transaction 10. Issue a check to our vendor for $20,000 as payment in full.

⇒ T(Cash-): Accounts Payable Paid (= $20,000)
⇒ [Accounts Payable -] ↔ [Cash -]

Transaction 15 Finish production of 19,500 cases of our applesauce. Move product from work-in-process ("WIP") Inventory into Finished Goods. This movement of inventory into a different class is really just an internal management control transaction as far as the financial statements are concerned. There is no effect on the three major financial statements of AppleSeed. INVENTORIES on the *Balance Sheet* remains the same. Our Inventory Valuation Worksheet, as shown below, reflects the change in inventory status.
This may be written as follows.

⇒ T: Completion (= 19,500 cases)
(⇒ Completion Value (= 19,500 * 10.2 dollar = $198,900))
⇒ [Work in Process Inventory -] ↔ [Finished Goods Inventory +]

Transaction 16 Scrap the value of 500 cases of applesauce from the work-in-process inventory. Take a loss on the *Income Statement* for this amount.

⇒ T: Scrapped Cases (= 500 cases)
(⇒ Scrapped Cases Value (= 500 * 10.2 dollar = $5,100))
⇒ [Work in Process Inventory -]

↔ [Retained Earnings -: Cost of Goods Sold]

Transaction 17 Pay a major supplier a portion of what is due for apples and jars. Cut a check for $150,000 in partial payment.

⇒ T: Accounts Payable Paid (= $150,000)
⇒ [Account Payable -] ↔ [Cash -]

K. Receive a month's raw material supply less labels. (see T10)	$166,200
L. Move a month's supply of raw materials into WIP. (see T12).	$171,000
M. Pay hourly workers/supervisor for another month. (see T12)	$17,180
N. Book manufacturing depreciation for the month. (see T13)	$7,143
O. Book "all other" mfg. overhead for another month. (see T13)	$8,677
P. Move 19,000 cases to finished goods standard cost.	$193,800
Q. Scrap 150 cases from WIP. (see T16)	$1,530

Table 3.5: Inventory Valuation Worksheet for Transaction 18

Transaction 18 Make entries in the *Income Statement, Cash Flow Statement* and *Balance Sheet* as shown in the total column at below right. Note that for each worksheet entry (K through Q below), the change in Assets equals the change in Liabilities.

⇒ T: Raw Material Purchase (= $166,200) (K)
⇒ [Raw Material Inventory +] ↔ [Accounts Payable +]

⇒ T(Cash-): Wages (= $9,020) (M)
⇒ [Work in Process Inventory +] ↔ [Cash -]

⇒ T: Payroll-associated Fringes and Taxes (= $8,160) (M)
⇒ [Work in Process Inventory +] ↔ [Accrued Expenses +]

⇒ T: Depreciation (= $7,143) (N)
⇒ [Work in Process Inventory +] ↔ [Book Value of PP&E -]

⇒ T: All Other Overhead (= $8,677) (O)
⇒ [Work in Process Inventory +] ↔ [Account Payable +]

⇒ T: Scrapped Cases (= 150 cases) (Q)
(⇒ Scrapped Cases Value (= 150 * 10.2 dollar = $1,530))
⇒ [Work in Process Inventory -]
↔ [Retained Earnings -: Cost of Goods Sold]

In addition, raw material use and completion of work in process may be written as follows.

⇒ T: Production (= 20,000 cases)
(⇒ Raw Material Use (= 20,000 * $8.55 = $171,000)) (L)
⇒ [Raw Material Inventory -] ↔ [Work in Process Inventory +]

⇒ T: Completion (= 19,000 cases)
(⇒ Completion Value (= 19,000 * 10.2 dollar = $193,800)) (P)
⇒ [Work in Process Inventory -] ↔ [Finished Goods Inventory +]

Transaction 19 Our advertising agency submits a bill for designing, printing and mailing 4,500 very fancy brochures for a $38,250 total cost. The T-shirts cost $6.50 each for a total of $65,000 for 10,000 shirts. Book these amounts (totaling $103,250) as an AppleSeed Enterprises marketing and selling expense.

⇒ T: Sales & Marketing (= $103,250)
⇒ [Account Payable +] ↔ [Retained Earnings -: Operating Expenses]

Transaction 20 Receive order for 1,000 cases of applesauce at a selling price of $15.90 per case. Ship product and send a $15,900 invoice to the customer. Book on the *Income Statement* the 2% commission ($318) for our broker as a SALES & MARKETING expense.

⇒ T: Customer Order (= 1,000 cases)
(⇒ Net Sales (= 1,000 * $15.90 = $15,900))
⇒ [Retained Earnings +: Revenues] ↔ [Accounts Receivable +]

⇒ Shipment Value (= 1,000 cases * $ 10.2 per case = $10,200)
⇒ [Finished Goods Inventory -]
↔ [Retained Earnings -: Costs of Goods Sold]

This transaction of sales invokes two different changes in stocks as illustrated in Figure 3.12. First, sales value increases both retained earnings and account receivable. Second, shipping value obtained by the unit cost has to be subtracted from finished goods inventory and simultaneously booked as costs of goods sold.

⇒ T: Sales & Marketing (= $318)
⇒ [Retained Earnings -] ↔ [Accrued Expenses +]

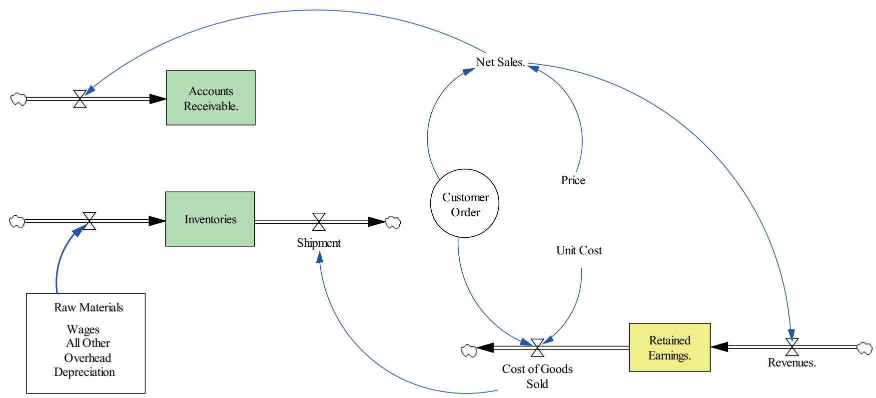


Figure 3.12: Double Transactions caused by Customer Order

Transaction 21 Receive an order for 15,000 cases of applesauce at a selling price of $15.66 per case, $234,900 for the total order.

Note: Receiving an order has no effect on the three major financial statements. Only when the product ordered is shipped to customers do you record a SALE and the associated COST OF GOODS SOLD. Yet, this could be recorded as an increase in backlog order.

Transaction 22 Ship 15,000 cases of applesauce and send a $234,900 invoice to the customer.

⇒ T: Customer Order (= 15,000 cases)
(⇒ Net Sales (= 15,000 * $15.66 = $234,900))
⇒ [Retained Earnings +: Revenues] ↔ [Accounts Receivable +]

⇒ Shipment Value (= 15,000 cases * $ 10.2 per case = $153,000)
⇒ [Finished Goods Inventory -]
↔ [Retained Earnings -: Costs of Goods Sold]

⇒ T: Sales & Marketing (= $4,698)
⇒ [Retained Earnings -] ↔ [Accrued Expenses +]

Transaction 23 Receive payment of $234,900 for shipment that was made in Transaction 22. Pay the broker his $4,698 selling commission.

Note: A customer's cash payment for goods in no way changes the *Income Statement*. The *Income Statement* recorded a sale when first, we shipped the goods, and second, the customer incurred the obligation to pay (our accounts receivable).

⇒ T: Accounts Receivable Paid (= $234,900)
⇒ [Cash +] ↔ [Accounts Receivable -]

⇒ T(Cash-): Accrued Expenses Paid (= $4,698)
⇒ [Accrued Expenses -] ↔ [Cash -]

Transaction 24 Write off the $15,900 accounts receivable that was entered when you made the 1,000 case shipment. Also, reduce the amount payable to our broker by what would have been his commission on the sale. If we don't get paid, he doesn't either !

Note: Our out-of-pocket loss is really just the $10,200 inventory value of the goods shipped. Remember that in Transaction 20 we booked a profit from this sale of $5,382 (= the $15,900 sale minus the $10,200 cost of goods minus the $318 selling commission). Thus, if you combine the $15,582 drop in RETAINED EARNINGS booked in this transaction plus the $5,382 increase in RETAINED EARNINGS from Transaction 20, you are left with our loss of $10,200 from this bad debt.

⇒ T: write-off (= $15,900)
⇒ [Retained Earnings -: Operating Expenses]
↔ [Accounts Receivable -]

⇒ T: Sales & Marketing (= $-318)
⇒ [Retained Earnings -: Operating Expenses]
↔ [Accrued Expenses +]

Transaction 25 With this transaction we will pay a full year's insurance premium of $26,000, giving us three months' prior coverage (the amount of time we have been in business) and also coverage for the remaining nine months in our fiscal year.

Note: As time goes by, we will take this remaining $19,500 as an expense through the *Income Statement*. The transaction at that time will be to book the expense in the *Income Statement* and at the same time lower the amount of PREPAID EXPENSE in the *Balance Sheet*.

⇒ T: Insurance Premium (= $26,000)
⇒ [Prepaid Expenses +] ↔ [Cash -]

⇒ T: Insurance Premium Paid (= $6,500)
⇒ [Prepaid Expenses -] ↔ [Retained Earnings -: Operating Expenses]

Transaction 26 Make a quarterly payment of $25,000 in principal and also a $25,000 interest payment on the building mortgage.

⇒ T: Current Debt Paid (= $25,000)
⇒ [Current Portion of Debt -] ↔ [Cash -]

⇒ T: Principal Payment (= $25,000)
⇒ [Long-Term Debt -] ↔ [Current Portion of Debt +]

⇒ T: Interest Expenses (= $25,000)
⇒ [Retained Earnings -] ↔ [Cash -]

Transaction 27 Pay payroll taxes, fringe benefits and insurance premiums. Write checks to the government and to insurance companies totaling $18,480 for payment of withholding and FICA taxes and for payroll associated fringe benefits.

Note: The Income Statement and RETAINED EARNINGS are not affected by this payment transaction. Because AppleSeed runs its books on an accrual basis, we already "expensed" these expenses when they occurred – not when the actual payment is made.

⇒ T: Accrued Expenses Paid (= $18,480)
⇒ [Accrued Expenses -] ↔ [Cash -]

Transaction 28 Pay suppliers a portion of what is due for apples and jars. Cut a check for $150,000 in partial payment.

⇒ T: Accounts Payable Paid (= $150,000)
⇒ [Accounts Payable -] ↔ [Cash -]

Transaction 29 Book a series of entries in the Income Statement, Cash Flow Statement and the Balance Sheet summarizing transactions that take place in the remaining nine months of AppleSeed Enterprises' first fiscal year.

(⇒ Transaction Items from this week on are not specified in the book Ittelson (1998). Consequently, our model here found some inconsistencies of figures in the book.) The reader who followed our description up to this point can easily fill in the transactions given in Table 3.4.

Transaction 30 On a pretax income of $391,687 AppleSeed owes 34% in federal income taxes ($133,173), and $6,631 in state income taxes for a total income tax bill of $139,804. We will not actually pay the tax for several

months.
Income tax is calculated as Income before tax times Income tax rate of 34%, and built in the program.

⇒ T: Income Taxes (= 34% * Income before Tax)
 ⇒ [Income Tax Payable +] ↔ [Retained Earnings -]

Transaction 31 Declare and pay a $0.375 per share dividend to AppleSeed's shareholders. (With 200,000 shares outstanding, this dividend will cost the company $75,000.)

⇒ T: Par Share Dividend (= $0.375 per share)
(⇒ Dividend (= $0.375 * Shares Outstanding)
 ⇒ [Cash -: Dividends Paid to Stockholders]
 ↔ [Retained Earnings -: Dividends]

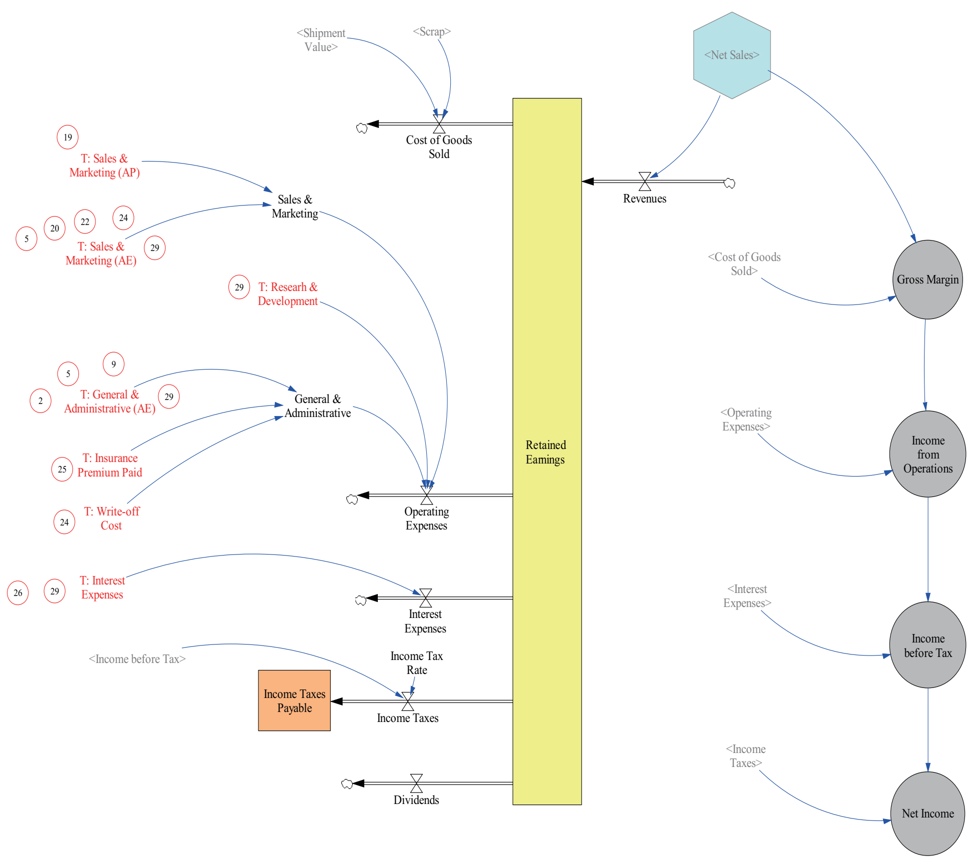


Figure 3.13: Income Statement

Modeling corporate financial statements are now completed. They consists of Income Statement (Figure 3.13) and Balance Sheet (Figure 3.14). Inventories (Figure 3.11) is a part of the balance sheet and Cash Flow Statements (Figures 3.15) is a part of balance sheet.

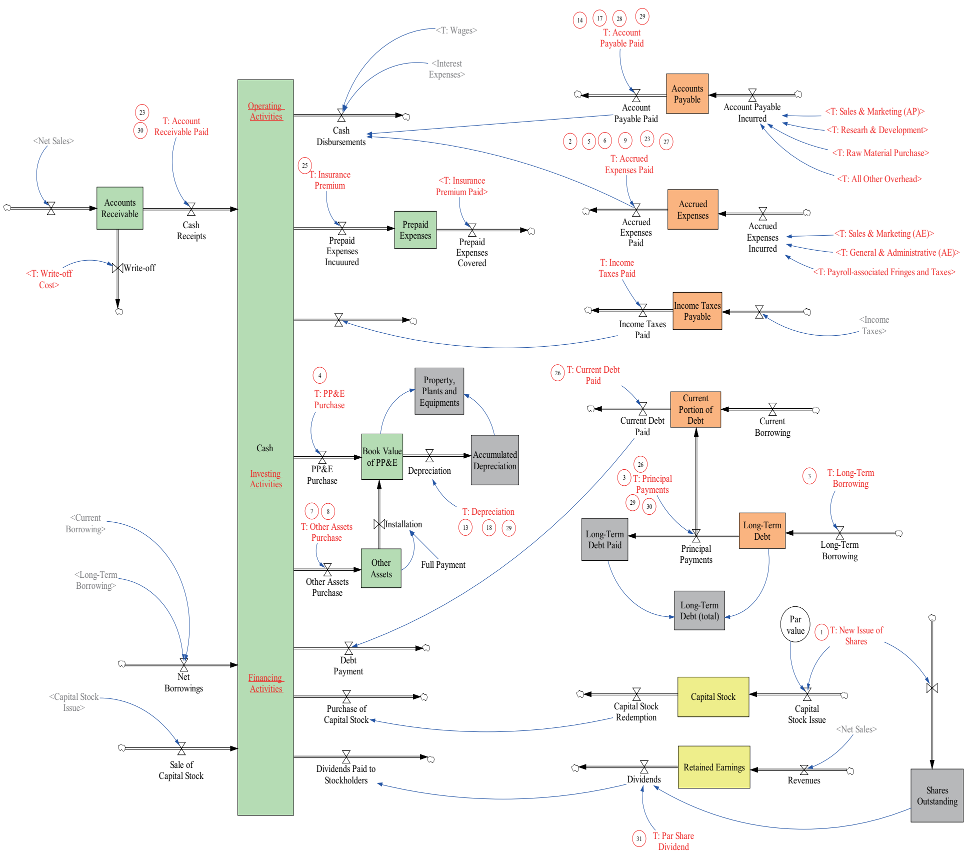


Figure 3.14: Balance Sheet

3.7 Making Financial Statements

Transactions given in the book Ittelson (1998) are not arranged as monthly data. To run the SD model, those data need to be reinterpreted as monthly data. For instance, Transaction 5 has to be regarded as the one in the 5th month. This is what is assumed here for the SD modeling.

There are two methods to import transaction data into the model. They could be put in the table functions, whose names are given in the list of Figure 3.16.

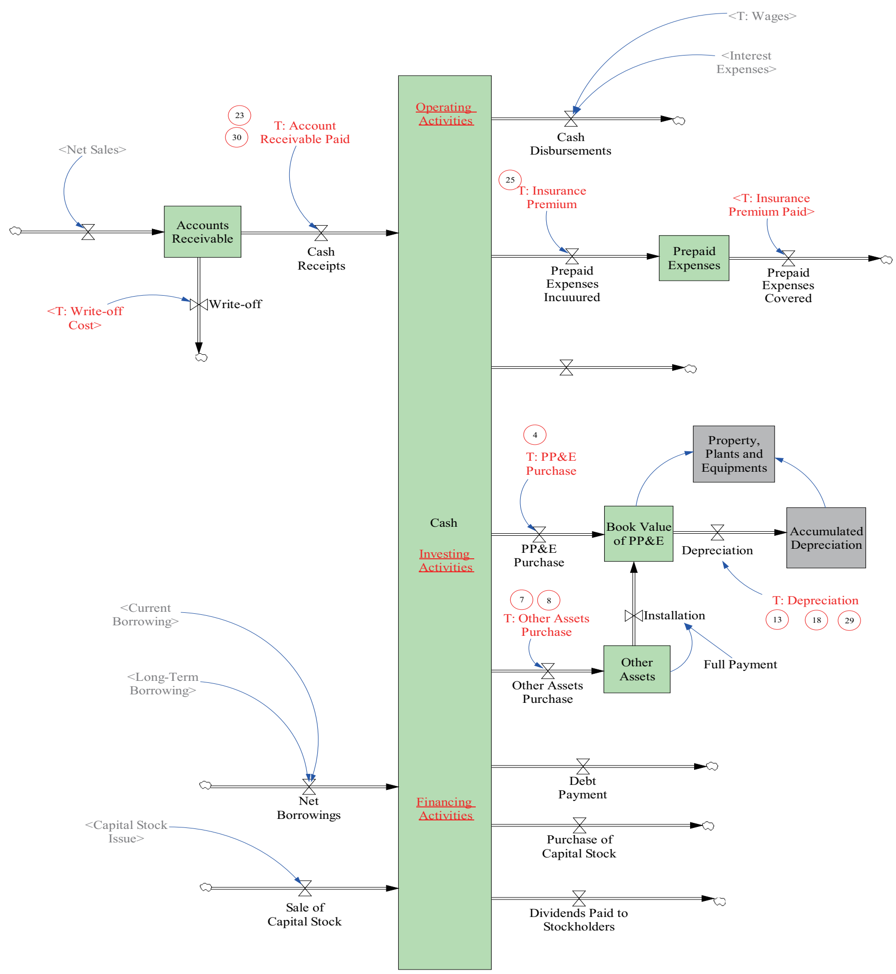


Figure 3.15: Cash Flow Statement

Almost half of the names in the list are related with the stock: Cash. This is because all transactions in a market economy need to be eventually paid in cash, and cash-related transactions constitute a large portion of transactions. Hence, Cash becomes the largest group among the primary stocks to be changed. The other major groups are related with the transactions by credits such as Accounts (Receivable or Payable), and (Prepaid or Accrued) Expenses. Transaction data in Figure 3.16 are arranged to reflect these facts.

Alternatively, transaction data could be prepared outside the model as those of spreadsheet such as Excel, then imported to the model. There are quite a few accounting software on the market that enable to keep recording daily transactions. These booked data are later classified as ledgers of items to construct balance sheet. Using spreadsheet such as Excel, therefore, it may not be hard to

Figure 3.16: List of Transaction Data

import them to the SD model as the data of inflows and outflows as shown in the list in Figure 3.16. The SD model could then become an alternative accounting software. Moreover, it could become a better one as a financial analysis tool as shown in the next section.

In fact, balance sheet in Table 3.6 is constructed by using the data given in Figure 3.16 (or alternatively by importing them as spreadsheet data). Due to a limitation of space, only figures of five different months among 31 months are shown here. Income statement and cash flow statement can be procured in a similar fashion.

3.8 Ratio Analysis of Financial Statements

Structure of the corporate financial model developed above is very static in the sense that accounting system is merely to keep records of all transactions of the past business activities. In other words, transaction data are just imported to the inflows and outflows of the model as the outside parameters. In this sense, accounting system is not a SD system. To be a truly dynamic SD system, information for dynamic decision-making needs to be obtained within the system

Time(Month)	1	5	10	15	20
Cash	50,000	1.046M	776,260	747,240	588,220
Accounts Receivable	0	0	0	0	0
Inventories	0	0	0	385,400	577,970
Prepaid Expenses	0	0	0	0	0
Current Assets	50,000	1.046M	776,260	1.132M	1.166M
Other Assets	0	0	0	0	0
Book Value of PP&E	0	1.5M	1.75M	1.742M	1.735M
Assets	50,000	2.546M	2.526M	2.875M	2.901M
Accounts Payable	0	0	0	341,077	469,204
Accrued Expenses	0	2,860	2,160	10,320	18,480
Current Portion of Debt	0	100,000	100,000	100,000	100,000
Income Taxes Payable	0	0	0	0	0
Current Liabilities	0	102,860	102,160	451,397	587,684
Long-Term Debt	0	900,000	900,000	900,000	900,000
Capital Stock	50,000	1.55M	1.55M	1.55M	1.55M
Retained Earnings	0	-6,230	-25,900	-25,900	-135,780
Shareholders' Equity	50,000	1.543M	1.524M	1.524M	1.414M
Liabilities & Equity	50,000	2.546M	2.526M	2.875M	2.901M

Table 3.6: Balance Sheet Table

through the information feedback loops as depicted in Principle 3.

In the accounting system, balance sheet could become a main source of information from which many important feedback loops originate for management strategies and policies. Traditional method of obtaining such feedback information is a so-called financial ratio analysis. In the book Ittelson (1998), eleven such ratios are defined and grouped into four types as follows.

Liquidity Ratios

$$\text{Current Ratio} = \frac{\text{Current Assets}}{\text{Current Liabilities}}$$

$$\text{Quick Ratio} = \frac{\text{Cash} + \text{Accounts Receivable}}{\text{Current Liabilities}}$$

Asset Management Ratios

$$\text{Inventory Turns} = \frac{\text{Cost of Goods Sold}}{\text{Inventories}}$$

$$\text{Asset Turn} = \frac{\text{Net Sales}}{\text{Assets}}$$

$$\text{Accounts Receivable Days} = \frac{\text{Accounts Receivable} \cdot (365)}{\text{Net Sales}}$$

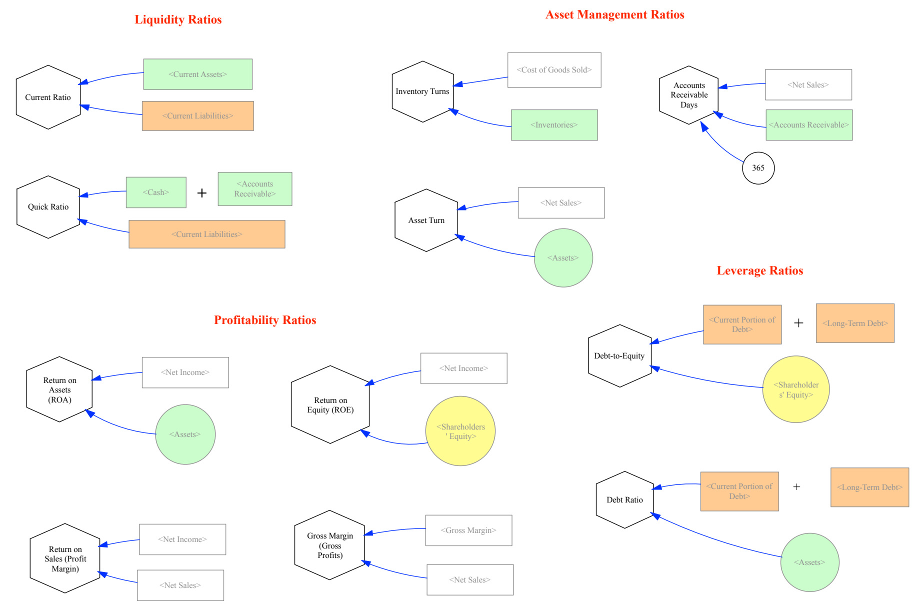


Figure 3.17: Ratio Analysis Diagram

Profitability Ratios

$$\text{Return on Assets (ROA)} = \frac{\text{Net Income}}{\text{Assets}}$$

$$\text{Return on Equity (ROE)} = \frac{\text{Net Income}}{\text{Shareholders' Equity}}$$

$$\text{Return on Sales (Profit Margin)} = \frac{\text{Net Income}}{\text{Net Sales}}$$

$$\text{Gross Margin (Gross Profits)} = \frac{\text{Gross Margin}}{\text{Net Sales}}$$

Leverage Ratios

$$\text{Debt-to-Equity} = \frac{\text{Current Portion of Debt} + \text{Long-Term Debt}}{\text{Shareholders' Equity}}$$

$$\text{Debt Ratio} = \frac{\text{Current Portion of Debt} + \text{Long-Term Debt}}{\text{Assets}}$$

In SD modeling, these ratios can be easily calculated for financial analysis as illustrated in Figure 3.17. For instance, Returns on Assets (ROA) and Equity (ROE) are illustrated as in Figures 3.18.

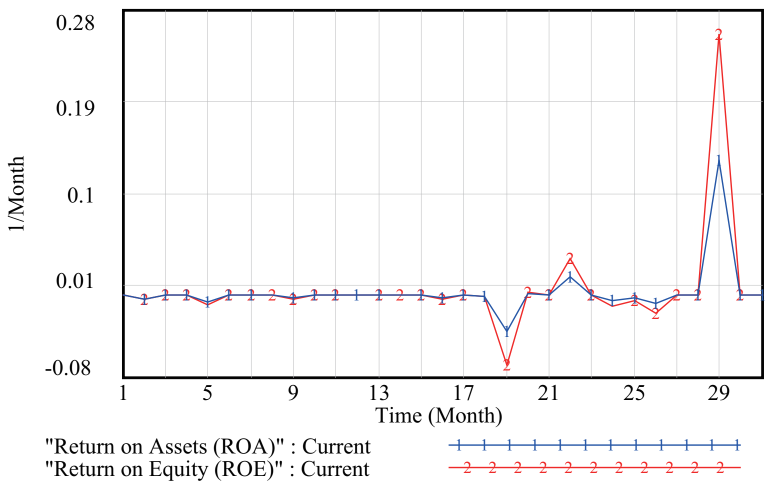


Figure 3.18: Returns on Assets and Equity

3.9 Toward A Corporate Archetype Modeling

Balance sheet represents a whole system of financial activities for corporations, and managers have to rely on the information obtained within the system for their strategies and policies. Liquidity ratios, asset management ratios, profitability ratios and leverage ratios presented in the previous section provides essential indices of management strategies and financial policies. In other words, stocks in the balance sheet provide very important sources of information for corporations. From system dynamics viewpoint, the use of such information is nothing but establishing feedback loops from the sources of information (that is, stocks in the balance sheet) to the inflows and outflows. In this sense, 11 ratios illustrated in Figure 3.17 could be important parts of system feedback loops. With the introduction of such feedback loops, our corporate financial model could become a relatively closed system and provide a wholistic picture of corporate dynamics.

It could be inferred, however, that such traditional ratio analysis is not the only method for managers to extract managerial information. For instance, a discrepancy between net cash flow and net income, as illustrated in Figure 3.19, could be another important source of information for better liquidity management. In this way, a lot of essential information could be derived within the SD accounting system, depending on the objectives of management.

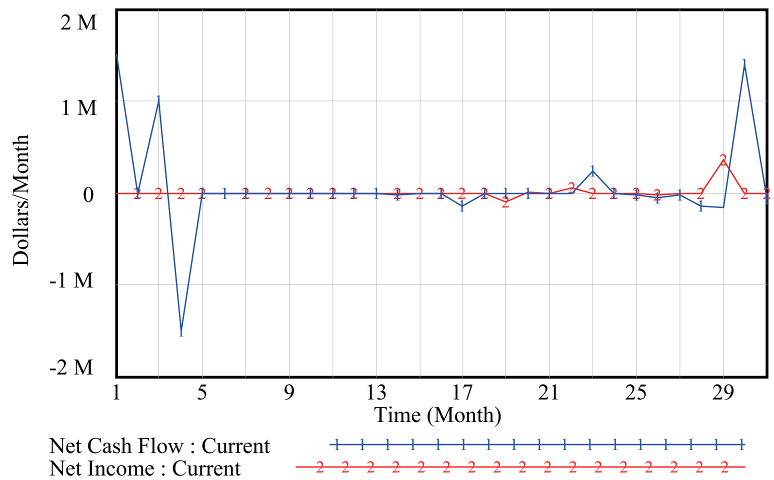


Figure 3.19: Net Cash Flow and Net Income

What kind of information feedback loops, then, need to be built and how? Learning the current accounting system merely gives us no clue. In order to incorporate information feedback loops, we have to know how decisions on transactions such as the ones considered in section 3.6 are made. The introduction of appropriate feedback loops, in this sense, depends on the types of business activities of corporations. Only when such decision-making processes are specifically incorporated into our corporate financial model, it becomes a truly SD accounting model.

Even so, as long as modern corporations are part of the global market economic system, there could be generally accepted rules of drawing financial information feedback loops to make our SD model a truly corporate financial model. Such a model, if constructed, could be a corporate business archetype. In this sense, our research here is nothing but a beginning, though an important start, toward a truly corporate archetype modeling. This will be our task to be challenged in the near future.

Conclusion

We have demonstrated how to construct a SD model of corporate financial statements such as given in the book Ittelson (1998), by establishing the principle of accounting system dynamics (PASD) that consists 5 principles obtained from system dynamics and accounting system. It is shown that cash flow statement is indispensable, contrary to the practice that it has been long neglected in the Japanese financial statements. The model is shown to be static in the sense that all transaction data are given as parameters outside the system and no information obtained from the stocks in the balance sheet is utilized for better management practices - a limitation of the current accounting system. To make it a truly dynamic SD model, information feedback loops have to be incorporated in it.

Questions for Deeper Understanding

ASD Simplified.vpmx model illustrates 8 stages of typical start-up business transactions based on the Principle of Accounting System Dynamics. These transactions covers almost all kind of double-entry bookkeeping practices accountants are following daily. Macroeconomic activities are nothing but the sum of such microeconomic activities of all economic agents such as firms and households. Accordingly, it must be essential for macroeconomic researchers to understand double-entry bookkeeping principles at the microeconomic level.

With these in mind, imagine any type of business you would like to start up. According to the 8 stages in the model, state a brief story of your business process, step by step, and specify transactions you need. Then, discuss how these transactions affect the items (stocks) of your Balance Sheet statement, by building your simple ASD business model at each stage; that is, only the model of stock and flows that are affected by the transactions of that stage. You need not fill in concrete numbers or data.

For example at each stage of i, i = 1, 2 ⋯, 8: briefly describe
(a) Your business story and
(b) Your transactions, then
(c) Illustrate conceptual stock-flow diagrams of these transactions.

Part II

Debt Money System

Chapter 4

Macroeconomic System Overview

This chapter applies the method of accounting system dynamics developed in the previous chapters to the macroeconomic modeling. We start with the description of a simple capitalist market economy with the traditional budget equations. In order to analyze its economic behaviors, then, a slightly revised Goodwin growth cycle model is introduced. Then, these two approaches are integrated to construct our first monetary macroeconomic model called here a monetary Goodwin model. It is demonstrated how money matters for the economic business cycles. Finally, the monetary Goodwin model is further expanded to the model with interest. This overview will provide a fundamental framework of our macroeconomic models in the following chapters.

4.1 Macroeconomic System

Macroeconomics is one of the core economic subjects which has been widely taught, with the use of standard textbooks, all over the world by many macro economists. Under such circumstances, are there still something remaining to which system dynamics can contribute, I posed. An affirmative answer to this question has led me to work on the series of macroeconomic modeling in (Yamaguchi, 2004b, 2004), (Yamaguchi, 2005, 2005), (Yamaguchi, 2006, 2006), (Yamaguchi, 2007, 2007), (Yamaguchi, 2008, 2008). For instance, macroeconomic variables such as GDP, inventory, investment, price, money stock, interest rate, etc, could be more precisely presented by using a basic concept of stock and flow in system dynamics. Moreover, using SD modeling methods, determination of GDP and creation process of credits (deposits) and money stock - two essential ingredients of macroeconomics - could be more precisely described as dynamic macroeconomic adjustment processes, compared with a traditional static approach.

System dynamics approach requires to capture macro economy as a holistic system consisting of many parts that are interacting with one another. Specifically, macroeconomic system is viewed here as consisting of six sectors such as the central bank, commercial banks, consumers (households), producers (firms), government and foreign sector. Figure 4.1 illustrates an overview of such macroeconomic system and shows how these macroeconomic sectors interact with one another and exchange goods and services for money.

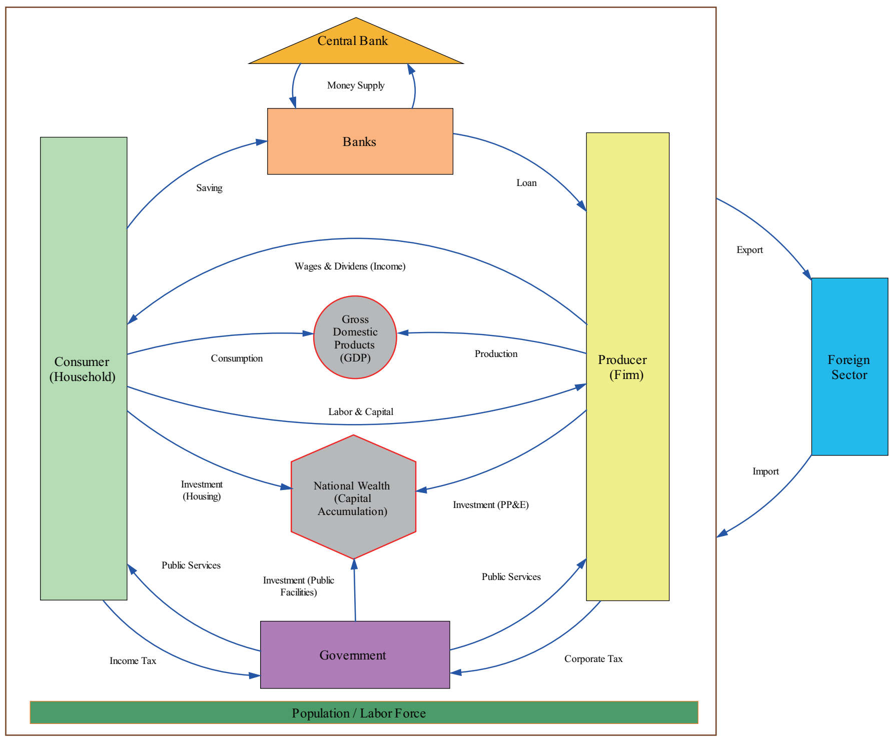


Figure 4.1: Macroeconomic System Overview

In this chapter, we show how to model a macroeconomic system illustrated in the above overview by constructing a simple macro economy consisting only consumers and producers in a capitalist market economy.

4.2 A Capitalist Market Economy

Market economy is an economic system in which goods and services are traded in the markets. A market economy we are currently living in is not the only market economy. For instance, a self-sufficient community, if any, may partly exchange goods and services with another community, or former socialist economies used to trade with another socialist economies. Accordingly, if we extend our concept of economic activities to cover all communities or international economies, their economy also form a kind of market economy. Or the MuRatopian economy consisting of co-workers I proposed in (Yamaguchi, 1988, 1988) as the most suitable economy to the information age is also a market economy.

To distinguish our market economy from these other types of market economy mentioned above, let us call it a capitalist market economy. It is defined as having the following features. It is an economic system which allows private ownership of factors of production such as labor, capital and land. Specifically, workers are allowed to own their labor (thus no longer slaves), shareholders or capitalists can own capital or shares, and landowners can own land and houses for rent. Producers have to organize production activities by purchasing those factors of production from owners in the markets in exchange for wages, profits (or dividends) and rents. The markets where those transactions are made are called labor market, financial capital market, and real estate market. On the other hand, workers and shareholders as consumers have to purchase goods and services in the commodity market. In this way, in a capitalist market economy, all factors of production and goods and services are exchanged in the markets. To make these transactions easy, money as a medium of exchange is invented, whose unit of value becomes a price.

Desired Budget Equations

To describe a market economy as simple as possible without losing generalization, let us consider the economy consisting of workers, shareholders (or capitalists) and producers. Workers and shareholders need not be mutually exclusive. Workers who own corporate shares can also be classified as shareholders. Consumers consist of those workers and shareholders. Their desired budget equations are formally written as follows:

First, workers (W) expect to receive wages against their labor supply and spend them as their income on consumption. The remaining is to be saved. Thus, their desired budget equation becomes

$$pC_W + S_W = wL^s \tag{4.1}$$

where p is a price, C_W is their consumption, S_W is their savings, w is a wage rate, and L^s is labor supply.

Next, shareholders (O) expect to receive profits (dividends) and spend them as their income on consumption. The remaining is to be saved. Then, their desired budget equation becomes

$$pC_O + S_O = \Pi(= pY - wL^d) \tag{4.2}$$

where Π is profits (dividends), C_O is their consumption, S_O is their savings, Y is output (or GDP, Gross Domestic Products, whose concept is assumed to be familiar for the reader), and L^d is their demand for labor.

Finally, producers organize production activities and are assumed to make investment I to expand their production capacity on behalf of shareholders. Since all revenues have to be distributed to workers as wages and shareholders as dividends in a private ownership economy, no fund is left available for new investment. Accordingly, in a capitalist market economy producers are destined all the time to raise fund I^d for investment. Thus, their desired budget equation becomes

$$pI = I^d \tag{4.3}$$

When all of these desired budget equations are added, the following equation is obtained. Since it holds all the time, it becomes an identity, and called Walras law.

$$p(C_W + C_O + I - Y) + w(L^d - L^s) + (S_W + S_O - I^d) \equiv 0 \tag{4.4}$$

The first component implies an excess demand for goods and services in commodity market, the second one is an excess demand for labor, and the third one is an excess demand for money in financial capital market. Once a capitalist market economy is formalized as above, the major question is whether there exist market prices which clear excess demand in all markets. To be precise, from Walras law, whenever two markets are in equilibrium, the remaining market attains equilibrium automatically. This problem is called the existence of general equilibrium. As already discussed in Chapter 2, it is proved by Arrow and Debreu.

The next major question is how to find the equilibrium prices. Such a finding process is said to be globally stable if any initial prices can eventually attain the equilibrium through tâtonnement processes. As already discussed in chapter 2, an emergence of chaos makes the attainment of equilibrium impossible under some circumstances. It is worth noting again that under the neoclassical framework of price adjustment, transactions can only start when equilibrium is attained. Until that moment, their budget equations are not the actual ones based on the actual receipts and payments. That is why above budget equations are called desired budget equations.

4.3 Modeling a Capitalist Market Economy

Our method of economic analysis is to allow off-equilibrium transactions on a historical time. The accounting system dynamics developed in the previous chapters enables to model the off-equilibrium transactions. Accordingly we are now in a position to model the above simple capitalist market economy as a generic macro economy [Companion model: MicroASD.vpmx].

Let us start with producers' balance sheet. Whenever output is produced it becomes their revenues and at the same time booked as inventory. In an actual booking practice of companies, it is usually booked as accounts receivable.

Producers pay wages and dividends to consumers consisting of workers and shareholders, who in turn spend their income on consumption, and the remaining amount is saved. Consumption thus becomes part of producers' sales, which reduces their inventory and increase their stock of cash. Producers also make

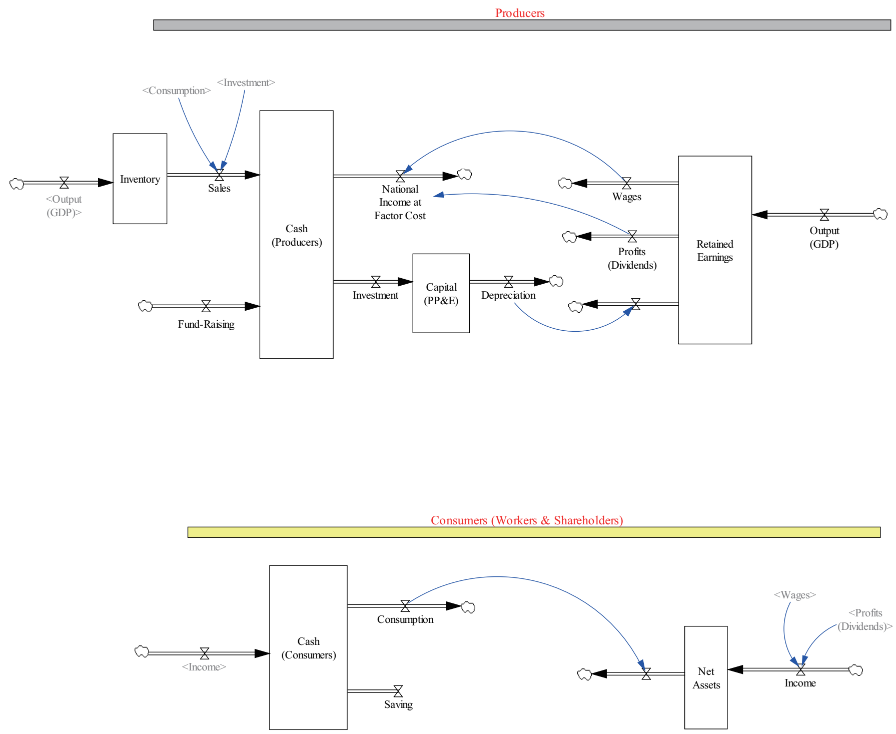


Figure 4.2: Macroeconomic System Flow Chart

investment, which in turn becomes sales to other producers. In our integrated stock of producers, these bookings are done in the same stock-flow diagram. Figure 4.2 illustrates our first macroeconomic modeling.

At this point, one remark may be needed. In the model, capital depreciation is added to make our modeling precise. Accordingly, investment in the model has to be interpreted as gross investment consisting of net investment and depreciation. Thus, income that consumers receive is also interpreted as net income; that is, output less depreciation.

Cash Flow of Producers

Let us now calculate net cash flow of producers. It is shown as inflow and outflow of producers' cash stock in Figure 4.3. Thus, it is obtained as follows:

$$\begin{aligned}\text{Net Cash Flow} &= \text{Cash Inflow - Cash Outflow}\\ &= \text{Consumption + Investment}\\ &\quad \text{- Wages - Profits (Dividends) - Investment}\\ &= \text{Consumption - National Income at Factor Cost}\\ &= \text{- Saving}\end{aligned} \quad (4.5)$$

where National Income at Factor Cost is defined as the sum of wages and profits (dividends).

The net cash flow of producers becomes equal to the negative amount of saving. In other words, in a capitalist market economy, producers are all the time in a state of cash deficiency. Accordingly, to make new investment, they are obliged to raise funds. This becomes a fundamental framework of our macro economy.

Theoretically, there are four ways to raise funds as follows:

- Borrowing from banks (bank loans)
- Issuing corporate bonds (borrowing from the public)
- Issuing corporate shares (sharing ownership)
- Retaining earnings for investment (retained saving)

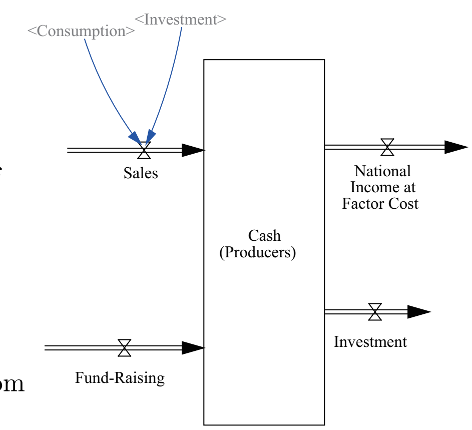


Figure 4.3: Cash Flow of Producers

4.4 Fund-Raising Methods

Bank Loans

Let us consider the fund-raising by bank loans. In this economy, consumers are supposed to deposit their savings with banks, which, in turn, make loans to producers as illustrated in Figure 4.4

In this fund-raising system, banks are merely intermediaries to facilitate the circulation of money as a means of exchange. Historically, however, usury evolved into banking activities, and interests are being imposed on producers. Accordingly, producers are forced to seek for economic growth incessantly to pay interests as well as principals. Remember the previous argument of reinforcing feedback of banking system in Chapter 1. Loans grow exponentially. To repay this increasing amount of loans, production also has to grow exponentially. If

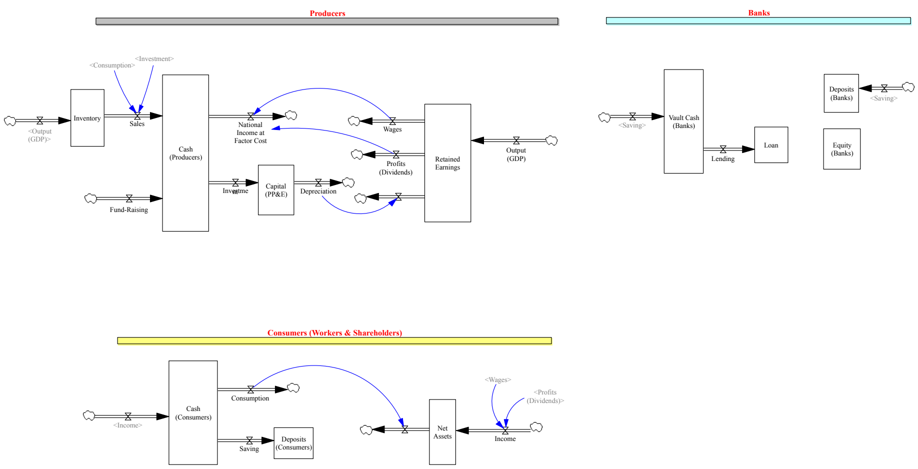


Figure 4.4: A Macroeconomic System Flow Chart with Banks

economic growth is not attained, those who cannot repay are forced to collapse. Apparently, this incessant growth is not possible under limited resources.

Accordingly, this system of fund-raising has a built-in mechanism of business cycles and economic recessions to be explored below. In addition, this interest-paying system creates unfair income distribution (the rich becomes richer due to the exponential growth), which has to be eventually reset by triggering economic collapses and/or wars, as history tells us. Moreover, forced economic growth is now causing environmental destructions. Accordingly, this interesting-bearing banking system may not be sustainable. These points are further discussed in Chapter 7.

Securities

In addition to bank loans, fund-raising could be more directly performed by issuing corporate bonds and stocks (shares), which are called securities. To make this fund-raising smooth, we need non-bank investment institutions that can handle these transactions as illustrated in Figure 4.5 [Companion model: MicroASD(NonBank).vpmx]. Problem with this fund-raising system is that there exists no way of creating money within the system that is needed to meet the increasing demand for money in a growing economy.

Historically, the above two fund-raising systems with banks and non-bank

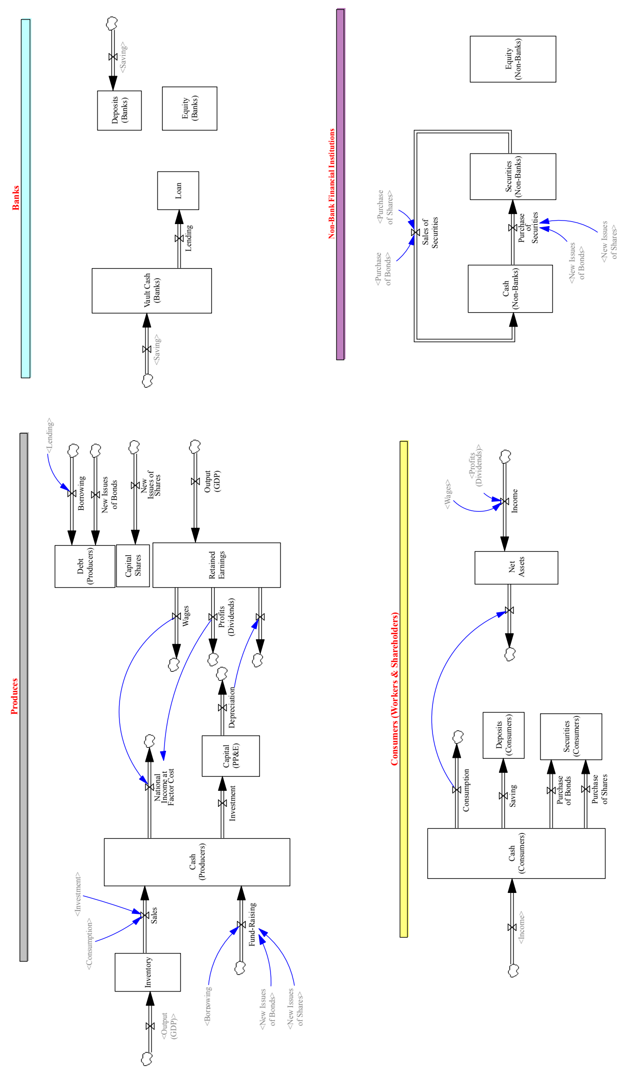


Figure 4.5: A Macroeconomic System Flow Chart with Investment Institutions

investment financial institutions co-evolved. And consumers have been provided with diversified portfolio choices among savings, bonds, and shares, while producers have been able to utilize three sources of fund-raising: loans, bonds and shares.

However, roles of banks and non-bank investment institutions have been separated by laws; for in stance, in the United States by the Glass-Steagall Act in 1933. Yet, under the strong deregulation forces of free financial activities from the Wall street the Act was repealed in 1999 by the Gram-Leach-Bailey Act. Since then, no clear distinction of financial transactions has been made between commercial banks and investment institutions. This excessive freedom of financial activities began to cause global financial crisis, starting in 2007. This issue will be further explored in Part V (Chapters 13 and 14).

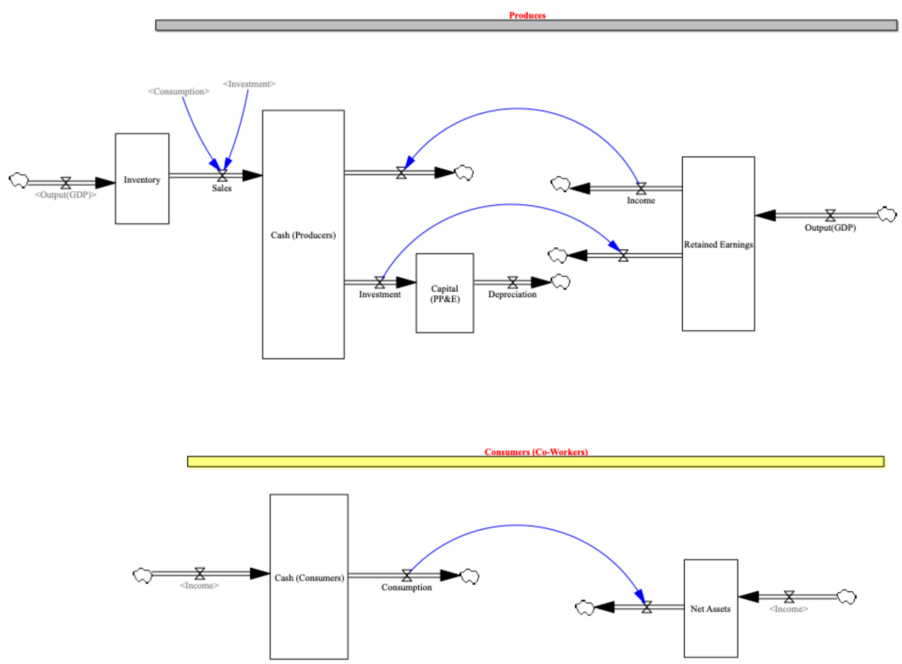


Figure 4.6: Macroeconomic System Flow Chart of MuRatopian Economy

Retained Earnings

Finally, producers may be allowed to save retained earnings entirely for future's investment, instead of being forced to distribute profits as dividends among shareholders. Japanese auto maker, Toyota, is known for its self-sustained financial management.

System dynamics is the method not only for solving problems, but designing better systems. In this sense, a better economic system of fund-raising would be the one in which producers are possessed by consumers, and no distinction is made between workers and shareholders. In other words, retained earnings become main source of fund. It is called the MuRatopian economy in (Yamaguchi, 1988, 1988). In this economy, investment is made first, and the remaining is distributed for consumption, as illustrated in Figure 4.6 [Companion model: MircoASD(MuRatopia).vpmx]. Part V: Macroeconomic System of Public Money will present new system design of macroeconomy.

4.5 A Goodwin Growth Cycle Model

Let us now construct a simple capitalist macroeconomic model that runs on the monetary flow chart presented above. The most appropriate reference model for this purpose may be the Goodwin growth cycle model (Goodwin, 1967, 1967). Since its publication, it has drawn attentions of many economists as a classical capitalist economic model that derives endogenous growth/business cycles or economic fluctuations out of class struggles.

The model itself, however, is highly mathematical, using a system of differential equations, and turns out to be very complicated for deriving its economic meaning intuitively. System dynamics modeling method allows us to introduce it more straightforwardly without losing the original spirit of the model. Our revised model consists of 8 equations as follows.

Output or GDP Y is produced by capital K as

$$Y = \frac{K}{\theta} \quad \text{(ProductionFunction)} \tag{4.6}$$

where θ is a capital-output ratio. To produce the output, workers are employed as demand for labor L^d such that

$$L^d = \frac{Y}{\alpha} \quad \text{(Employment)} \tag{4.7}$$

where α is a labor productivity. The level of employment is thus determined by the output.

A wage rate w is determined in the labor market by the following adjustment process:

$$\frac{dw}{dt} = \frac{w^* - w}{AT} \quad \text{(Determination of WageRate)} \tag{4.8}$$

where w^* is a desired wage rate and AT is an adjustment time of wage gap between a desired and actual wage rates. The desired wage rate is defined as

$$w^* = \frac{w}{\left(\frac{L^s}{L^d}\right)^e} \text{ (Desired Wage Rate)} \tag{4.9}$$

where (L^s/L^d) is a labor-employment ratio and e is its elasticity of desired wage rate. This is a standard price adjustment mechanism uniformly applied to the determination of prices and wage rate in this book (See equation (2.8) in

Chapter 2); that is, a wage rate is determined by a ratio discrepancy between labor supply L^s and employment L^d and its elasticity[1].

Workers are assumed to consume all of their actual wage income wL^d and do not save; that is, $S_W = 0$. For simplicity price is assumed to be $p = 1$, so that their budget equation (4.1) now becomes

$$C_W = wL^d \quad \text{(Workers' Consumption)} \tag{4.10}$$

On the other hand, capitalists are assumed not to consume; that is, $C_O = 0$, and save the whole amount of profits so that their budget equation (4.2) becomes

$$S_O = \Pi(= Y - wL^d) \text{ (Capitalists' Saving)} \tag{4.11}$$

Producers raise fund directly from the saving of capitalists so that their budget equation (4.3) becomes

$$I = I^d = S_O \quad \text{(Investment = Saving = Profits)} \tag{4.12}$$

This equation, accordingly, assumes an equilibrium in a commodity market so that a so-called Say's law is always met; that is to say, supply creates its own demand in this Goodwin economy.

Capital accumulates by the amount of investment less depreciation

$$\frac{dK}{dt} = I - \delta K \quad \text{(Net Capital Accumulation)} \tag{4.13}$$

where δ is a depreciation rate.

A slightly revised Goodwin growth cycle model is now complete. This macroeconomic model consists of 8 equations with 8 unknowns; that is, Y, K, L^d, w, w^*, C_W, S_O, I, and with 6 exogenously determined parameters whose values are set here at $\theta = 3,\ \alpha = 1,\ L^s = 100,\ AT = 1,\ e = 1,\ \delta = 0.1$.[2]

A causal loop diagram of the Goodwin model in Figure 4.7 illustrates how these 8 unknowns will be interdependently determined. The Goodwin model consists of one reinforcing feedback loop of capital accumulation and two balancing feedback loops of workers' share and wage determination. Accordingly, its system behaviors depend on which loop becomes dominant. For instance, if the capital accumulation loop governs, the economy may continue to grow.

[1] In the original Goodwin model, a wage rate is assumed to be determined as a linear approximation of Phillips curve such that

$$\frac{dw}{dt}/w = -\gamma + \rho\left(\frac{L^d}{L^s}\right) \text{ (Linearized Phillips Curve)}$$

where γ is an intersection of the y-axis and ρ is its slope. Our standard wage determination process, it is claimed, includes the Phillips curve adjustment.

[2] In the original Goodwin model, supply of labor, L, is assumed to grow at a constant growth rate n such as

$$\frac{dL^s}{dt} = nL^s.$$

For simplicity labor supply is assumed here not to grow. This assumption can be easily removed by the reader.

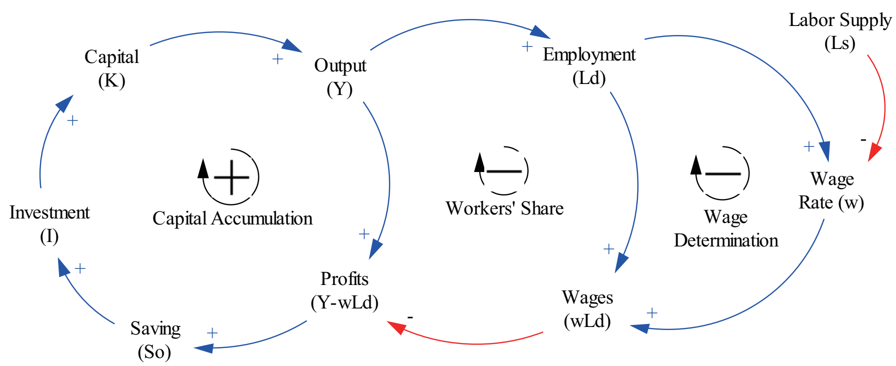


Figure 4.7: Causal loops of the Goodwin Model

On the other hand, if the workers' share loop dominates, profits and investment shrink and the economy become stagnant.

To analyze these dynamic behaviors, we need to build a Goodwin model of system dynamics. Figure 4.8 illustrates a complete system dynamics Goodwin model[Companion model: Goodwin.vpmx]. From the system dynamics viewpoint in Chapter 1, this is a system with two stocks such as capital and wage rate, so that behaviors such as overshoot and collapse and oscillation could be triggered in principle. In this sense, it could also be one of the best macroeconomic examples to learn system behaviors of two stocks.

A Steady-state Equilibrium

In the Goodwin model, an equilibrium of commodity market is assumed to be automatically met as Say's Law, since gross investment is determined to be equal to saving which is equal to profits. Accordingly, market adjustments occur only in the labor market and financial capital markets. From Walras law, if an equilibrium is attained in the labor market, then the equilibrium of financial capital market is also automatically attained. Yet, no financial capital market is explicitly brought to the Goodwin model. Accordingly, a market adjustment has to be sought in the labor market.

With these model structure in mind, let us search for a steady-state equilibrium of the Goodwin system. It can be obtained only when we have $\frac{dK}{dt} = \frac{dw}{dt} = 0$. To attain $\frac{dK}{dt} = 0$, a simple calculation entails that the following equation needs be met:

$$w = (1 - \delta\theta)\alpha \quad \text{(No Capital Accumulation)} \tag{4.14}$$

In our model, this steady-state equilibrium condition is reflected in the initial value of wage rate.

To achieve $\frac{dw}{dt} = 0$, we must have

$$L^s = L^d \quad \text{(Full Employment).} \tag{4.15}$$

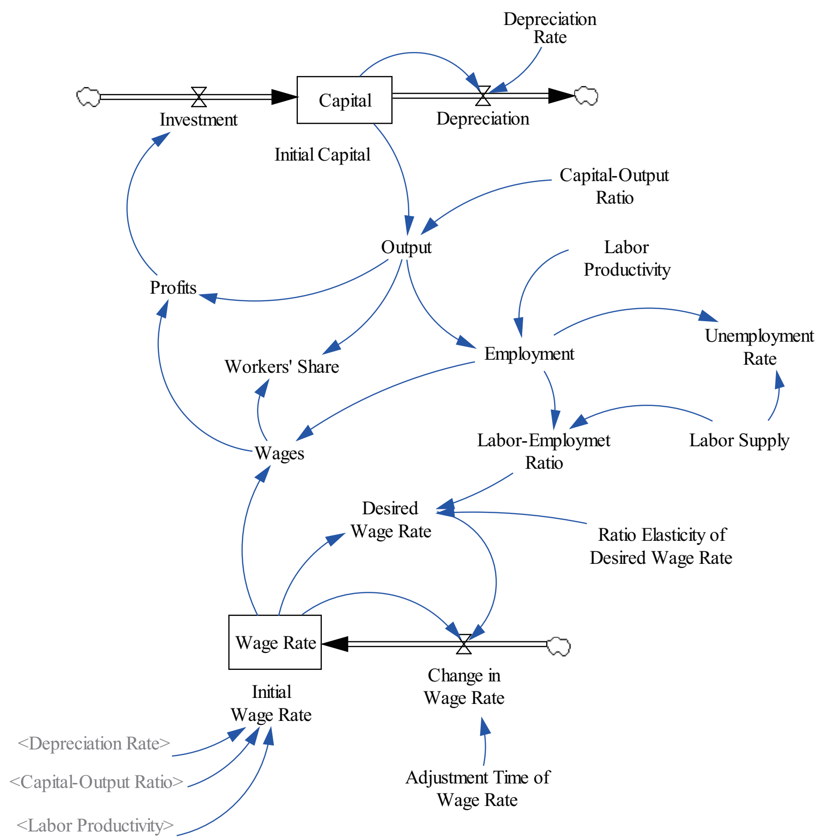


Figure 4.8: The Goodwin Growth Cycle Model

Accordingly, the steady-state equilibrium is attained only when $w = (1 - 0.1 \cdot 3) \cdot 1 = 0.7$ and $L^d = L^s = 100$. Lines 1 in Figure 4.9 shows the equilibrium wage rate of 0.7 and output of 100.

Business Cycles

The steady-state equilibrium in the Goodwin model can be broken only when one of the three model parameters change their values from the initial equilibrium conditions at $\theta = 3,\ \alpha = 1,\ L^s = 100$. To explore off-equilibrium economic behaviors, let us focus on the change in the values of labor supply here. The other two cases of parameter value changes will be left to the reader as exercise.

When labor supply is $L^s = 110$, and becomes higher than the equilibrium employment of 100, wage rate begins to decline as indicated by line 2 in the left-hand diagram of Figure 4.9, which simultaneously causes the decrease in workers'share and increases in profits and investment, which in turn expands capital accumulation and output with a delay as indicated by line 2 in the right-hand diagram of output. When labor supply is $L^s = 90$, and becomes less than the equilibrium employment of 100, wage rate begins to increase, and exactly the opposite behaviors start to dominate as lines 3 in both diagrams demonstrate.

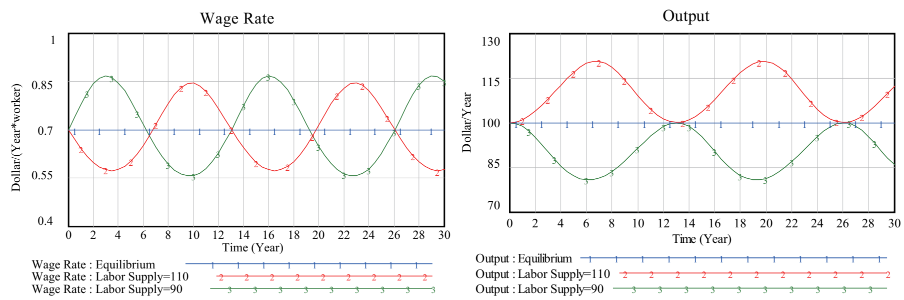


Figure 4.9: Wage Rates and Output

In this way, in the case of $L^s = 110$, wage rate tries to go down and up to attain an equilibrium in the labor market unsuccessfully; that is, employment overshoots and undershoots the labor supply as illustrated by line 2 in Figure 4.10. This fluctuation is caused by the delay in stocks. Similarly, in the case of $L^s = 90$, employment overshoots and undershoots as illustrated by line 4. In other words, equilibrium in the labor market can never be attained in the capitalist market economy due to the delay in system (a well-known behaviors in system dynamics), though wage rate is perfectly flexible as neoclassical economists postulate.

Let us examine this business cycle in detail in the case of $L^s = 110$ by referring to Figure 4.11. Whenever there exists excess labor supply in the labor market, wage rate begins to decline as well as workers' share (line 1). This causes the increase in profits as well as investment (line 2). This increases capital accumulation with a delay (line 3), which increases output with a delay as well (line 4). The delayed increase in output causes an increase in the demand for employment, causing wage rate to increase with a delay (line 1).

Period of Business Cycles

The period of business cycles depends on how wage rate responds in the labor market; that is, a wage rigidity which is specified by a labor-employment ratio elasticity of desired wage rate in our model. Figure 4.12 illustrates three different business cycles for the disequilibrium case of $L^s = 110$. When the elasticity is 0.4; that is, wage rate is rigid, the period of business cycle becomes about 20 years (line 1). When the elasticity is unitary, the period becomes about 13 years (line 2), and becomes about 8 years when the elasticity is 2.4 (line 3); that is, wage rate is very flexible. From these simulations, it can be easily envisioned

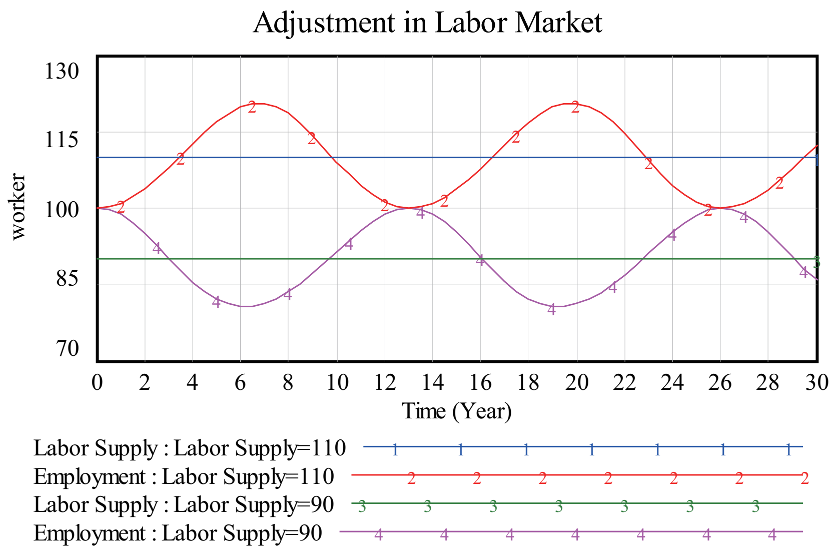


Figure 4.10: Adjustment in Labor Market

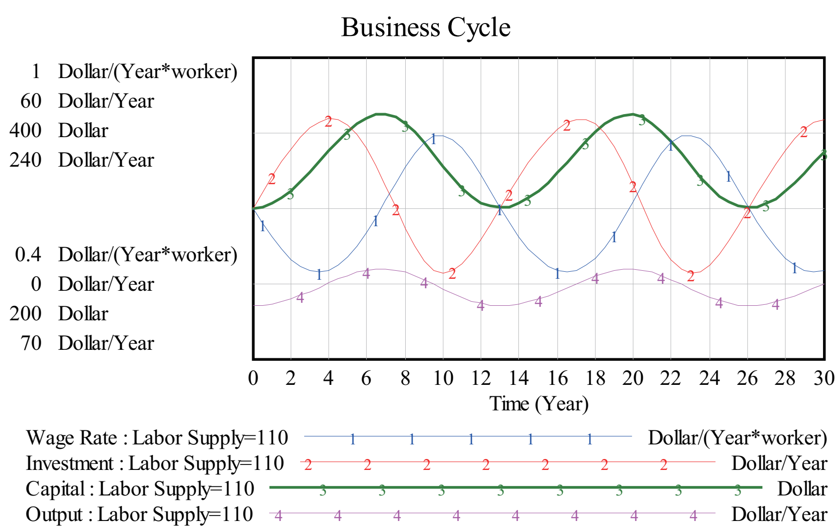


Figure 4.11: Business Cycle

that as the wage rate becomes more flexible, the shorter becomes the period of business cycles.

In this way, our Goodwin growth cycle model has demonstrated that business cycles are endogenously generated within a capitalist market economy, whose periods depend on the wage flexibility in the labor market.

Goodwin's original work illustrated this endogenous growth cycle by his

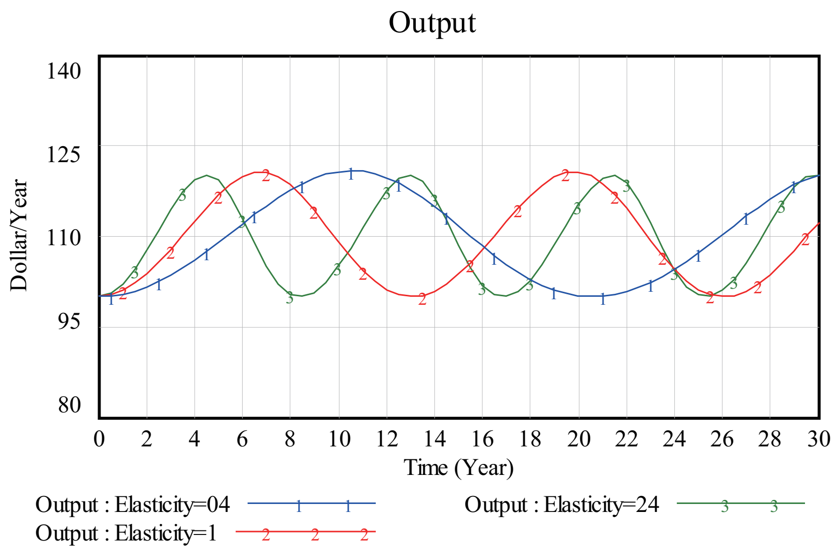


Figure 4.12: Ratio Elasticity of Desired Wage Rate

famous phase diagram of employment rate on the y-axis and workers' share on the x-axis. Figure 4.13 illustrates similar phase diagram for different levels of labor supply and elasticity. In our phase diagram, a labor-employment ratio,

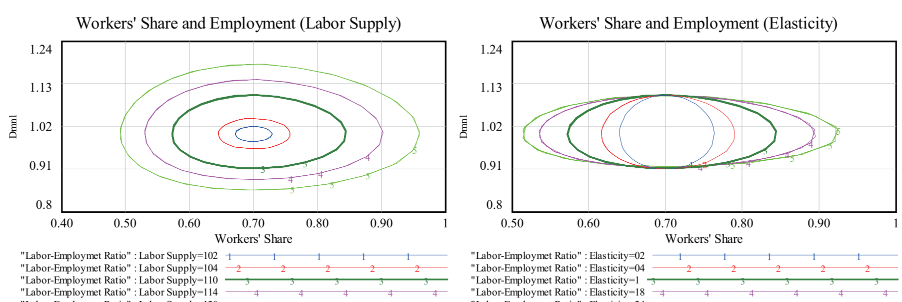


Figure 4.13: Phase Diagram of Labor-Employment Ratio and Workers' Share

a reciprocal of Goodwin's employment rate, is used without losing generality. Specifically, the left-hand diagram shows how circular relation between labor-employment ratio and workers' share begins to expand from the equilibrium center of (0.7, 1) as labor supply increases from the equilibrium level of $L^s = 100$ to 102, 104, 110, 114 and 120. Meanwhile, the right-hand diagram shows how this circular relation begin to expand horizontally, under the $L^s = 110$, as the elasticity of desired wage rate increases from $e = 0.2$ to 0.4, 1, 1.8 and 2.4.

4.6 A Monetary Goodwin Model

We are now in a position to unify the above Goodwin growth cycle model of macroeconomic dynamics with our analytical method of the accounting system dynamics, and explore macroeconomic behaviors on a circulation of money. Among four fund-raising methods discussed above, bank loans will be adopted here as a typical fund-raising method for producers. Specifically, a macroeconomic system flow chart with banks in Figure 4.4 is integrated with the Goodwin growth cycle model in Figure 4.8. This integrated Goodwin growth cycle model running on the circulation of money may be called here a monetary Goodwin model. Figure 4.14 illustrates its revised part of the balanced sheet sub-model [Companion model: Goodwin(Money).vpmx][3].

A Steady-state under Monetary Constraints

We have already discussed above that a steady-state equilibrium can not be broken unless initial parameter values such as $\theta = 3$, $\alpha = 1$, $L^s = 100$ are changed. At the steady-state, the output becomes 100, out of which workers receive 70 as wages and spend them all on consumption. The remaining amount of 30 becomes profits, all of which in turn are invested. Meanwhile, initial capital stock is 300, 10% of which is assumed to depreciate. Accordingly, to maintain the initial level of capital, depreciation of 30 has to be incessantly replenished by the investment of 30, which will be done out of profits. In this way, the economy is sustained at the steady-state so long as the above-mentioned initial parameter values are held constant, as argued by many growth economists.

Yet, these conditions for the steady-state equilibrium are no longer sufficient whenever a circulation of money is explicitly introduced to the economy. To maintain the steady-state equilibrium in a capitalist market economy, produces have to keep investing the amount of 30. Surely, the source of this investment is provided by their savings and profits of 30. This is a macroeconomic level of steady-state condition. What will happen if some producers do not have enough cash for their investment at a microeconomic level of economic activities, or if they may be asked to pay their investment before receiving profits, because their products have to be sold out as consumption and investment before they realize profits?

In either case, to ascertain their investment, they must have at least the same amount of cash as their desired level of investment. What will happen if initial cash of producers is less than 30; say, 28 in our case of steady-state; that is, initial investment is reduced by 2 due to the shortage of money or liquidity? Surely, they are forced to raise additional fund by the amount of 2 as an initial desired borrowing. To our surprise, this small amount of cash constraint triggers business cycle as illustrated by Figure 4.15. In this way we have successfully identified the fourth condition that beaks down the steady-state equilibrium; that is, a monetary or cash constraint. Money is no longer

[3]The monetary Goodwin model is the same as Goodwin model. To run this model, the default value of the variable Switch(Cash Constraint)=0 has to be reset to be equal to 1.

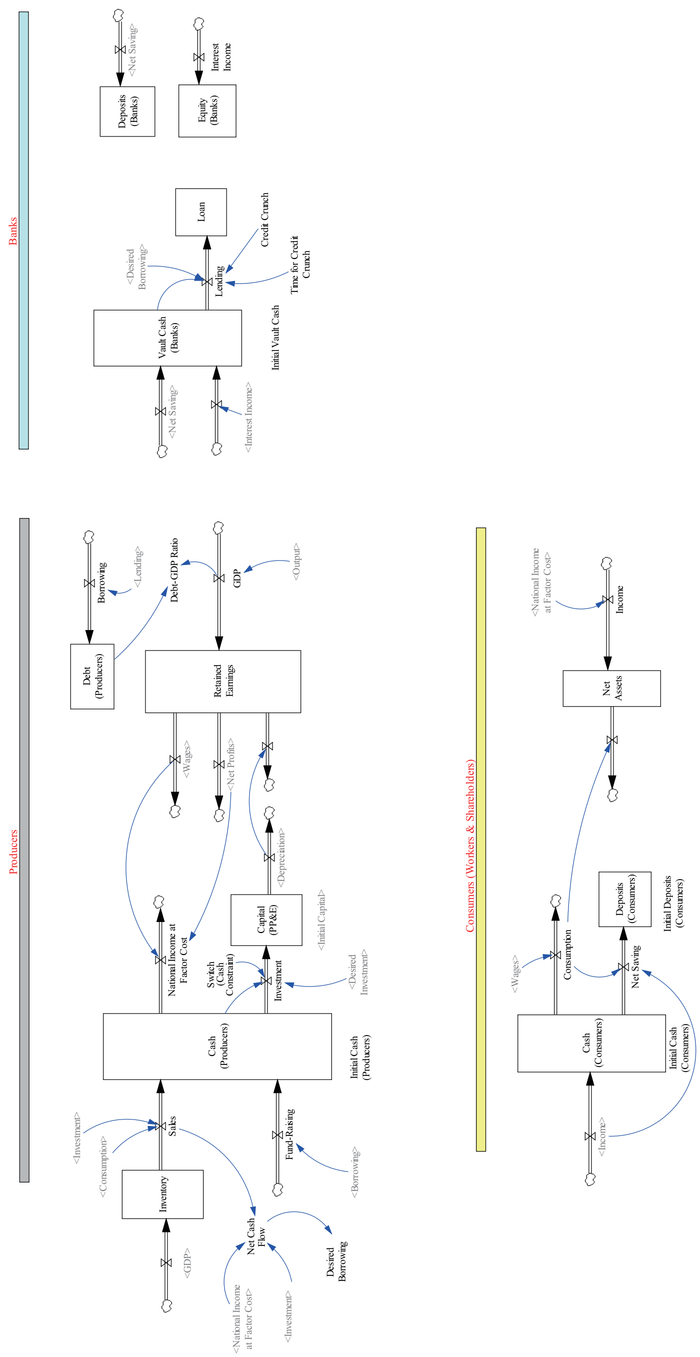


Figure 4.14: A Monetary Goodwin Model

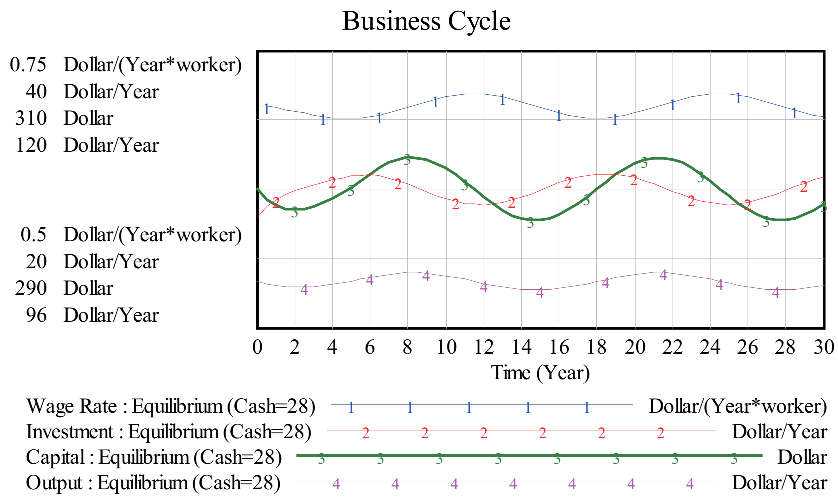


Figure 4.15: Business Cycle caused by A Monetary Constraint

neutral as neoclassical general equilibrium economists argue. It DOES indeed matter!

A Credit Crunch and Economic Recession

In the above business cycle triggered by the cash constraint, the first trough of investment cycle visits at the year 12 as line 2 in Figure 4.15 indicates. Now suppose that banks, being discouraged by the decline in investment, get worried about the economic prospect and constrain their bank lending by 30% of the desired borrowing amount by producers. In other words, banks caused credit crunch by 30% out of fear. This credit crunch is illustrated as a gap between desired borrowing (line 3) and actual lending (line 4) in Figure 4.16.

Due to this lending restriction, producers can no longer borrow their desired amount for investment. This investment gap is illustrated as a gap between the desired investment (line 1) and actual investment (line 2). Credit crunch thus caused by the banks now affects output and employment as demonstrated by Figure 4.17. Line 2 in the left-hand diagram indicates the fluctuation of output caused by the initial cash constraint of 2, while line 3 reveals a prolonged output reduction cycle. Line 2 in the right-hand diagram indicates the fluctuation of unemployment caused by the initial cash constraint of 2, while line 3 reveals a prolonged higher unemployment rate caused by credit crunch. In this way, it is shown that a credit crunch not only breaks a symmetry behavior of business cycles but worsens the economic performance. In other words, it causes an economic recession!

To be worse for the producers, their debt continues to accumulate as Figure 4.18 demonstrates. Left-hand diagram shows the values of debt and the right-hand one shows Debt-GDP ratio, which indicates close to 30% of GDP. This

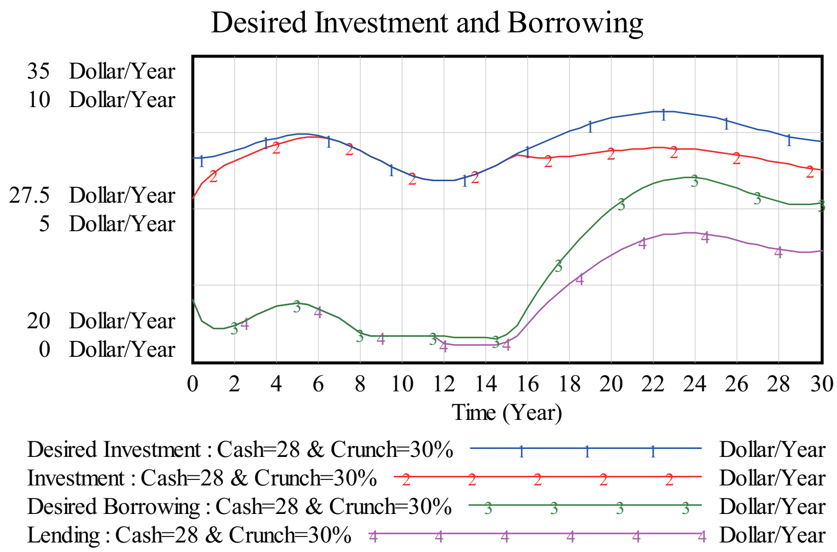


Figure 4.16: Desired Investment and Borrowing

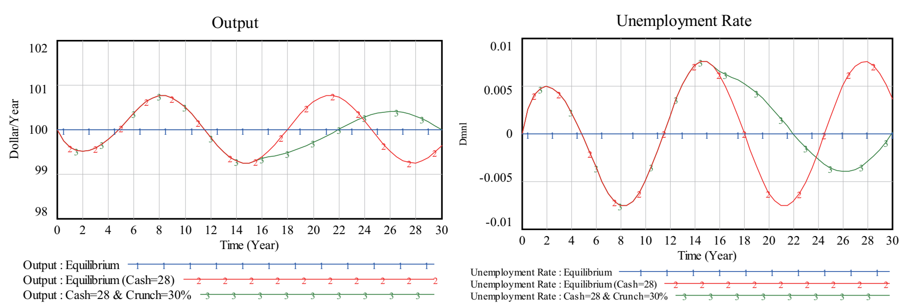


Figure 4.17: Output and Unemployment Rate caused by A Credit Crunch

is a monetary behavior which has been thoroughly neglected in the standard analysis of Goodwin model. Behind the well-discussed business cycles, a run-away accumulation of debt continues to grow. This debt accumulation may trigger another economic recession through the constraint of liquidity due to the increase in the interest payment as well as loan disbursement. To explore the possibility of this economic recession, the monetary Goodwin model further needs be revised with the introduction of interest.

4.7 A Monetary Goodwin Model with Interest

The monetary Goodwin model or the integrated Goodwin model with a circulation of money analyzed above is not still complete in the sense that interest

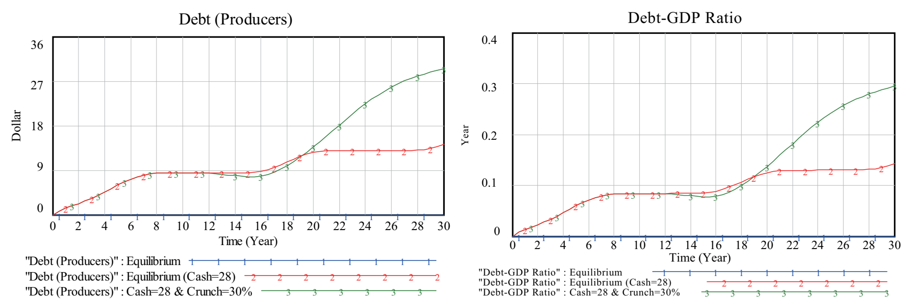


Figure 4.18: Accumulating Debt caused by A Business Cycle and Credit Crunch

payments are not considered. The nature of interest will be extensively analyzed in Chapter 7. Here we just explore how the introduction of interest affects economic behaviors in the monetary Goodwin economy. In the above analyses only the possibilities of business cycles that collapse into economic recessions were shown by introducing liquidity constraint and credit crunch due to outside shocks or fears of bankruptcies. In this section, let us complete our monetary Goodwin model with the introduction of interest, and explore whether economic recessions could be triggered endogenously out of perpetual Goodwin-type business cycles.

The model is completed in the following fashion. First, consumers receive interest income against their deposits. The interest rate applied to the calculation of this income is set to be 2% by default. Secondly, producers pay interest and loan disbursement to banks for the debts out of their retained earnings. Interest thus paid becomes interest income for the banks. The interest rate applied to the calculation is called a prime rate which has to be higher than the interest rate in order for the banks to realize positive income. The difference between prime rate and interest rate is called a prime rate spread here, and set to be 2% by default. In this way, banks can accumulate their equity by the flow amount of their interest income paid by producers less interest paid by banks to consumers. Finally, producers' (gross) profits now need to be redefined as follows:

$$\text{Profits} = \text{Output - Wages - Interest Income (Banks)} \tag{4.16}$$

Figure 4.19 illustrates a balance sheet of the monetary Goodwin model with interest[Companion model: Goodwin(Interest).vpmx].

Business Cycles into Economic Recessions!

The introduction of the interest into the monetary Goodwin model turns out to affect the perpetual business cycles of the above Goodwin model. Let us start with the same situation of labor supply; that is, $L^s = 110$ that causes perpetual

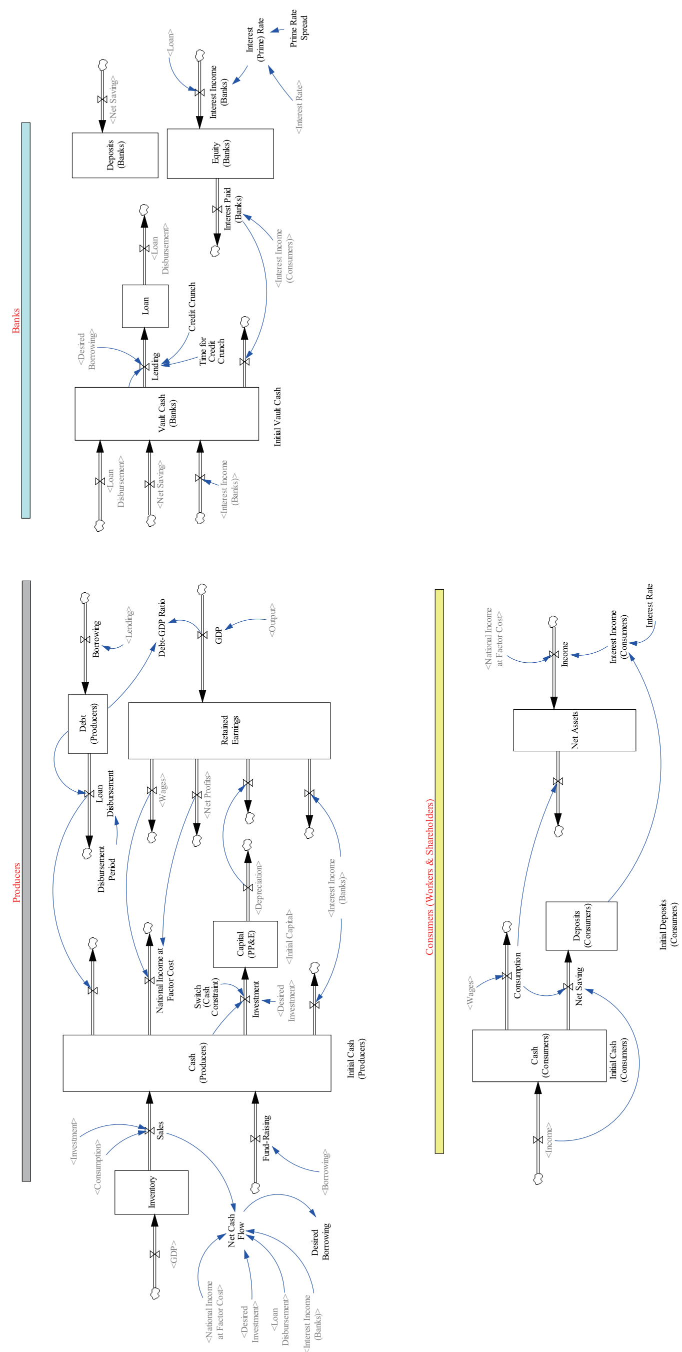
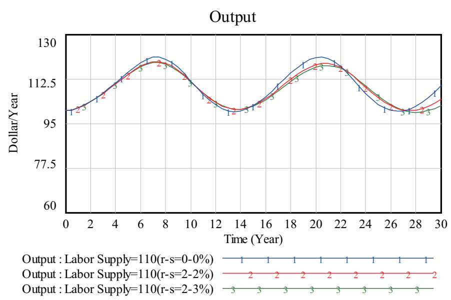


Figure 4.19: Balance Sheet of the Monetary Goodwin Model with Interest

business cycles[4]. Specifically, line 1 in the left-hand diagram of Figure 4.20 indicates the same output business cycles as the original one in the Goodwin model when there is no interest. Line 2 is our new output business cycle caused by the interest rate of 2% and prime rate spread of 2%; that is, 4% of prime rate. Line 3 is additionally produced for the interest rate of 2% and the prime rate of 5%. These three business cycle curves thus produced with or without the introduction of interest rate obviously demonstrates that the nature of perpetual Goodwin business cycles remains unaffected over the first 30 years. The right-hand diagram also demonstrates similar unemployment business cycles over 30 years. That is to say, unemployment cycles seem to have not being affected by the introduction of interest.



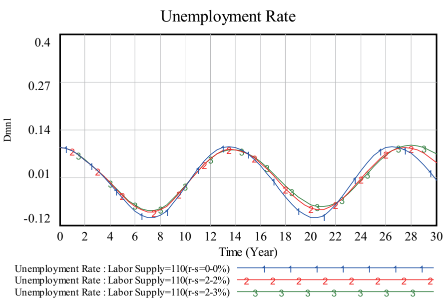


Figure 4.20: Output and Unemployment with Interest Rate: 0 - 30 years

These observation may suggest that money does NOT matter on the formation of business cycles, because they look alike with or without money and interest rate. To confirm this furthermore, I have extended the simulation period to the next 20 years. To our surprise, then, one of the perpetual business cycles begins to break and fall down as illustrated by line 3 in left-hand diagram of Fig 4.21. In other words, this breakdown seems to have occurred when a prime rate spread becomes larger than 3% in our model. Meanwhile, unemployment rate begins to rise out of its perpetual business cycle as illustrated by line 3 in the right-hand diagram.

Compared with these breakdowns of business cycles, lines 2 being produced at the prime rate spread of 2% seem to remain unaffected by the introduction of interest. The reader may easily confirm that this is not true when the simulation is further extended over 60 years[5]. In other words, it may be conjectured that a capitalist monetary economy of Goodwin type eventually triggers economic recessions out of perpetual business cycles in 50 years, 60 years, or 100 years.

Why cannot the perpetual business cycles be sustained, then? Left-hand diagram of Figure 4.22 shows how banks keep accumulating their equity due to the incessant flows of interest income. Moreover, right-hand diagram of Figure

[4]Analyses done above under the subsection of "A Credit Crunch and Economic Recession" are not tried in this section. They are left to the reader as exercise.

[5]Refer to lines 3 in Figures 4.26 and 4.27 below.

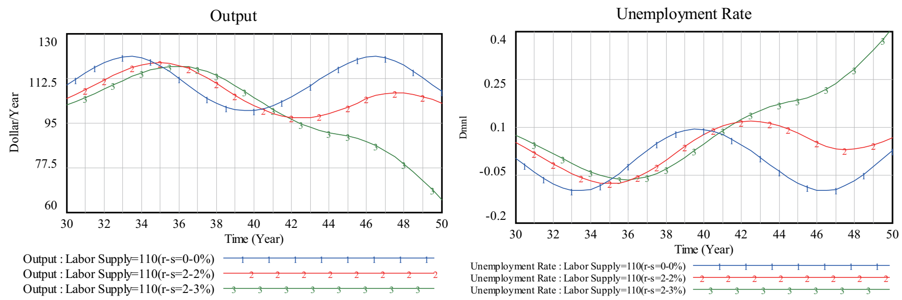


Figure 4.21: Output and Unemployment with Interest Rate: 30 - 50 years

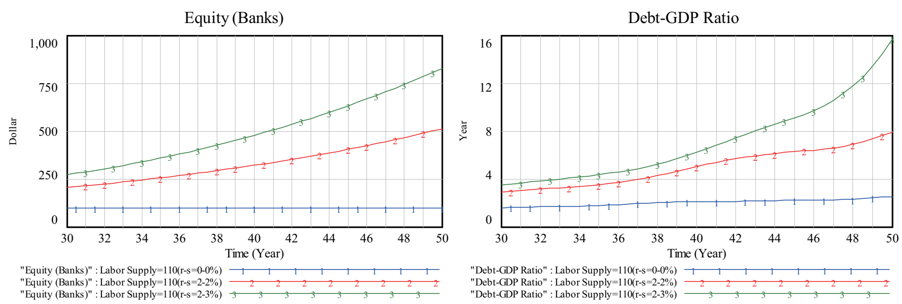


Figure 4.22: Increasing Bank Equity and Debt-GDP ratio: 30 - 50 years

4.22 shows how producers are forced to borrow from banks and, as a result, keep accumulating their debt (and debt-GDP ratio).

What do the banks do with the increasing amount of equity? In the model it is assumed to be sitting idle, without being productively used as investment, because banks have no incentives to do so. Instead, they may become "Ponzi financier" (Keen, 2011, p.328) and engage in unproductive financial gambles. This implies in our model a substantial decline in profits and investment as indicated by line 1 in Figure 4.23. Surely, due to the higher prime rate payments, the desired borrowing of producers begins to sky-rocket as illustrated in line 3 of the Figure, yet lending amount of banks cannot meet the demand of producers from the year 40 as indicated by line 4. In this way, the actual investment (line 2) begins to be constrained from the year 45. The reduced investment, then, collapses capital accumulation and eventually output, triggering economic recessions. To be worse, an economic recession thus provoked may turn into a great depression in 50 to 100 years of time span.

Figure 4.24 gives another view of the collapse of perpetual business cycles into economic recessions. Left-hand diagram shows a perpetual cycle of workers' share and labor-employment ratio, while the right-hand diagram indicates a cyclical decline in workers' share and a cyclical increase in the labor-employment ratio; that is, an increase in unemployment.

Figure 4.25 illustrates a skyrocketing increase in debt-GDP ratio from 1.8

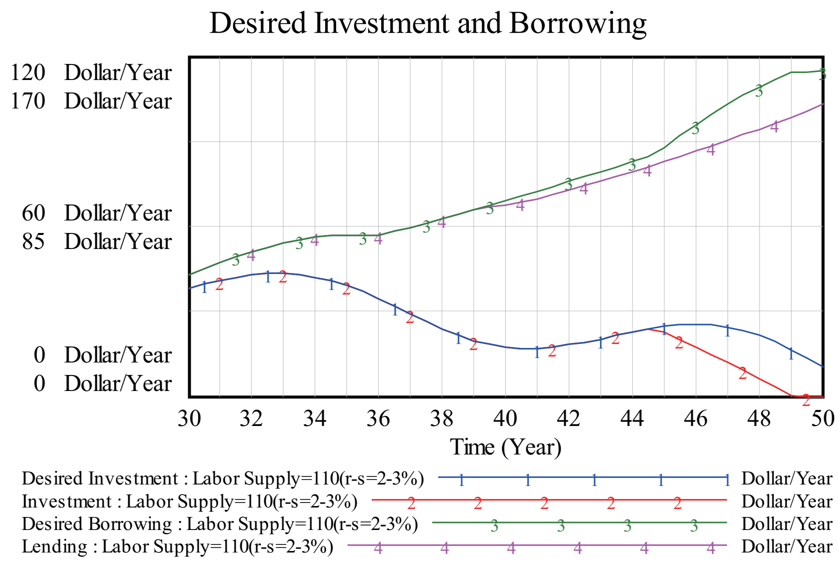


Figure 4.23: Desired Investment and Borrowing at a Prime Rate Spread=3%

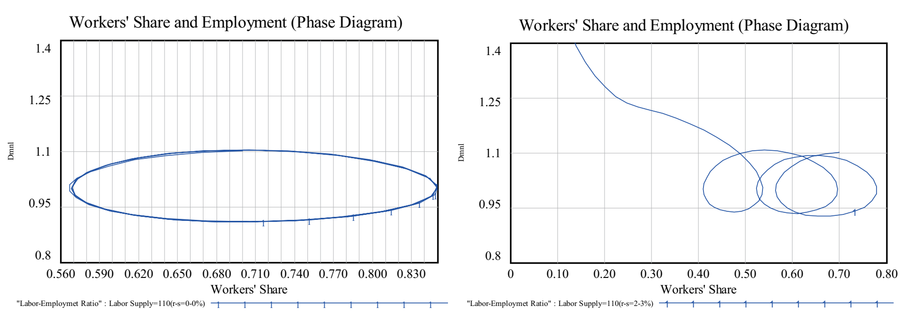


Figure 4.24: Breaking Phase Diagram of Labor-Employment Ratio and Workers' Share

in the year 20 to 15.7 in the year 50 (line 1). Line 2 shows its change rate; for instance, 8.5% in the year 20 and 14.8% in the year 50. In relation with the recent financial crisis in 2008, Steve Keen pointed out an interesting correlation between the change in debt-GDP ratio and unemployment in (Keen, 2011, Chapter 13). To examine the correlation in our model, unemployment rate is drawn as line 3. A closer look at the lines 2 and 3 suggests that cycles of unemployment rate follow those of the change in debt-GDP ratio with a delay. In other words, change in debt-GDP ratio could be an appropriate indicator of economic recessions in a capitalist monetary economy.

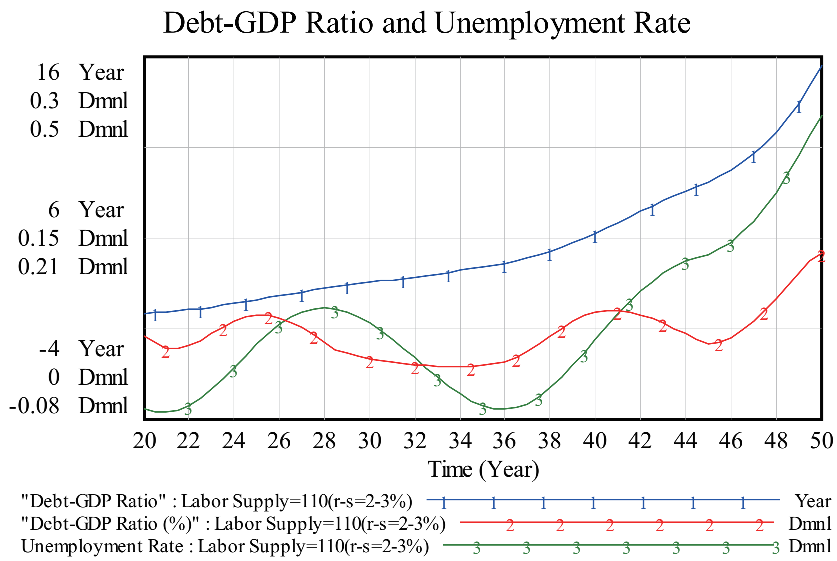


Figure 4.25: Debt-GDP Ratio and Unemployment Rate: 20 - 50 years

Economic Recovery

How can we avoid the collapse of perpetual business cycles into economic recessions? In Figure 4.23 that desired investment begins to be constrained around the year 45. Accordingly, it can be easily conjectured that additional cash being put into circulation may remove the monetary constraint and lead the economy once again to recovery.

To examine this conjecture, let us put a new amount of 60 cash at the year 45 into circulation (without asking where it comes from!). Our simulation this time is extended to the year 55 to explore its effect. Figures 4.26 and 4.27 thus obtained are the same as the left-hand and right-hand diagrams of Figure 4.21 in the case of lines 1 through 3. In addition, effects of the input of new cash on the output and unemployment are illustrated by lines 4.

Output now seems to stop plummeting for a while, and unemployment rate seems to stop rising temporarily. The reader may easily predict that output sooner or later begin to decline, and unemployment rate begins to rise if simulations are extended beyond the year 55. To avoid this, the reader may also predict that another additional input of cash into circulation might improve the situation. Additional simulation has proved that no such effect is attained. The reason is that the increasing interest income for banks continues to squeeze the profits of producers, and accordingly their desired investment. Surely, declines of capital accumulation and output are to follow.

From these reasoning it is now clear that to regain economic recoveries, interest income of banks has to be restricted. To do so, let us reduce the primary rate spread to be zero at the year 45, together with the input of cash.

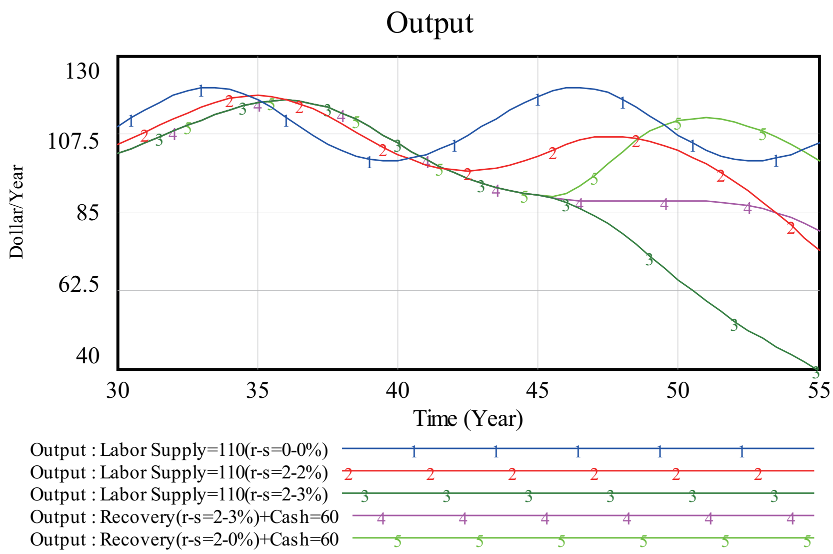


Figure 4.26: Recovering Output with Interest Rate: 30 - 55 years

Figure 4.27: Recovering Unemployment with Interest Rate: 30 - 55 years

Lines 5 in Figures 4.26 and 4.27 are thus obtained. They indicate the recovery of perpetual output cycles as well as that of perpetual unemployment cycles.

Can the perpetual recoveries thus attained, then, be sustained? When simulation period is further extended beyond 65 years, they turned out to collapse again. Only when interest rate is additionally set to be 1% from the beginning in our model, perpetual business cycles are shown to be sustained without collapsing into economic recessions. This may indicate that banking services with interest is an obstacle to the sustainability of the economic activities. The sustainability issue will be further discussed in Chapter 7 in which the nature of interest will be extensively investigated.

Conclusion

We have over-viewed our macroeconomic system with an introduction of a simple capitalist market economy under the framework of accounting system dynamics method. Next, for analyzing its economic behavior we have introduced a Goodwin growth cycle model. Then, those two models are integrated as a monetary Goodwin model. In addition to the standard analyses of Goodwin model, what was newly obtained from our integrated analysis is that money matters to sustain a steady-state equilibrium. It is also shown that a credit crunch by banks breaks down a symmetric business cycle and worsens it to the state of economic recession.

Furthermore, to explore a role of interest in a capitalist monetary economy, the monetary Goodwin model is more comprehensively revised to include interest payments, Under this revised monetary economy with interest, it is shown that perpetual business cycles could collapse into economic recessions so long as the simulation period is extended far enough. In our example, with the interest rate of 2% and a primary rate of 4%, economic recessions are shown to be triggered between the year 40 and 50. Economic recoveries from these recessions can be shown to be attained only when additional cash is put into circulation and interest income by banks are decisively restricted. In this way, money is shown to matter on the formation of business cycles and economic recessions. Moreover, it is shown that banking system with interest may be an obstacle to the economic recoveries.

From this overview chapter, the reader may be convinced why our accounting system dynamics approach is essential to the analysis of economic behaviors and why money matters in our economy. Therefore, it's now time to move to the next trilogy chapters to consider, with accounting system dynamics approach, what money is and where it does come from as well as how interest affects our economy.

Additionally, from this overview chapter, the reader might have realize that Goodwin model assumes a so-called Say's law. Actual output or GDP, however, is determined by the aggregate demand level as Keynesian macroeconomics proposes. To introduce the Keynesian determination of GDP, a Goodwin model has to be drastically revised. This will be challenged in Part III after we visit next trilogy chapters on money.

Questions for Deeper Understanding

1. Desired wage rate w^* in Goodwin model is defined by the equation (4.9). Define "labor-employment ratio elasticity of the desired wage rate, and prove that it becomes e as presented in the equation.

2. Analyze how the ratio elasticity of desired wage rate affects business cycle periods of output, and discuss why.

Chapter 5

Money

This chapter[1] first explores the nature of money with its classification table. It is constructed with front definition of money issuance and back definition of fiat status. As a case research, classification of money in Japan is discussed in detail. Following the classification of money, two different approaches of money creation under a fractional reserve banking system are introduced; that is, flow approach of banks as intermediaries and stock approach of banks as deposit(credit) creators. with their accounting presentations. It is concluded that economists have masqueraded, until recently, as supporters of the flow approach of money creation. Finally, monetary theories discussed so far are simply classified into four theories.

5.1 What is Money?

5.1.1 The World's Oldest Coin Issued as Public Money

What is money? Where does it come from? These are fundamental questions that have been repeatedly raised through human history. Historically speaking, Lydian Lion in Figure 5.1 is said to be the world's oldest coin made of electrum,

Figure 5.1: Lydian Lion (https://rg.ancients.info)

[1]This chapter is based on the paper Yamaguchi (2004b): Money Supply and Creation of Deposits – SD Macroeconomic Modeling (1) – in "Proceedings of the 22nd International Conference of the System Dynamics Society", Oxford, U.K. , July 25-29, 2004, ISBN 0-9745329-1-6. It is further revised for the Edition 3.0 on the basis of the paper Yamaguchi and Yamguchi (2016): The Heads and Tails of Money Creation and its System Design Failures – Toward the Alternative System Design – in "Proceedings of the 34th International Conference of the System Dynamics Society", Delft, the Netherlands, July 17-21, 2016.

an alloy of gold (55%), silver (43%) and copper (2%), in Lydia, Asian Minor (present-day Turkey) around 610-600 BC. The Lydian king, Alyattes, is said to have declared that the only coin with his roaring lion mark must be used for trades. In this sense, as explained below, the world's oldest coin was issued as interest-free public money. The systematic coinage is said to have first developed in the city states of Sardis, Ephesus and Miletus in Lydia in the 7th century BC (Zarlenga, 2002, p.33). This systemic coinage is considered to have developed in the region because it was located at the junction of numerous trade routes and traders needed coins for their trades. And to meet these demand, the Lydians controlled the electrum-rich Paktolos River to produce coins.

Aristotle's Definition of Money

The Lost Science of Money by Zarlenga (2002) is one of the best books on money for authentic economists to explorer these questions.

Across the Aegean Sea to the west of Ephesus and Miletus, is located the Greek city state Athens in which Greek philosopher Aristotle (384-322 BC) used to live around 2 to 3 BC later. He must have observed the trading activities among those city states in the region and explored the nature of money as follows:

In the book, Greek philosopher Aristotle (384-322 BC) is quoted to have articulated money as follows:

> and this is why it has the name *nomisma* - because **it exists not by nature, but by law (*nomos*)** and it is in our power to change it and make it useless (Zarlenga, 2002, p.34).

Following Aristotle, let us begin to define money similarly as *legal tender*. What is *legal tender*, then? Legal tender is money that people cannot refuse to accept in exchange for commodity. In other words, money is *legal tender* that coflows along with commodity inseparably as illustrated in Figure 5.2.

From SD modeling point of view, in order to model coflows of money and commodity, we need at least following three pieces of information on money: money as stock, its unit to define the amount of stock, and its flow amount as a medium of exchange for commodity. Hence, from these modeling requirements we can easily derive three essential functions of money as explained

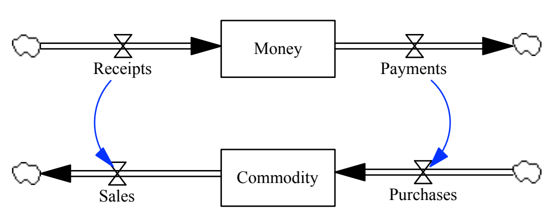


Figure 5.2: Coflow of Money and Commodity

in many standard textbooks[2]:

- Unit of Account (unit of money stock as *information* has to be determined before modeling)
- Medium of Exchange (flow amount of money stock has to be determined to coflow commodity)
- Store of Value (money has to be modeled as the amount of stock)

In short, money has to be declared as legal tender first of all. Whenever it is put into circulation, then, it begins to entail three inevitable functions mentioned above, not *vice versa* at all. It can be easily understood consequently that SD modeling method is essential for the dynamic description of money.

According to the double-entry bookkeeping rule of accounting, commodity transaction with cash as money in Figure 5.2 can be equivalently described in Table 5.1 as follows:

Buyers		Sellers	
Debit (Assets)	Credit (Assets)	Debit (Assets)	Credit (Assets)
Commodity (+)	Cash (-)	Cash (+)	Commodity (-)

Table 5.1: Journal Entries of Transaction with Cash

in which plus sign (+) implies the increase in amount and minus sign (-) its decrease. In this transactions, buyers have to give up their cash assets to increase their commodity assets, while sellers have to give up commodity assets to increase their cash assets. In short, commodity transactions with cash are always booked as increase and decrease of assets simultaneously.

Meanwhile, Adam Smith (1723-1790), known as the father of economics, reversed the above definition of money by Aristotle as follows:

> By the money price of goods it is to be observed, I understand always, *the quantity of pure gold and silver* for which they are sold, without any regard to denomination of the coin (Zarlenga, 2002, p.313).

In this way, Adam Smith reversely defined money as commodity. Advancing his idea more axiomatically, many textbooks currently define money as the entity that meets the above three functions. According to this axiom of money, gold and silver are best qualified as ideal money *by nature*, because their physical nature meets three functional conditions of money perfectly. This reversed

[2]One more important function of money is that it plays as *means of control*. Historically those who lend money have been always in a position to control borrowers as their debt slaves. This means of control is fully analyzed in the recent Japanese book of this author Yamaguchi (2015).

definition of money as commodity has become a root cause of confusion for centuries among mainstream economists as well as ordinary people who are heavily influenced by them. Consequently, we logically refute this definition of money as commodity.

5.1.2 Issuance of Legal Tender

In order to define money as legal tender, there must be specific laws that stipulate the issuance of money legally. Historically such laws hav been established by public (sovereign) authorities such as kings, queens, sovereign states, and modern legislative branches of governments such as Congresses, Parliaments and Diets. In other words, the intended issuers of legal tender had to establish its law first, then issue money by themselves *at interest-free*. Money as legal tender issued in this way by public (sovereign) authorities are called here *public money*.

The issuance of money as legal tender has been exercised in a similar fashion even today. For instance, in Japan "Currency Unit and Money Issuance Act (revised in 1987)" enables the government to issue coins (called money) by a unit of yen (¥); that is, 1, 5, 10, 50, 100 and 500 yen coins. On the other hand, "Bank of Japan Act (revised in 1997)" enables the Bank of Japan, a privately owned central bank[3] with 55% ownership of the government, to issue "Bank of Japan Note" with denominations of 1000, 2000, 5000 and 10000 yen notes.

In the Constitution of of the United States of America, the issuance (coinage) of money is clearly stipulated in Article 1 as follows:

> Section 8. The Congress shall have power to lay and collect taxes, duties, imposts and excises, $\cdots$;
>
> To coin money, regulate the value thereof, and of foreign coin, and fix the standard of weights and measures;

The reader is, therefore, advised to examine his or her nation's monetary laws that stipulate money as legal tender.

At a closer look at these current laws of legal tender, the reader may find that the main issuers of legal tender have been separated from historical public (sovereign) authorities since modern banking system emerged in the 18th and 19th centuries. To speak more straightforwardly, the powers of issuing legal tender by public (sovereign) authorities have been replaced with global bankers. In this way, legal tender has been nowadays issued mostly by private issuers such as privately owned central bank and commercial banks *at interest*. Such type of money is called *debt money* (including functional-money to be discussed below).

[3]The expression "a privately owned" here means that the shares of Bank of Japan are owned by private individuals and institutions and freely traded in the stock market. Yet, there is no annual shareholders' meeting held in by the Bank of Japan. National Bank of Belgium, on the other hand, holds annual shareholders' meeting and its shares are traded in the stock market. For a brief comparative survey on differences of central bank ownership around the world, see Rossouw (2014).

5.1.3 Classification of Money

Considering these transitions of issuers of money, our definition of money needs to reflect two monetary faces in terms of its issuance and fiat status. Front face of money is defined according to the issuance of money: public money issued by public (sovereign) authorities at interest-free, or debt money issued by banks at interest. Back face of money is defined according to the fiat status of money: money is issued as legal tender or functional-money. First and second rows of Table 5.2 illustrate our definition of money by its front and back faces.

Classification of Money

Front: Issuance	Public Money	Debt Money (at interest)	
Back: Fiat Status	Money as Legal Tender		Functional-Money
Non-metal Commodities	Shell, Cloth (Silk) Woods, Stones, etc		
Metal Coinage	Non-precious Metal Coins Gold, Silver & Copper Coins		Metal Ingots (such as Gold)
Paper Notes	Public Money Notes by PM Admin.	Goldsmith Certificates Central Bank Notes	
Digital Accounts & Cards	Public Money Deposits	Central Bank Reserves	Bank Deposits (Credits by Loans)
Digital Tokens (Blockchain etc.)	(since 2008)	To be covered in Part VI	(Bitcoin, etc.)

Table 5.2: Public Money vs Debt Money

Money functions, at its abstract level, as a unit of account or a piece of information, as discussed above, so that it needs a medium to carry its information value. Accordingly, 3rd row through 7th row of our classification table indicate various media of monetary values. Historically, media of information value took a form of commodities such as shell, silk (cloth) and stones; of precious metals such as gold, silver and copper coins; of papers such as Goldsmith certificates and (central) banknotes. In short, information values as money have been inseparable from their media, and any form of media that performs three features of money as legal tender, as discussed above, has been accepted as money that has a purchasing power.

Tangible media currently in use are coinage and banknotes. Coins are minted by the government as subsidiary currency. Hence, they are public money by definition. On the other hand, banknotes are issued by central banks that are independent of the government and privately owned in many countries. For instance, Federal Reserve System, the central bank of the United States, is 100% privately owned (Griffin, 2006) and Bank of Japan is 45% privately owned. Banknotes are loaned out to banks at interest. Hence, they are debt money by definition. Meanwhile, metal ingots such as gold ingots have historically functioned as money to pay for international imbalances of trades, etc. Hence, they are additionally classified under functional-money in parenthesis.

Intangible media of information values as money have been separated, under the information technology, from physical media such as metal and paper, and nowadays made available as electronic money (intangible digits) kept in digital cards and digital accounts. Most important example of digital accounts are bank deposits which are classified under functional-money (as explained below). Furthermore, recent blockchain technology enables us to send electronic money peer-to-peer directly, faster and safely at lower cost without banks as intermediaries[4]. Our classification of money is now completed as in Table 5.2.

5.1.4 Base Money as Legal Tender

Let us now examine the component of legal tender more in detail. In Japan *currency*, or cash, consisting of the Government *coins* and Bank of Japan *notes*, is specifically defined by law as legal tender in a sense that it cannot be refused to accept as a means of payment; that is why it is alternatively called *fiat money*. Figure 5.3 illustrates the state of currency (coins and banknotes) as legal tender.

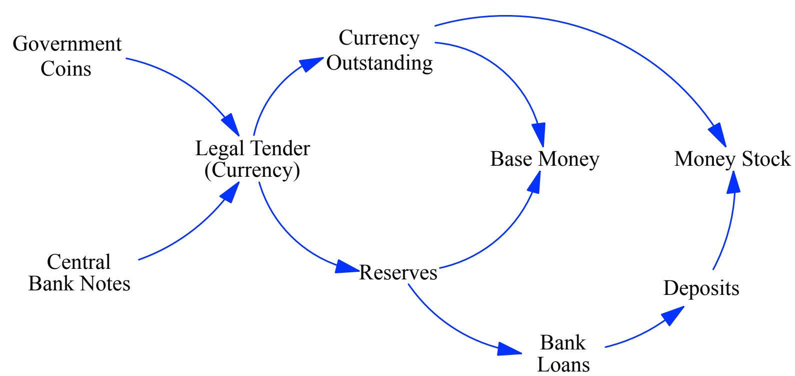


Figure 5.3: Base Money as Legal Tender

Once currency as legal tender is being put into circulation under the current fractional reserve banking system, it begins to be split into two parts: currency outstanding and reserves with the central bank, as explained below. The sum

[4]Bitcoin, originally proposed by Satoshi Nakamoto with blockchain technology in 2008, is one such example, though it's not claimed as *legal tender*. Accordingly, it should be classified under functional-money, similar to metal ingots such as gold. Money of the futures under blockchain technology will be covered, as one of the most important subjects, in Chapter 18 of Part VI: Electronic Public Money.

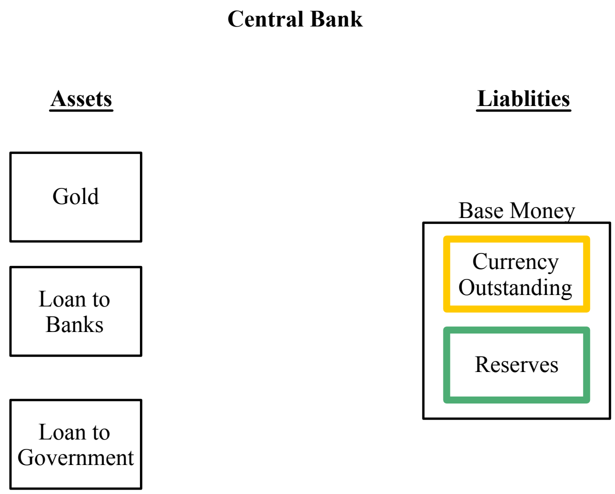


Figure 5.4: Issuance of Base Money Backed by Various Types of Assets

of these parts are called *base money*[5]: that is,

$$\text{Base Money} = \text{Currency Outstanding} + \text{Reserves} \tag{5.1}$$

Hence, base money is by definition the only legal tender as illustrated in Figure 5.3.

Although central bank is legally allowed to issue base money, it can issue base money only when someone comes to borrow at interest. Those who come to borrow from the central bank are mainly commercial banks and government. Accordingly, the practice of issuing base money has to be backed by various asset purchases such as gold, loans to banks and loans to government, as illustrated in Figure 5.4, according to the double-entry accounting rule. Base money is booked as liabilities in the balance sheet of the central bank, and backed by various types of assets such as gold, discount loans to commercial banks and loans to the government (securities).

5.1.5 Bank Deposits as Functional-Money

So far banks deposits are not discussed under the classification of money. Are they money? Under the current debt money system of fractional reserve banking, banks can create deposits out of nothing by granting loans to non-banking

[5]Base money is alternatively named *monetary base* in the following chapters of this book, and they are interchangeably used. In the older version of the book, *monetary base* is used, while in this new version, *base money* is used wherever contents are updated. This is because "monetary base" gives us a misleading impression that bank deposits, being created out of monetary base as explained below, constitute the expanded base of currency as legal tender. Base money is, on the contrary, the only *legal money*.

sectors such as producers, consumers and government, to be explained below. Figure 5.5 illustrates that bank deposits thus created are used for transactions

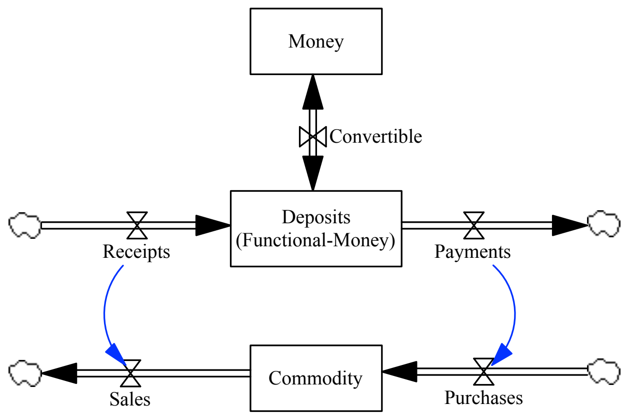


Figure 5.5: Deposits as Functional-Money

as if they are money.

This transaction is booked by the double-entry accounting rule as in Table 5.3. Hence all transactions are booked under the assets of balance sheet as in Table 5.1. Does this imply that deposits, created out of nothing through loans, become legal tender, similar to cash, such that no one can refuse to accept? According to Masaaki Shirakawa, former governor of the Bank of Japan, the

Buyers		Sellers	
Debit (Assets)	Credit (Assets)	Debit (Assets)	Credit (Assets)
Commodity (+)	Deposits (-)	Deposits (+)	Commodity (-)

Table 5.3: Journal Entries of Transaction with Deposits

answer is negative.

> Contrary to the central banknotes, creditors can refuse to accept bank deposits as the payments of debt obligations because of credit risks associated with bankruptcies of debtors' banks. However, in normal times, bank deposits **function as money** because of creditors' confidence that bank deposits can be converted to central banknotes (Shirakawa, 2008, p.13) .

What is meant here is that deposits are accepted for commodity transaction in Figure 5.5 only when their convertibility assumption with money is presumed by their recipients. In this sense, they are not legal tender. Henceforth, deposits are in this book regarded as f*unctional-money*, and the misleading naming of "credit creation" that has been used in standard textbooks is interchangeably replaced with "functional-money creation".

Assuming that *deposits function as money*, standard textbooks define another concept of *monetary aggregate* in addition to *money* as

$$\text{Money Stock} = \text{Currency in Circulation} + \text{Deposits} \tag{5.2}$$

Money stock[6] thus defined is the expanded amount of money available in the economy as medium of exchange, regulating transactions and economic activities.

Though this concept of money stock is theoretically rigorous to capture the expanded amount of money available in the economy, it is hard to calculate it statistically in practice. Accordingly, money stock is practically obtained more easily according to the monetary data available at the central bank and commercial banks by the following formula:

$$\text{Money Stock (Data)} = \text{Currency Outstanding} + \text{Deposits} \tag{5.3}$$

This relation is illustrated in the above Figure 5.3. The difference of these two definitions is "vault cash" held by commercial banks such that

$$\text{Currency Outstanding} = \text{Currency in Circulation} + \text{Vault Cash (Banks)} \tag{5.4}$$

Money stock thus defined begin to play a role as money as if it is legal tender under the assumption of its convertibility with money.

5.1.6 Debt Money vs Public Money System

Debt money system is defined as a system in which money is issued by private central bank at interest, and deposits are created out of nothing by commercial banks and function as money at interest. In this system money is only created when government and commercial banks come to borrow from the central bank, and producers and consumers come to borrow from commercial banks in the form of bank deposits (called functional-money). To distinguish this type of money from *public money*, it is called *debt money* or *money as debt* here.

Current macroeconomies are being run under this type of debt money. Hence, our economic system is *a debt money system* as illustrated in Figure 5.6. Almost all of macroeconomic textbooks in use such as Hall and Taylor (1997), Mankiw (2016), Mishkin (2006), McConnell and Bruce (2008) justify the current macroeconomic system of debt money, as if it is the only system, without mentioning the alternative system of public money.

[6]Money stock is alternatively named *money supply*, and they are interchangeably used in this book.

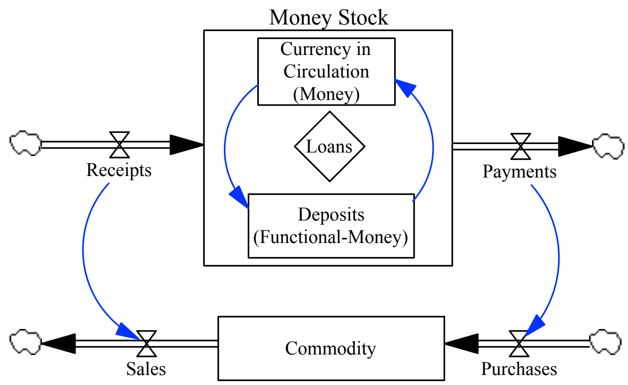


Figure 5.6: Debt Money System

Accordingly, it is essential to understand the workings of the current debt money system in detail as most economists do so. In this book, Parts II, III and IV are wholly devoted to the study of macroeconomic systems of *debt money*. Money thus used in these parts should be understood as debt money from now on without specifically mentioning it. Workings of a macroeconomic system of public money will be fully investigated in Part V as an alternative system to the current macroeconomic system of debt money.

5.2 Classification of Money in Japan

5.2.1 Money Stocks in 2018

So far we have introduced basic concepts of money such as base money and various types of money stock. In actual monetary analysis, money stocks have to be further classified according to the nature of bank deposits. Following the definition of the Bank of Japan,[7] we have further defined money stocks, whenever appropriate in this book, as follows (Yamaguchi and Yamaguchi, 2019).

M_0 consists of Government Coins (Public Money), Banknotes and Bank Rserves at the Central Bank. This type of money is simultaneously regarded as *legal tender* in the sense that no one cannot reject its receipts. It is called *base money* or monetary base.

[7] The Bank of Japan defines various concepts of the amount of money as follows.
M_0 = Base Money
M_1 = Currency Outstanding + Demand Deposits
M_2 = M_1 + Quasi-money + CD (Certificate of Deposit)
(Quasi-money = Time Deposits + Foreign Exchange Deposits,
excluding the Japan Post Bank, Japan Agricultural Cooperatives, etc.)
M_3 = M_1 + Quasi-money + CD (Certificate of Deposit)

M_1 consists of Government Coins, Banknotes and Demand Deposits that can be used daily as means of payments or transactions. Demand deposits are created out of nothing by depositing a fraction of total demands as *reserves* at the central bank. Thus, a fractional reserve banking system is institutionalized under the current debt money system.

M_f is newly defined as $M_1 - M_0$, or more simply as demand deposits less reserves, which is created out of nothing by bank loans and only *functions as money* for payments during a normal period of economic activities. In case of *bank runs* this amount of deposits fails to be withdrawn because of the non-availability of its corresponding base money. Thus, the reader may cynically regard this type of deposits as *ficticious* or *fake money*[8].

M_T is the amount of demand deposits that leaked out of circulation. It is equivalent of *time deposits*, which yields higher interest but with a fixed period of time at the cost of liquidity.

M_3 consists of M_1 and M_T and constitutes the whole amount of money available in the economy. In many countries this amount of money stock is called M_2. In Japan, deposits of Postal Savings used to be excluded from the amount of M_2. Hence, the total amount of deposits including Postal Savings needs to be additionally defined as M_3.

These money stocks are summarized in equations as follows:

$$M_0 = \text{Government Coins} + \text{Banknotes} + \text{Reserves (Legal Tender)} \quad (5.5)$$

$$\begin{aligned} M_1 &= \text{Government Coins} + \text{Banknotes} + \text{Demand Deposits} \\ &= \text{Government Coins} + \text{Banknotes} + \text{Reserves} + \text{Functional Money} \\ &= M_0 \text{ (Base Money)} + M_f \text{ (Functional Money)} \end{aligned} \quad (5.6)$$

$$\begin{aligned} M_3 &= M_1 + M_T\text{(Time Deposits)} \\ &= M_0 + M_f + M_T. \end{aligned} \quad (5.7)$$

Table 5.4 indicates the amount of Japanese money stocks and their decomposition values in the year 2018. Note that public money of government coins is negligible amount of 0.6% of money stock M_1, and 0.3% of money stock M_3. Yet, public money has survived in Japan !

Table 5.5 illustrates our most comprehensive definition of money stocks in Japan. Various types of money stocks defined above are sandwiched between front face and back face of our money definitions. This table provides the astonishing fact that 99.7% of money stock in Japan are debt money, while only 35.5% of money stock are legal tender. Historically, before the establishment of

[8]When functional-money is more comprehensively defined as money stock that is not backed up by M_0 (denoted here by $\bar{M}_f$), we have, for the money stock M_3, $\bar{M}_f \equiv M_3 - M_0 = M_f + M_T$. Thus, M_T (Time Deposits) must be interpreted as a part of functional-money in the expanded sense as illustrated in Table 5.5. This makes sense, because in a case of bank runs, both M_f and M_T may not be thoroughly withdrawn by depositors.

Money Stock	Trillion Yen	(% of M_1)	(% of M_3)
Coins (Public Money)	4.8	0.6	0.3
Banknotes	107.6	12.9	7.6
Reserves	393.9	47.4	27.6
Base Money M_0	506.3	60.9	35.5
Functional Money M_f	324.9	39.1	22.8
Money Stock M_1	831.2	100.0	58.3
Time Deposits M_T	594.5		41.7
Money Stock M_3	1,425.8		100.0

Table 5.4: Money Stock & its Composition in Japan (2018)

Classification of Money Stock in Japan (trillion yen as of 2018)

<table>
<tr><td>Money (Front)
(Issuance)</td><td>Public Money
4.8</td><td colspan="4">Debt Money (at interest) (99.7%)
1,420.9 (Total Sum of Firms, Households and Government)</td></tr>
<tr><td>Money Stock
(Classified)</td><td>Coins
4.8</td><td>Banknotes
107.6</td><td>Reserves
393.9</td><td>Functional-Money (M_f)
324.9</td><td></td></tr>
<tr><td>Base Money (M_0)</td><td colspan="3">506.3</td><td colspan="2"></td></tr>
<tr><td>Money Stock
(Classified)</td><td colspan="2">Currency (Cash)
112.4</td><td colspan="2">Demand Deposits
718.8</td><td>Time Deposits(M_T)
594.5</td></tr>
<tr><td>Money Stock (M_1)</td><td colspan="4">831.2</td><td></td></tr>
<tr><td>Money Stock (M_3)</td><td colspan="5">1,425.7</td></tr>
<tr><td>Money (Back)
(Fiat Status)</td><td colspan="3">Legal Tender (35.5%)
506.3</td><td colspan="2">Expanded Functional-Money ($\underline{M_f}$) (64.5%)
919.4</td></tr>
</table>

Table 5.5: Classification of Money (Front & Back)

the Bank of Japan in 1882, money stocks in Japan have been 100% public money and 100% legal tender. In this sense, Japanese monetary system today is heavily dominated by the debt money system.

5.2.2 Money Stocks between 1980 and 2018

Let us now observe how money stocks of 2018 obtained in Tables 5.4 and 5.5 have behaved overtime. Figure 5.7 illustrates behaviors of money stocks between 1980 and 2018.[9] Government Coins is denoted by line 1, Banknotes by line 2, Reserves by line 3, Base Money M_0 by line 4, Functional Money M_f by line 5, and Money Stock M_1 by line 6, respectively.

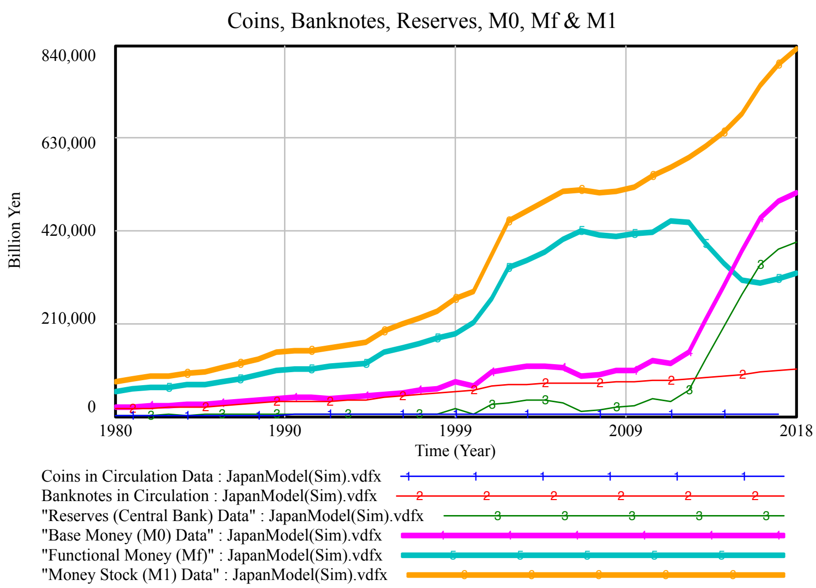


Figure 5.7: $M_0 + M_f = M_1$ in Japan (1980 - 2018)

Figure 5.8 further illustrates behaviors of all money stocks between 1980 and 2018. Base Money M_0 is shown by line 4, Functional Money M_f by line 5, and Money Stock M_1 by line 6; up to these lines, line numbers are the same as in Figure 5.7. Then, Time Deposits M_T is added by line 2, and Money Stock M_3 by line 1, respectively.

Yet, it is essential to understand that interest-free government coins (called here *public money*) manage to survive even under the system of debt money at

[9]Time-series data for this case study in Japan are taken from the Flow of Funds Account (FFA) statistics by the Bank of Japan: http://www.boj.or.jp/en/statistics/sj/index.htm. FFA data are provided in a matrix format consisting of 51 rows (transactions items) and 45 columns (sectors); that is, 2,295 cells for a single year. In order to systematically handle such large set of FFA data, we have built a model for this case study with system dynamics modeling software called Vensim that imports all stock and flow data since 1980.

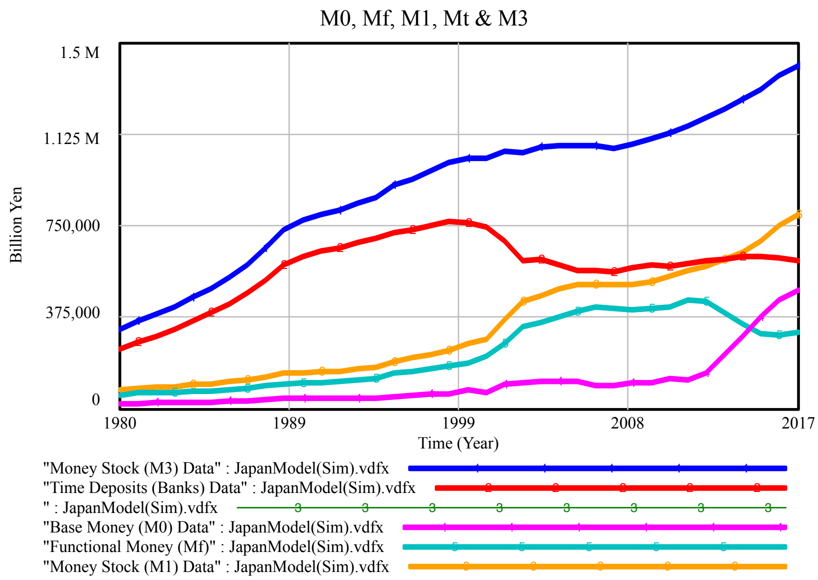


Figure 5.8: $M_0 + M_f = M_1$ and $M_1 + M_T = M_3$ in Japan

interest! Functional money that cannot be converted to legal tender in a time of *bank runs* is close to 40% of M_1 in 2018. In other words, this is the amount of money created out of nothing, which endogenously increases or decreases, depending on our economic activities, causing booms and bust.

To stabilize the economy, M_f needs to be eliminated; that is $M_f = 0$, so that banks cannot create money out of nothing. This was the original idea of monetary reform called t*he Chicago Plan*. This subject will be discussed in Part V: Macroeconomic Systems of Public Money.

5.3 Flow Approach of Functional-Money Creation

5.3.1 Three Sectors and Twofold Double Entry Rule

Under the debt money system, deposits are introduced as a part of money stock in addition to base money. As discussed above, deposits are not money as legal tender, but function as money; that is, functional-money. Where do deposits come from, then, and how are they created?

For the analysis of money stock and deposits creation, it is sufficient to reorganize six macroeconomic sectors illustrated in Figure 4.1 in the previous chapter into three sectors: the central bank, commercial banks and non-financial sector (consisting of producers, consumers, and government). Foreign sector is excluded in this analysis. Figure 5.9 shows the reorganized three sectors among which deposits is being created.

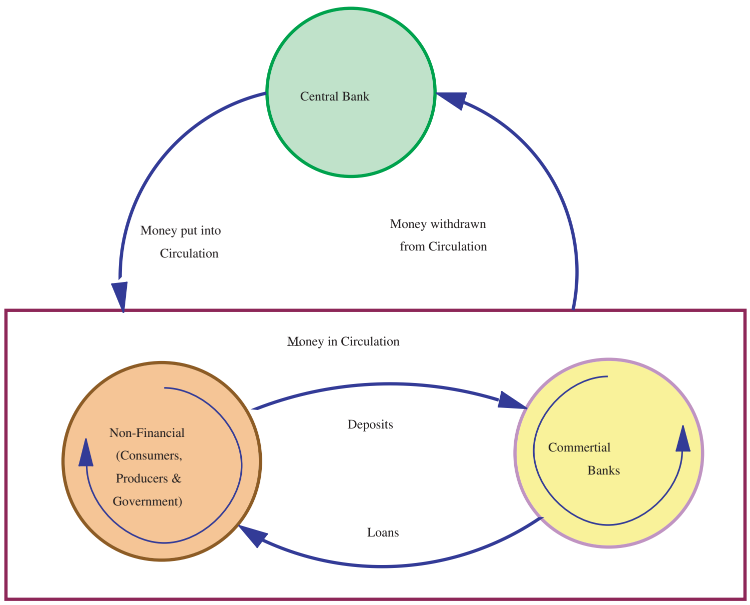


Figure 5.9: Three Sectors for Money Stock

This does not imply, however, that three sectors are always required for understanding a process of functional-money creation. Historically, there was a time when central bank did not exist, yet functional-money has been created for economic activities. This suggests that for designing a new monetary system for sustainable macroeconomies, the central bank needs not be necessarily required. The reason why the central bank is included in our modeling here is to reflect the currently existing macroeconomic sectors in our model. Yet, it does not justify its existence for sustainable macroeconomy. We will fully explore the issue in Part V.

How can we describe economic transactions and circulation of money among three sectors? The method we employ here is based on the accounting system dynamics in which balance sheet plays a key role. Balance sheet is an accounting method of keeping records of all transactions in both credit and debit sides so that they are kept in balance all the time as follows:

$$\text{Assets} = \text{Liabilities} + \text{Equity} \tag{5.8}$$

As already discussed as the Principle 5 in Chapter 3, a modeling method of corporate balance sheet is based on the double entry rule of bookkeeping. In system dynamics modeling, this principle is compactly illustrated as Figure 3.5.

Hence, all transactions of the central bank, commercial banks and non-financial sector are modeled respectively as inflows and outflows of money in their balance sheets. Moreover, macroeconomic transactions of money among three sectors not only influence their own balance sheets, but also other's balance sheets simultaneously. For instance, whenever a commercial bank makes loan to a producer, it affects the balance sheets of both the bank and the producer, simultaneously. In other words, one transaction in macroeconomy activates twofold double entries of bookkeeping among two sectors. In this sense, macroeconomic transactions can be said to be governed by *a twofold double entry rule*. This makes our modeling a little bit more complicated compared with the case of corporate balance sheet in which we only need to focus on the balance of credit and debit sides of a specific company.

5.3.2 A *Fractional Reserve* Banking: Flow Approach

Under the current debt money system of modern capitalist market economy, currencies consisting of government coins and central banknotes are in circulation. Whenever they are newly created, they are booked as currency outstanding under liabilities in the balance sheet of central bank[10]. To balance the account, the central bank needs to back them with corresponding assets. In this chapter, we consider three major assets such as gold, discount loans to banks and loans to government (purchase of securities) as illustrated in Figure 5.4.

This amount of currency outstanding becomes base money, out of which currencies begin to circulate among macroeconomic sectors. Once currency outstanding is put into circulation, they begin to be used for transaction payments. If more than enough currencies are in circulation, they will be deposited with commercial banks, out of which a fraction is further deposited with the central bank as reserves. Money in this way begins to be used as currency in circulation and deposits.

To model this circulation of currency by system dynamics method, two approaches turn out to be equally feasible; that is, flow approach of banks as intermediaries and stock approach of banks as deposit(credit) creators. Let us start with the flow approach first. According to this approach, commercial banks are assumed to run their banking business by accepting savings (deposits) from depositors and making loans to investors out of the deposits. Hence, banks are ostensibly regarded as being mere intermediaries just like other financial institutions and nothing more.

When commercial banks receive deposits, they are obliged to keep the deposits at a safe place to meet the request of depositors for withdrawal in the future. However, through such banking practices they gradually realized that only a portion of deposits were to be withdrawn. Accordingly, they started to make loans out of deposits at interest, so that they can earn extra income of interest. In this way, once-prohibited usury became a dominating practice, and modern banking practices have begun.

[10]To be precise, government coins are not liabilities of the central bank. Yet, in practice, the Bank of Japan, for instance, integrates them as a part of its currency outstanding as monetary data due to the small amount of their values.

To meet insufficiency of deposits against a sudden withdrawal, private banks secretly formed a cartel. One such example is the Federal Reserve System in the United States that was created in 1913. Fascinating story about its birth was described in Griffin (2006). Though it is a privately owned bank, it pretends to be the public central bank.

Once central banks are established in many capitalist economies, they begin to request a portion of deposits from commercial banks to protect liquidity shortage among banks. Specifically, commercial banks are required by law to open an account with the central bank and keep some portion of their deposits in it in order to meet unpredictable withdrawal by depositors. These deposits of commercial banks at the central bank are called required reserves. Now commercial banks can freely make loans out of their deposits (less required reserves) without any risk. This modern banking system is called a *fractional reserve* banking system.

Let us explain this banking practice as intermediaries by illustrating conceptual Figure 5.10. The itemized numbers below are the same as those in the Figure.

(1) First, banks collect deposits from the non-banking public sector consisting of households, producers and non-banking financial institutions in our model. Under the current fractional reserve banking system, a portion of deposits thus collected is required to be reserved with the central bank to avoid risks of cash deficiencies, according to a required reserve ratio[11] such that

$$\text{Required Reserve Ratio } (\beta) = \frac{\text{Required Reserves}}{\text{Deposits}} \tag{5.10}$$

(2) Then, the remaining amount of deposits are loaned out to borrowers.

(3) Now borrowers receive cash as assets.

(4) Since the public as a whole needs not to hold all the amount of cash at hand as liquidity[12], a portion of cash is deposited with banks according to a currency ratio(α) such that

$$\text{Currency Ratio } (\alpha) = \frac{\text{Currency in Circulation}}{\text{Deposits}} \tag{5.11}$$

In other words, one dollar put into circulation is further divided between currency in circulation and deposits according to the following proportion:

[11] Whenever appropriate, a reserve ratio is further broken down as follows:

$$\begin{aligned}\text{Reserve Ratio } (\beta) &= \frac{\text{Required Reserves}}{\text{Deposits}} + \frac{\text{Excess Reserves}}{\text{Deposits}} \\ &= \beta_r + \beta_e. \end{aligned} \tag{5.9}$$

[12] Among the non-banking public sector, producers and financial institutions tend to borrow for real and financial investment, while households tend to save out of their income revenues.

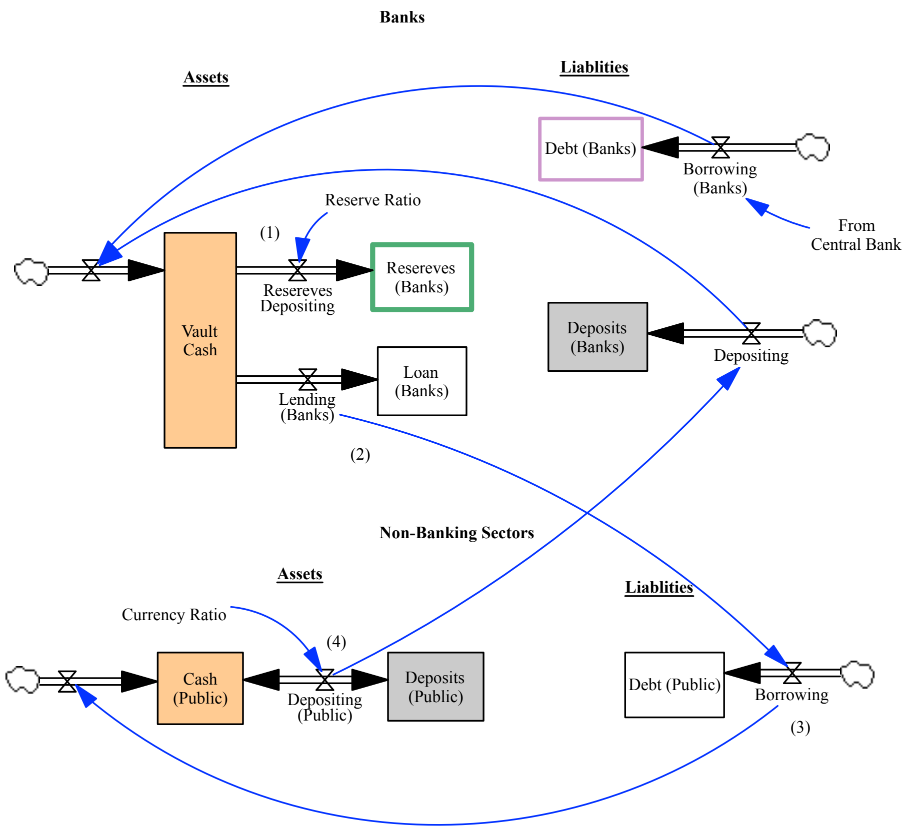


Figure 5.10: Flow Approach of Money Creation

$$1 \Rightarrow \begin{cases} \frac{\alpha}{\alpha+1} & : \text{Currency in Circulation} \\ \frac{1}{\alpha+1} & : \text{Deposits with Banks} \end{cases} \tag{5.12}$$

Let us now consider how one dollar put into circulation keeps being used for transactions. From the equation (5.12), $1/(\alpha+1)$ dollars are first deposited, out of which commercial banks are allowed to make maximum loans of $(1-\beta)/(\alpha+1)$ dollars. This amount will be put into circulation again as a loan to the non-banking public sector. In a capitalist market economy, producers in the non-banking public sector is always in a state of liquidity deficiency. In this way, one dollar put into circulation keeps being loaned out repeatedly for transactions. The accumulated total sum of money stock put into circulation through bank loans is calculated as follows;

Accumulated money stock put into circulation through bank loans

$$= 1 + \frac{1-\beta}{\alpha+1} + \left(\frac{1-\beta}{\alpha+1}\right)^2 + \left(\frac{1-\beta}{\alpha+1}\right)^3 + \cdots$$
$$= \frac{1}{1-\frac{1-\beta}{\alpha+1}}$$
$$= \frac{\alpha+1}{\alpha+\beta} \tag{5.13}$$

This is a process of creating money in circulation *out of nothing* by commercial banks, in which one dollar put into circulation is increased by its multiple amount. It is called money multiplier (m); that is,

$$\text{Money Multiplier } (m) = \frac{\alpha+1}{\alpha+\beta} (= \frac{\alpha+1}{\alpha+\beta_r+\beta_e}) \tag{5.14}$$

Since $1 \geq \beta \geq 0$, we have

$$1 + \frac{1}{\alpha} \geq m \geq 1 \tag{5.15}$$

Hence, money multiplier can be easily calculated if currency ratio and required reserve ratio as well as excess reserve ratio are given in a macroeconomy. Three sectors in Figure 5.9 play a role of determining these ratios. Depositors in the non-financial sector (consumers & producers) determine the currency ratio: how much money to keep at hand as cash and how much to deposit. Central bank sets a level of required reserve ratio as a part of its monetary policies, while commercial banks decide excess reserve ratio: how much extra reserves to hold against the need for deposit withdrawals.

In this way, an additional dollar put into circulation will eventually create its multiple amount of money stock, which is being used as currency in circulation and deposits with banks as follows:

$$1 \Rightarrow \begin{cases} \frac{\alpha}{\alpha+1}\frac{\alpha+1}{\alpha+\beta} = \frac{\alpha}{\alpha+\beta} & : \text{Currency in Circulation} \\ \frac{1}{\alpha+1}\frac{\alpha+1}{\alpha+\beta} = \frac{1}{\alpha+\beta} & : \text{Deposits with Banks} \end{cases} \tag{5.16}$$

In a real economy, then, how much real currency or cash is actually being put into circulation? It is the sum of currency in current circulation and reserves that commercial banks withhold at the central bank. This sum indeed constitutes a real part of money stock issued by the central bank through which creation of deposits and money stock are made as shown above. In this sense, the sum is occasionally called high-powered money; that is,

$$\text{High-Powered Money} = \text{Currency in Circulation} + \text{Reserves} \tag{5.17}$$

To interpret the amount of money stock created by high-powered money, let us calculate a ratio between money stock and high-powered money as follows:

$$\begin{aligned}
&\frac{\text{Money Stock}}{\text{High-Powered Money}} \\
&= \frac{\text{Currency in Circulation} + \text{Deposits}}{\text{Currency in Circulation} + \text{Reserves}} \\
&= \frac{\text{Currency in Circulation/Deposits} + 1}{\text{Currency in Circulation/Deposits} + \text{Reserves/Deposits}} \\
&= \frac{\alpha + 1}{\alpha + \beta} \qquad (5.18)
\end{aligned}$$

This ratio becomes exactly the same as money multiplier obtained in equation (5.14). Thus, money stock can be uniformly expressed as[13]

$$\text{Money Stock} = m * \text{High-Powered Money} \qquad (5.19)$$

In the above definitions, currency in circulation appears both in money stock and high-powered money. However, it is hard to calculate it in a real economy and in practice it is approximated by the amount of currency outstanding which is recorded in the balance sheet of the central bank. Accordingly, high-powered money is also approximated by the sum of currency outstanding and reserves, which is defined as base money in equation (5.1).

Base money is the amount of currency that the central bank can control. And most macroeconomic textbooks treat high-powered money equivalently as monetary base (base money). For instance, a well-established textbook says: "This is why the monetary base is also called high-powered money" (Mishkin, 2006, p. 394). However, our SD modeling below strictly requires them to be treated differently.

If high-powered money is approximated by the base money, money stock could also be estimated similar to the equation (5.19) and it is called here money stock (base).

$$\text{Money Stock (Base)} = m * \text{Base Money} \qquad (5.20)$$

It could be used as a reference amount of money stock with which true money stock is compared (or to which true money stock converges, as it turns out below).

In a real economy, however, money stock is calculated from the existing data as follows:

$$\text{Money Stock (Data)} = \text{Currency Outstanding} + \text{Deposits} \qquad (5.21)$$

[13] When money multiplier is calculated as the equation (5.14) and applied to the equation (5.19) to obtain money stock, it turns out that money suddenly jumps from the money stock defined in (5.2) as the currency ratio and reserve ratio are changed during a simulation. To avoid this problem, currency and reserve ratios need be constantly recalculated during the simulation. In the money creation model below, they are obtained as "actual currency and reserve ratios".

It is called money stock (data) here to distinguish it from the money stocks previously defined in equations (5.2) (or 5.19) and (5.20).

In this way, we have now obtained three different expressions of money stock such as the equations (5.19), (5.20), and (5.21). It is one of the purposes of this chapter to investigate how these three expressions of money stock behave one another under flow and stock approaches. By calculating actual currency ratio and reserve ratio at each time step in our model money stock can be dynamically obtained, as illustrated in Figure 5.11. This is the definition diagram of money stocks used from now on in our money creation models of both flow and stock approaches.

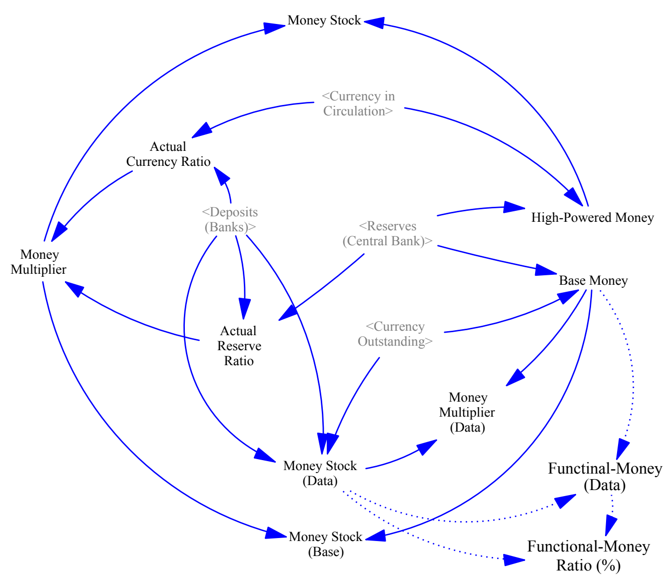


Figure 5.11: Money Stock Definitions for Flow and Stock Approaches

5.3.3 Money Convertibility Coefficient

Money stock thus calculated includes deposits as functional-money. To calculate a portion of legal tender out of money stock in circulation, equation (5.19) can be rewritten as

$$\text{High-Powered Money (as legal tender)} = mc * \text{Money Stock} \tag{5.22}$$

in which mc is defined as *money convertibility* coefficient. The coefficient thus defined is obviously a reciprocal of money multiplier m.

Under the default assumption of coefficient values in our model below; that is, $\alpha = 0.2$ and $\beta = 0.1$, money multiplier becomes $m = \frac{0.2+1}{0.2+0.1} = 4$, and money convertibility coefficient becomes $mc = 0.25$[14]. That is to say, only 25% of money stock (as *functional-money*) could be convertible to *genuine money* as legal tender. This implies that under the fractional reserve banking in our model, for instance, only 25% of money stock in circulation for transactions could be convertible to legal tender, and the remaining 75% of money stock are functional-money (deposits) created by banks out of nothing. This amount is defined as Functional-Money Ratio (%) in Figure 5.11.

Money Multiplier and Convertibility Coefficient: Cases in Japan

With the introduction of money multiplier and money convertibility, it is worthwhile to examine how these values actually have taken place in Japan. As the left-hand diagram of Figure 5.12 indicates, money multiplier in Japan, which is obtained by m $= M_1/M_0$, has been stable between 3 and 4 from 1980 through 1999, and begun to increase to 5.6 in 2006 due to the introduction of QE policy between 2001 and 2006. Then, it has begun to decline to 1.6 in 2018 due to the failure of the second QE policies introduced in 2013. On the other hand, money convertibility coefficient in Japan, which is obtained by mc $= M_0/M_1$, has been less than 3% from 1980 till 2012, then, begun to increase due the QE policies as shown in the right-hand diagram. In 2018 it became 60%. This implies Japanese depositors can convert 60% of their deposits to genuine money as legal tender in case of bank-runs. Yet, 40% of their deposits must be abandoned in case of bankruptcies of banks. Indeed we are forced to live in a fragile economic edifice constructed on shaky deserts.

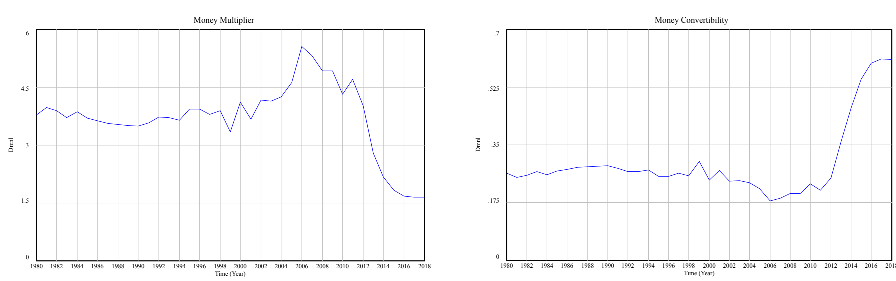


Figure 5.12: Money Multiplier and Convertibility Coefficient in Japan

[14]When $\beta = 1$ (100% reserve) under the public money system to be discussed in Part IV, we have $m = mc = 1$ so that the entire amount of money stock in circulation becomes legal tender.

5.3.4 Accounting Presentation of Flow Approach

Banks playing in practice as intermediaries are now described according to the double-entry bookkeeping rule. In the flow approach, bank loans do not seem to create deposits, simply because they are assumed to make loans out of cash assets in the model as shown in top left balance sheet of Banks in Table 5.6. In other words, banks increase their loan assets to gain interest revenues by

Banks		Non-Banking Public Sector	
Debit (Assets)	Credit (Assets)	Debit (Assets)	Credit (Liabilities)
Loan (+)	Cash (-)	Cash (+)	Debt (+)
Debit (Assets)	Credit (Liabilities)	Debit (Assets)	Credit (Assets)
Cash (+)	Deposits (+)	Commodity (+)	Cash (-)

Table 5.6: Journal Entries of Flow Approach in (2) and (3)

giving up their own cash assets. This transaction seems fair and reasonable as a profit-seeking management out of their cash assets.

Where does that cash come from, then? Surely it is tied with deposits as shown in the bottom left balance sheet of Banks. When cash accounts are cancelled out in this balance sheet, bank loan (debit of assets) can be said to be balanced by deposits (credit of liabilities)[15]. Under the situation, can the banks, then, make loans out of these deposits at their disposal? If deposits are time deposits entrusted with banks by savers for better financial management, then the answer is surely "Yes, they can". But if deposits are demand deposits for transactional purposes, then the answer should be "No, they cannot", because banks are obliged to hold them anytime to meet withdrawal requests from depositors.

Accordingly, it becomes fraudulent to make loans out of demand deposits. Yet, Irving Fisher once pointed out:

> When money is deposited in a checking account (i.e. demand deposits), the depositor still thinks of the money as his, though *legally it is the bank's* (italicized by the author). (Fisher, 1945, p.12).

Hence, deposits are legally owned by banks and they can make loans out of depositors' money[16]. In this way, fraudulent-looking loans out of depositors' money have been made legitimate under the fractional reserve banking system.

[15] Whenever transactions are traced back in this way, balance sheet of flow approach becomes structurally the same as that of stock approach as shown in Table 5.8 below. In the flow approach, loans are made out of deposits (Deposits→Loan), while in the stock approach, deposits are made out of loans (Loan→Deposits).

[16] In Japan this practice is guaranteed by Article 590, Civil Code.

Hence, in the flow approach deposits (credit) creation process out of nothing is masqueraded behind the double-entry bookkeeping practice of making loans out of cash. That is why this flow approach of banking practice has been deliberately supported so that many economists as well as ordinary people have been enticed to believe that banks are not creating money out of nothing, but merely intermediating money between lenders and borrowers (this point will be discussed more in detail below).

When cash keeps being loaned out in circulation as explained above, deposits simultaneously gets accumulated as well. These accumulated deposits are used for transactions in the non-banking public sector, though they are not legal tender, as if they are functional-money (or convertible to money) as illustrated in Figure 5.5. In other words, cash and deposits gets interchangeably used for transactions; that is, buyers and sellers keep their transactions as recorded in Table 5.7. In reality, transactions through deposits occupy a large portion of economic activities.

Buyers		Sellers	
Debit (A)	Credit (A)	Debit (A)	Credit (A)
Commodity (+)	Cash (-)	Cash (+)	Commodity (-)
Commodity (+)	Deposits (-)	Deposits (+)	Commodity (-)

Table 5.7: Transactions of Non-Banking Sectors: Flow Approach

Surely these deposits are created out of nothing through fraudulent practice of loans out of depositors' money under the fractional reserve banking system.

5.4 Stock Approach of Functional-Money Creation

5.4.1 A *Fractional Reserve* Banking: Stock Approach

Flow approach to the fractional reserve banking system is based on the flow analysis in the sense that inflows of deposits with banks are made out of currency in circulation, out of which banks make loans after reserving a required amount with the central bank. This has been standard explanation adopted by almost all textbooks on macroeconomics and many economists, including Nobel laureates in economics.

However, this approach blurs the role of banks as deposit (credit) creators out of nothing, because the flow analysis gives us an impression that banks are nothing but mere intermediaries of money, and can only make loans out of the deposits they receive. This has caused confusions among students in economics as well as experts.

Irving Fisher once explained the essence of the current fractional reserve system of deposit (credit) creation in a very succinct way as follows:

> Under our present system, the banks create and destroy check-book money by granting, or calling, loans. When a bank grants me a \$1,000 loan, and so adds \$1,000 to my checking deposit, that \$1,000 of "money I have in the bank" is new. It was freshly manufactured by the bank out of my loan and written by pen and ink on the stub of my check book and on the books of the bank.
>
> As already noted, except for these pen and ink records, this "money" has no real physical existence. When later I repay the bank that \$1,000, I take it out of my checking deposit, and that much circulating medium is destroyed on the stub of my check book and on the books of the bank. That is, it disappears altogether. (Fisher, 1945, p.7)

In this way, banks can easily create "functional-money" or deposits in our deposit account by hitting keyboard. This banking practice looks very different from that of the flow approach. Hence, it is called stock approach to the fractional reserve banking in this chapter.

Let us now explore the stock approach of lending practice of banks as illustrated in conceptual Figure 5.13. The itemized numbers below are the same as those indicated in the Figure.

(1) Whenever banks collect deposits, they reserve the entire amount of deposits with the central bank[17].
(2) Under the fractional reserve banking system, banks try to lend maximum loanable funds according to the following formula[18]:

$$\begin{aligned}
&\text{Maximum Loanable Funds (Banks)}\\
&= \frac{\text{Reserves (Banks)}}{\text{Required Reserve Ratio}} - \text{Deposits (Banks)}\\
&= \frac{1-\beta}{\beta}\ \text{Reserves (Banks)} \qquad (5.23)
\end{aligned}$$

(3) Banks enter this amount of loans as deposits with borrower's deposits account. This lending practice of loans differs from the flow approach in which borrows receive real cash instead of deposits as digital number in their account. In this way, banks can create $\frac{1-\beta}{\beta}$ factors of functional-money out of nothing for a unit increase in deposits, or, vice versa, they can destroy $\frac{1-\beta}{\beta}$ factors of functional-money for a unit decrease in deposits. For example, a consumer's withdrawal of \$1 destroys \$9 of functional-money when $\beta = 0.1$, and vice versa.

[17]In the stock approach model, deposits are assumed to go directly into "Reserves (Banks)". In practice, when customers put deposits at the bank, they are first debited as "Cash (Banks)" instead of "Reserves (Banks)" as in the flow approach. Deposits of cash in the stock approach are assumed to be directly debited as Reserves, and the amount of Vault Cash is later adjusted according to liquidity demand by non-banking sector.

[18]The last equation holds only when bank's deposits are fully reserved with the central bank; that is, Deposits(Banks) = Reserves(Banks).

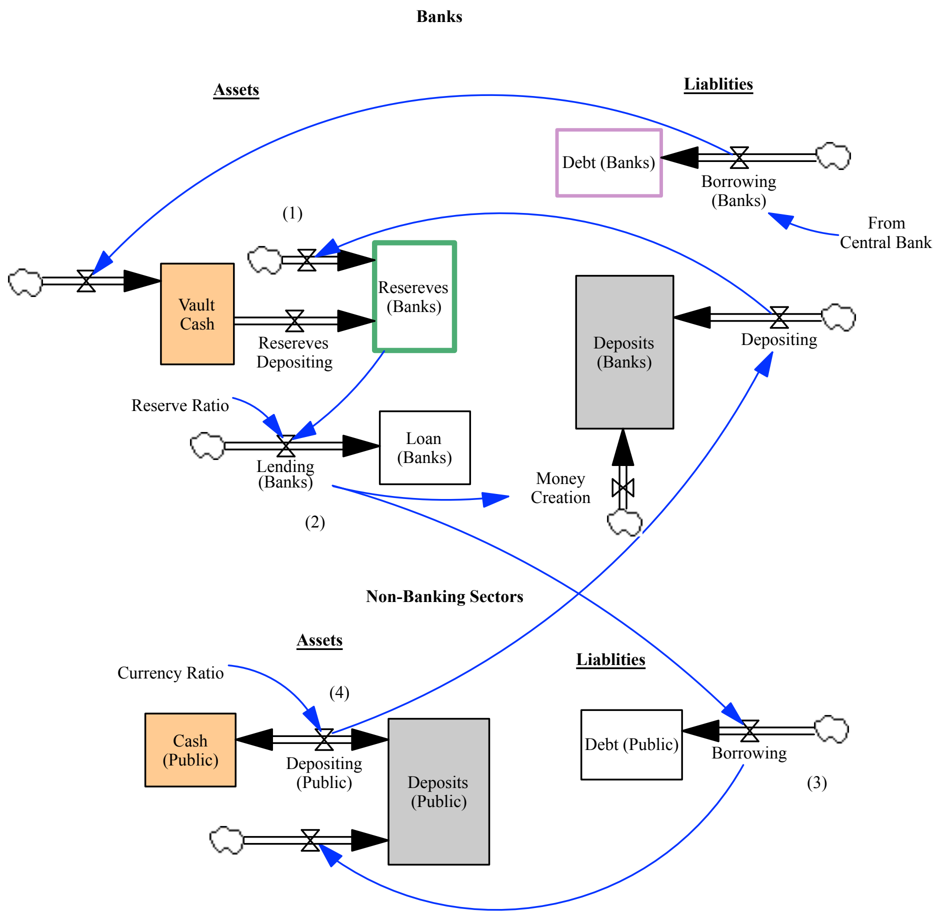


Figure 5.13: Stock Approach of Money Creation

Irving Fisher called this magnified behavior of money stock "the chief cause of both booms and depressions, namely, the instability of demand deposits, tied as they are now, to bank loans" (Fisher, 1945, p.xviii)[19].

(4) Borrowers withdraw cash out of their deposits account according to the currency ratio(α), then the remaining amount is deposited again.

5.4.2 Accounting Presentation of Stock Approach

Banking practice of this stock approach is now described according to the double-entry bookkeeping rule in Table 5.8.

[19]This issue will be discussed in Chapter 14.

Banks		Non-Banking Public Sector	
Debit (Assets)	Credit (Liabilities)	Debit (Assets)	Credit (Liabilities)
Loan (+)	Deposits (+)	Deposits (+)	Debt (+)
		Debit (Assets)	Credit (Assets)
		Commodity (+)	Deposits (-)

Table 5.8: Journal Entries of Stock Approach in (2) and (3)

It may be worthwhile at this stage to explain the difference between flow and stock approaches in terms to accounting principle. In the flow approach, banks' loan (+) (debit assets) is increased at the cost of cash (-) (credit assets), while in the stock approach, banks' loan (+) (debit assets) is increased simultaneously with the deposits (+) (credit liabilities). In other words, in the flow approach assets of banks are cancelled out, while in the stock approach without sacrificing the cash assets banks can increase loan assets by increasing deposits as liabilities out of nothing, and increase their interest revenues in an unearned fashion.

Is this *free-lunch* practice of bookkeeping acceptable? In the open letter to FASB, IASB, and IFAC[20], Michael Schemmann, publisher of the reprint of Irving Fisher's "100% Money (Fisher, 1945)" pointed out:

> The creation of units of account by MFIs (monetary financial institutions) that are masquerading as demand deposits defined by the FASB's ASC 305-10-20 as "cash in bank" do not comply with GAAP (Generally Accepted Accounting Principles) or IFRS (International Financial Reporting Standards). (Schemmann, 2013, p.2, 1st May).

In other words, "demand deposits are created *bank-internally* and therefore in violation of **self-dealing** (p.2)"; that is to say, free-lunch is fraudulent and against economic principle of transactions! Accordingly, he continues, "Such internally created units of account are not transferable among banks because they are unique to the MFI that created the units of account in their books of account, and can only be offset in what MFIs call their payment clearing" (p.3)". This implies that deposits are not "legal tender", supporting the quoted statement in Section 5.1.5 by the former governor of the Bank of Japan that "deposits are functioning as money".

Moreover, deposits thus created are not literally liabilities to the banks. As Irving Fisher pointed out in the previous section, "*legally it is the bank's*". Therefore, deposits are legally not liabilities or obligations to the banks. Stock approach unquestionably reveals the free-lunch nature of Loan→Deposits out of nothing, tied with the increase in unearned interest revenues. To hide away this inconvenient fact, flow approach has been favorably used in the textbooks, instead of stock approach, so that banks can pretend to be intermediaries.

[20]FASB = Financial Accounting Standards Board, IASB = International Accounting Standards Board, IFAC = International Federation of Accountants

Buyers		Sellers	
Debit (Assets)	Credit (Assets)	Debit (Assets)	Credit (Assets)
Commodity (+)	Deposits (-)	Deposits (+)	Commodity (-)
Commodity (+)	Cash (-)	Cash (+)	Commodity (-)

Table 5.9: Transactions of Non-Banking Sector: Stock Approach

As long as deposits function as money, deposits and cash are convertibly used in actual transactions as exhibited in Table 5.9. For buyers and sellers in the non-banking public sector, flow and stock approaches turn out to be indistinguishable in their balance sheets in the sense that cash and deposits are practically booked under the same Cash/Deposits account of assets[21].

5.4.3 Masqueraded Economists for Flow Approach

Facing repeated financial crises after the so-called second Great Depression triggered by the bankruptcy of Lehman Brothers in 2008, some monetary economists began to throw serious suspicion against the standard textbook view on the role of banks as intermediaries (flow approach), and tend to argue that the view of banks as credit creators out of nothing (stock approach) is more accurate in consideration of banking practices in real economy. In short, according to their arguments, flow approach is incorrect, and stock approach is correct.

For instance, Werner (2016) classifies the flow approach further into two theories; *the financial intermediation theory of banking* and t*he fractional reserve theory of banking*, while the stock approach as *the credit creation theory of banking*. In the working paper of the Bank of England, Jakab and Kumhof (2015) classifies the flow approach as *the intermediation of loanable funds* (ILF), while the stock approach as *financing through money creation* (FMC). Another well-cited "Bank of England" paper Michael Mcleay and Thomas (4 Q1) criticizes the flow approach by arguing that "one common misconception is that banks act simply as intermediaries, lending out the deposits that savers place with them."

Having classified the process of money creation in these ways, these authors, then, put themselves all in a supporting position of the stock approach by criticizing the view of banks as intermediaries. Accordingly it may be worth while, following Richard Werner, to show how economists have been confused for more than a century among these two or three theories when modeling the magical process of credit creation.

Flow Approach. This approach is further broken down into two theories. Examples of *the financial intermediation theory* of banking include some well-

[21] In fact, cash and deposits items in many balance sheets are integrated as an inseparable Cash/Deposits asset.

kmown economists. They are[22] : Keynes(1936); Gurley and Show (1955); Tobin (1963, 1969); Sealey and Lindley (1977); Balernsperger (1980); Mises(1980); Diamond and Dybvin (1983); Diamond (1984, 1991, 1997); Bernanke and Blinder(1988); Eatwell, Milgate and Newman (1989); Gorton and Pennacchi (1990); Bencivenga and Smith (1991); Bernanke and Gertler (1995); Rajan (1998); Myers and Rajan (1998); Allen and Gale (2004); Allen an Santomero (2001); Diamond and Rajan (2001); Kashyap, Rajan and Stein (2002); Mattews and Thompson (2005); Casu and Girardone (2006); Dewatripont et a. (2010); Gertler and Kiyotaki (2011); Stein (2014); Carney(2014) and Krugman (2015).

Examples of *the fractional reserve theory* of those who argue that banking system creates money through the process of 'multiple-deposit creation' are: Hayek (1929); Samuelson(1948); Gurley and Show (1955); Warren Simith (1955); Gulbertson (1958); Aschheim (1959); Solomon (1959); Paul Smith (1966); Guttentag and Lindsay (1968); Stiglitz(1997).

Stock Approach: Examples of *the credit creation theory* are: Macleod(1856); Wicksell (1989); Withers(1909, 1916); Schumpeter (1912); Cassel (1918); Hahn (1920) Hawtrey (1919); Howe(1915); Gustav Cassel(1923); Macmillan Committee(1931); Fisher(1935); Rochon and Rossi(2003); Werner(2005); Bank of England (Michael Mcleay and Thomas, 4 Q1); Jakab and Kumhof (2015).

It is interesting to observe from these lists of economists that Nobel laureate economists such as Samuelson, Tobin, Krugman and Stiglitz all belong to the flow approach group, while the stock approach group disappeared entirely since Fisher (1945) till quite recently as if it has been *a taboo subject* for economists (Turner, 2013, p.31).

Our system dynamics approach of modeling "money and its creation" has revealed here that either flow approach or stock approach of modeling money is equally feasible. Yet, in a long history of economic analysis, most economists have favored to describe banks as mere intermediaries of transactional money and concealed the fact that bank deposits (or credits) are indeed created out of nothing. That is to say, they have masqueraded, until recently, as supporters of the flow approach of money creation. This chapter unmasks them to the effect that banks create functional-money (credits) out of nothing even under the flow approach. In contrast, stock approach unquestionably reveals that banks are not intermediaries, but actually creating credits out of nothing.

Accordingly from now on let us show, with the SD models of flow and stock approaches, that both flow and stock approaches are indeed identical as if they are heads and tails of the same coin, bringing century-long masquerades of economists to an end.

[22]References of these economists quoted here under flow and stock approaches are not listed in the references of this book. Please refer to the original paper (Werner, 2016) for detailed references.

5.5 Classification of Monetary Theories

Monetary theories discussed so far seem to be complicated and diverse at first glance. From the perspective of money classification, however, it turns out that there exist only four monetary theories, as roughly classified in Figure 5.14. Let us review them briefly in this section.

Classification of Monetary Theory				
Monetary Theory		Overview	Models	Representative Economits
Public Money	Public Money Theory	Public money is issued by the legislature branch of government as net equity. This will overcome inflation and depression, and achieve price stability, sustainable economic growth, full employment and welfare. EPM (Electronic Public Money) is advocated as Money of the Futures.	ASD (Accounting System Dynamics) macroeconomic model, etc. Flow and stock approaches of debt money are integrated as the Heads and Tails of the same endogenous money.	Aristotle, Frederick Soddy, Irving Fisher, Stephen Zarlenga, Kaoru Yamaguchi, Yokei Yamaguchi, etc.
	—Mainstream 1 — Moneyless Price Theory (Commodity Money)	Relative prices are determined by general equilibrium. Its numeraire commodity becomes money and determines absolute price levels. Money is neutral and just a veil of economic activities.	Neoclassical economic models such as Dynamic Stochastic General Equilibrium (DSGE) model and Real Business Cycle (RBC) model, etc.	Adam Smith, Karl Marx, Kenneth Arrow, Gerald Debreu, Robert Lucas, Neoclassical economists, etc.
Debt Money	—Mainstream 2 — Exogenous Debt Money (Flow Approach)	The central bank supplies base money and money stock is determined by money multiplier. Banks are merely intermediaries of exogenous money in circulation.	Keynesian macroeconomic models such as testbook IS-LM model, and macro-econometric model, etc.	Friedrich Hayek, John M. Keynes, Paul Samuelson, James Tobin, Josehp Stiglitz, Paul Krugman, New Keynesian economists, etc.
Debt Money	Endogenous Debt Money (Stock Approach)	The central bank supplies base money, with which banks create deposits (credits) out of nothing and destruct them. MMT defines money as IOU (Promissory Notes) and considers government bond issuance (debts) as money issuance.	Monetary reform program such as the Chicago Plan (a taboo subject since 1930s). Monetary reform groups of American Monetary Institute and MMT are in fruitless conflict without economic models.	Joseph Schumpeter, Eight Chicago Plan economists, Irving Fisher, Milton Friedman, Hyman Minsky, Steve Keen, Richard Werner, Post-Keynesian and MMT economits, etc.

Figure 5.14: Classification of Monetary Theories

5.5.1 Mainstream Theory 1: Moneyless Price Theory

Moneyless Transactions: Money as Veil

Historically speaking, the electrum coin of Lydian Lion explained in section 1 was the oldest public money issued at interest-free, and interest-free public money has been widely used until the modern banking system began to emerge along with the Industrial Revolution in 18th century. That is why public money is listed first in the table. Yet, let us start with two mainstream monetary theories first here, because in economics these two theories have been deliberately taught as dominant monetary theories.

Mainstream theory 1 (moneyless price theory or commodity money theory) comes from the general equilibrium theory, which is said to have originated from Walras's "Elements of Pure economics (1874)". It can be traced back to Adam Smith's "An Inquiry into the Nature and Causes of the Wealth of Nations (1776)". The framework of general equilibrium theory can be well understood by considering a pure exchange game in the markets in which producers bring N goods and services to maximize profits, and consumers want to maximize utility by the purchases of these goods and services. If there is a common value scale at the time of an exchange game, the exchange will be smoother. So the exchange game is better played by choosing a value scale commodity called *numeraire*. That is, it is a market exchange game consisting of (N-1) goods and services and one commodity good of money. Commodity money theory claims that gold and silver had been historically selected as this commodity money and became the *numeraire* money of the other (N-1) goods and services. As a result, a relative price valued by weight of gold or silver is determined to match supply and demand in all markets. This raised a difficult question in economics on the existence of general equilibrium, whose proof was provided by Arrow and Debreu (1954). In this general equilibrium game, money is always supplied as an exogenous commodity, and its market becomes always in equilibrium so long as (N-1) markets are in equilibrium. This is the so-called Walras law.

In this general equilibrium framework, no money is needed at all as all transactions are settled at these relative equilibrium prices; that is, producers and consumers are able to achieve equilibrium in all markets. In other words, economic transactions in this neoclassical economic theory become transactions only in the logical world of general equilibrium; that is, transactions become moneyless. In this way all exchanges are completed within the markets of N goods and services. However, no one would believe in such an unrealistic economic theory, because money is always required for exchanges in the real world in which money indeed exists. I was fortunate, while studying at UC Berkeley, to have attended Professor Debreu's seminar on mathematical economics and learned general equilibrium theory directly from him. Soon after, I became very critical of this general equilibrium theory as a moneyless economic fiction[23].

Commodity Money

Eventually commodity money began to replace moneyless transactions in mainstream monetary theory. Any value-scale commodity called *numeraire* could be selected during the process of attaining general equilibrium. Historically, gold and silver had been chosen as the *numeraire* commodity for other (N-1) goods and services. This is the theory of commodity money. In this exchange game, for example, if gold is chosen, its weight of 1 pound = 16 ounces (= about 454 grams) becomes a unit of money and a unit of value scale for other goods and services. In order to explain the real market economy classical economics had to rely on such commodity money theory. They had no choice but to build a fictitious monetary theory that gold and silver had been extracted as commodity money from barter economy. Marx's theory of the Capital also starts with this fiction.

Furthermore, if the gold price is set at 1 ounce = \$20, the dollar-denominated absolute price of commodity will be determined. Therefore, even if money such

[23]See Yamaguchi (1988, pp.42-48) for my seven points of criticisms of general equilibrium theory.

as dollar notes is in circulation, its convertibility into gold is useless in this exchange game. The price of *numeraire* only determines the absolute price of goods and services, and it becomes neutral from the relative prices determined by the general equilibrium. As gold production increases, as in the Gold Dash in California in the 1850s, the relative price of gold rises and the monetary value of gold decreases. Yet the absolute price of 1 ounce = $20 dollar notes does not change. In other words, the dollar note becomes neutral to the real economy as if it is just a veil. Therefore, commodity money remains neutral and cannot affect the real economy, and the construction of monetary theory becomes useless in the neoclassical theory of general equilibrium. In this way, no matter what kind of commodity money it is, it will become neutral and will not affect the real economy.

Along with this line of thinking, classical economics constructed a fictitious commodity money theory that gold and silver had been extracted as commodity money from barter economy. It has been criticized in recent years that this is merely a fictional fantasy in the heads of classical economists since there is no evidence that money has evolved from barter economy into a monetary economy. Adam Smith, called the father of economics, discussed in the Wealth of Nations in 1776 that the metallic nature of gold (such that it can be stored without rusting, easy to divide and process etc.) provides the intrinsic value of gold. Then, he erroneously argued that gold began to circulate as money as already discussed in section 1. Historically, gold standard system based on gold as a commodity money has continued for a long time. Accordingly, there are still many economists and politicians who are brainwashed by this commodity money theory.

In the process of considering this way we have posed a question; where should this commodity money be positioned in our classification table of money Table **??** shown in Chapter **??**? Because *numeraire* commodity was chosen as money, it must be *legal tender* according to our back definition of money. Furthermore, since this commodity money is cast using materials such as gold and silver as media, it cannot be one of N goods and must be (N+1)st money at this point of coinage. In other words, if the Nth good is gold, (N+1)st gold coin using Nth gold as its media must be born as *legal tender*. And a gold coin weighing 1 ounce is stamped with value information of $20. Commodity money must be analyzed in this way from our classification table of money.

However, most neoclassical economists since Adam Smith have regarded the Nth gold material itself as commodity money. If they try to complete their logic of general equilibrium, they have no choice but to do so. However, the birth of gold as legal tender implies a creation of new market economy consisting of N goods and services and (N+1)st commodity money (gold, silver, copper, etc.). In the logical world of general equilibrium, transactions are completed with N goods and services. However, it cannot be completed in the actual market economy of (N+1) dimensions. Money as the (N+1)st entity must be all the time required.[24] Considering this way, the methodology of general equilibrium theory

[24] In Chapter 2 market exchange models are constructed by strictly dividing the time into

itself becomes fictional, because it assumes that if (N-1) markets of goods and services are in equilibrium, the Nth money market must also be in equilibrium according to the Walras' law. Does a new monetary general equilibrium exist in the real market economy consisting of N goods and services and (N+1)st money? It indeed failed in the 1930s, and its revised version of gold-dollar standard system again collapsed in August 1971, as briefly discussed in the next chapter.

To summarize, the mainstream theory 1 of commodity money theory has the following characteristics.

- Relative prices are determined by general equilibrium, a *numeraire* commodity becomes money, and this commodity money is supplied exogenously.
- The absolute price of money is neutral to the determination of relative prices and is only a veil of real economic activity.
- The gold standard collapsed in the 1930s due to the restriction of production and supply of gold as commodity money.
- The gold-dollar system in 1944 also collapsed in 1971, after which it shifted to a managed currency system.

5.5.2 Mainstream Theory 2: Exogenous Debt Money

Currently, the Mainstream Theory 2 (called Flow Approach in this chapter) is widely disseminated in macroeconomic textbooks as the only mainstream monetary theory. It may also be called the exogenous debt money theory. Under the gold standard, instead of the circulation of precious gold, gold was deposited with goldsmiths, who issued gold certificates in exchange, which eventually began to be distributed as convertible banknotes. This transaction is said to be the beginning of the modern banking business. In fact, many banks (goldsmiths) issued banknotes until the British Peel Banking Act of 1844 was enacted. The same was true in the United States during the Gold Dash in the 1850s. Banks soon realized that there was not much demand for conversion to the gold deposited with them, and began to lend more banknotes at interest than the convertible banknotes they issued. This is the beginning of the fractional reserve banking system.

In the unlikely event that banks do not have enough gold to meet its conversion demand, they got together to provide money gold with one another. This is the beginning of the central bank. Under the Peel Banking Act of 1844, the private Bank of England (established in 1694) acquired the status of the central bank as the only issuing bank of banknotes. Other private banks was able to create deposits (credits) out of nothing at interest, by using the Bank of England notes as base money, and began to devour unearned income of interest. In

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logical time of neoclassical economics and *historical* time of actual economies.

this way, a modern banking system has developed by separating the banknotes-issuing business of the central bank from the deposits (credits) creation business of private banks .

Historically, the 1800s became the dashing era of establishing central banks. One after another the central banks have been established such as Bank of France in 1800, Bank of Norway in 1816, Deutsche Bank in 1876, Bank of Japan in 1882, The Bank of Italy in 1893, the Swiss National Bank in 1907, and the Federal Reserve System in 1913. In this way, the central bank network of the debt monetary system was established, As the final finishing touch, the Bank for International Settlements (BIS), the central bank of the central banks, was founded in 1930 in Basel, Switzerland. Furthermore, the IMF (International Monetary Fund) was established in 1947 with the gold-dollar standard system under the Bretton Woods system. In 1969 as a BIS executive branch, it began issuing SDR (Special Drawing Rights) as money for settlement among central banks.

Debt money theory (flow approach) as the second mainstream monetary theory aimed at justifying the interest-earning operations of central banks and private banks. The characteristics of this mainstream monetary theory, which is currently prevalent in standard macroeconomic textbooks, are as follows.

- The central bank is a government bank and the only issuer of banknotes (legal tender, debt money).
- The government issues only small amounts of coins (legal tender, public money) as subsidiary coins.
- The central bank can directly control base money and indirectly control money stock through a stable money multiplier.
- Private banks lend (finance) households' deposits (debt money) that are leaked from circulation to corporate investment activities. Accordingly, they are merely financial intermediaries or money lender so that the so-called "deposits (credits) creation out of nothing" is impossible.
- Government financing can only be done by issuing government bonds and borrowing from banks
- When government debt accumulates, a crowding out occurs and interest rates rise, collapsing public finances. The government must maintain a balanced budget (called primary balance) through tax increases and austerity spending.

5.5.3 Monetary Reform: Endogenous Debt Money

Until the Great Depression of 1929, exogenous commodity money was the mainstream theory in classical economics. Schumpeter, a great economist in those days famous for his advocacy of creative destruction, was working on building a new monetary theory based on the endogenous creation of credits. Unfortunately, his monetary theory was not completed. However, we should understand that, at that time, it was the endogenous credit-creating monetary theory that opposed the mainstream exogenous commodity money theory.

The Great Depression that occurred during that period shocked classical economists who had previously adhered to liberalism and harmonious equilibrium market economy. Among them there were eight economists at the University of Chicago. They argued that the cause of the Great Depression was credits creation by banks under the fractional reserve banking system, and put together a monetary reform plan for banks. This is the so-called Chicago Plan[25]. The essence of the plan is that (1) the Federal Reserve System is to be nationalized and integrated with the Treasury, and (2) the fractional reserve banking system that will create and/or destruct credits is to be abolished. It was exactly against the Wall Street bankers' business model.

The University of Chicago, founded by the international banker John Rockefeller, was a stronghold of liberalism and market fundamentalism for bankers. The proposal of the Chicago Plan, which struck a chord with the founder Rockefeller, must have been an unimaginable pressure to the eight economists at the university. In fact, the central figure, Professor Henry Simons, died unexpectedly (suicided ?) of unknown cause at the younger age of 46. However, they maintained their morale as researchers, saying that their banking reform of the Chicago Plan is logically consistent with the principles of liberalism and market fundamentalism. Milton Friedman (a monetarist who won the Nobel Prize in Economics in 1976) learned the banking reform directly from them as a graduate student at the time, and initially agreed with the Chicago plan. The Chicago plan was secretly handed over to President Franklin D. Roosevelt in 1933, but the president, who feared international bankers, ignored it. Instead, he enacted the Glass-Steagall Act, a watered-down banking regulation law of the plan. In the storm of neoliberal financial liberalization, this act was also repealed by President Bill Clinton in 1999.

Irving Fisher, a leading US economist at the time, received the Chicago plan and immediately understood the correctness of the proposal. Two years later in 1935, he published "100% Money, Fisher (1945)" and advocated the importance of monetary reform. It can be said that Fisher completed Schumpeter's unfinished monetary theory of endogenous credits creation. In 1939, Fisher co-authored a booklet entitled "A Program for Monetary Reform, Fisher et al. (1939)" with five economists, and proposed monetary reform to economists across the United States. 86% of economists agreed with this program, yet it was also ignored. Since then the Chicago Plan and monetary reform programs altogether have been ignored and made a *taboo* subject in economics. Researchers who touched the subject were banished from the universities, including myself.

Zarlenga (2002), an economic historian, published the great book "The Lost Science of Money". In its Chapter 24 "Proposals for US Monetary Reform" he has revived the forgotten and tabooed subjects in economics such as the Chicago

[25]See Chapter 8 of "Public Money"

Plan and Fisher's 100% Money since 1930s. He founded the American Monetary Institute (AMI) and inherited the will of his predecessors for monetary reform. Since 2005 he has annually held the international conference on monetary reform in Chicago. Centered around this conference, the US monetary reform group drafted the modern version of the Chicago Plan and 100% Money as "The American Monetary Act." He had been actively working to establish this act in the US Congress. The main gists of the American Monetary Act are the following three points.

- Integration of the Federal Reserve System (FRB) with the Treasury.
- Abolishment of the credits creation out of nothing through the fractional reserve banking system.
- The government issuance of money needed for economic growth and social welfare.

I happened to know this proposal online and immediately understood its correctness just like Fisher did. Then, using the ASD (Accounting System Dynamics) macroeconomic modeling method, a new approach to macroeconomic modeling completed at that time, I have started building an ASD macroeconomic model of the American Monetary Act. Then I have performed simulation analyses and obtained the results such that if the American Monetary Act is enacted, the cumulative debts of the US government can be reduced to zero. I have presented them in succession at the 28th International Conference of the System Dynamics Society (Yamaguchi (2010)), and the 6th International Monetary Reform Conference in September 2010 in Chicago. Since then, till recently, I have attended this international conference on monetary reform every year.

What is debt money theory (called Stock Approach in this chapter), then, as opposed to debt money theory (Flow Approach)? As the name "debt money theory" indicates, both are monetary theories on debt money system, but they differ in the following points. As already discussed in Section 5.3, debt money theory (Flow Approach) starts with saving deposits first, then assumes that banks make loans out of the deposits to producers and households for their investment. On the other hand, in debt money theory (Stock Approach) as discussed in Section 5.4, base money deposited with the central bank is assumed as bank reserves, then banks, following a fractional reserve requirement, make loans out of nothing by hitting keyboard even if they do not have corresponding deposits at hand. As a result, the debt money theory (Stock Approach) analyzes the characteristics of the current debt monetary system as follows.

- Central bank is nothing but a private bank, but steals the right of the government to issue money[26].

[26] It is indeed given in the US by the Constitution, Article1, section 8 as follows: "The Congress shall have power to lay and collect taxes, $\cdots$, to coin money, regulate the value thereof, and of foreign coin, and fix the standard of weights and measures;"

- Private banks are not just financial intermediaries and lenders, but create "deposits (credits) out of nothing" endogenously through a fractional reserve banking system and make loans to private sectors and the government at interest.
- The central bank can only control base money, but not money stock that is endogenously created or destructed by banks.
- The government not only issues small amounts of coins (legal tender) as subsidiary coins, but also can authoritatively issue all kinds of money. It does not need to raise (or borrow) funds by issuing government bonds.

Why has the debt money theory (Stock Approach) that analyzes the current debt money in this way been made like an enemy by international bankers and financiers in the Wall Street, and wiped out of economics? And why do economics textbooks deal only with the debt money theory (Flow Approach) as mainstream theory? It is because the Flow Approach can hide the truth that bankers do not want to disclose. That is, the truth such that (1) the central bank is not a government bank, but a private bank pursuing profits, and (2) money is endogenously created out of nothing and lent out at interest.

There are several groups that have been critical of the debt money theory (Flow Approach) and aimed at the monetary reform. Typical two groups are the Monetary Reform and the MMT (Modern Monetary Theory) groups. At the International Conference on Money Reform held in Chicago every year, many researchers, monetary reform promoters, financial professionals, etc. participated from the United States and Europe, including British positive money group. Participants gathered every year toward the common goal of establishing monetary reform with intentions to expand their activities by uncovering the lies of the mainstream theory 2: debt money theory (Flow Approach). They were full of passion to free economics from the *taboo* of debt money theory (stock approach).

Unfortunately, however, MMT group insisted that money is an IOU; that is; debt money is the only type of money according to the classification Table 5.2, while Monetary Reform group, including myself, insisted that money has to be public money. In this way two groups which shared the similar view on Endogenous Debt Money got into severe debates during the Monetary Reform Conference in Chicago in 2012[27], then have been split since then.

5.5.4 Public Money Theory

In order to analyze the same current debt money, why do we have two different monetary theories such as the debt money theory of flow approach (so-called mainstream) and that of stock approach (criticized as heretic)? Since the publication of "Public Money (in Japanese)(Yamaguchi, 2015, 2015)", I have been

[27] This conference has bee annually held in Chicago by the American Monetary Institute established by Zarlenga (2002).

annoyed by this question. As we have already considered, the only monetary theory that confronted the commodity money theory was debt money theory (stock approach) until the 1930s. However, with the advent of the Chicago plan and the monetary reform program of "100% money", the stock approach of debt money had been buried in the darkness as a *taboo* by the international bankers and financiers, because it would disclose, they feared, a hidden mechanism of devouring profits. Since then, only the debt money theory of the flow approach has been treated as a mainstream theory in economics textbooks.

To explore the behaviors of these two approaches, we have constructed two different ADS macroeconomic models, the flow approach and the stock approach of the fractional reserve banking system, and compared the monetary behaviors of both models. Our simulations found that both models produced almost the same monetary behaviors. We were convinced that these two monetary theories describe almost the same behaviors of money stocks as if we are looking at the same coin from the front (Heads) and the back (Tails) to emphasize its differences. We came to the conclusion that the process of creating money out of nothing under the debt money system of fractional reserve banking is the same whether it is the flow approach or the stock approach. Banks are not merely money lenders as intermediaries, they are indeed endogenously creating money out of nothing and destructing it. Hence, exogenous creation view of debt money by central bank, which is assumed by all Keynesian macroeconomic models, is completely refuted. The simulation results were immediately reported at the 34th International System Dynamics Society in July 2016[28].

We'll analyze these behaviors in detail in the following Chapter 6. Series of our ASD macroeconomic models in the next chapter have demonstrated that the interpretation of mainstream exogenous debt money theory (flow approach) that has dominated textbooks for 90 years since the days of the Chicago Plan in 1930s to the present was incorrect. All Keynesian monetary theories based on the assumption that money is exogenously supplied are false. A typical example is the IS-LM model currently used in most macroeconomics textbooks in which money supply is assumed to be controlled by monetary policies. Therefore, it is a natural consequence that the monetary and fiscal policies as well as the recent quantitative easing (PE) policies of the reflation theory are all destined to fail. Specifically, economic disasters such as the Great Depression of 1929 and the failures of the quantitative easing (QE) policy introduced by the BoJ cannot be explained by the IS-LM model. **?**, Chapter 1 have examined that all Keynesian monetary and fiscal policies as well as QE policies failed in Japan during the so-called "lost 30 years of Japan". The view of endogenous debt money theory (stock approach), which has long been made a *taboo*, was correct.

A series of ASD macroeconomic models in Part III will step by step expose that our current debt money system has serious system design failures. The system design failures imply that no matter how wise government introduces wise policies, they cannot escape from failures. As a parable, imagine a defec-

[28]The Heads and Tails of Money Creation and its System Design Failures –Toward the Alternative System Design, by Kaoru Yamaguchi and Yokei Yamaguchi, Delft, The Netherlands, July (Yamaguchi and Yamguchi, 2016, 2016).

tively designed airplane. It cannot be safely flown no matter how its pilot is skillful and full of long flight experiences. Public money, stolen by international bankers for the last several centuries, has to be restored. This is the main theme of this book.

Conclusion

We have started this chapter by defining money as legal tender according to the definition by the Greek philosopher Aristotle, and presented classification table of money, followed by its case analysis in Japan. Under the current debt money system legal tender is created by the privately-owned central bank as base money. Commercial banks then create deposits as functional-money out of nothing under the fractional reserve banking. Deposits thus created only function as money so long as they are accepted for transactions.

Concerning this functional-money creation process, two or three different theories have been presented in the history of economics. They are called flow and stock approaches in this chapter according to our accounting system dynamics modeling method.

Finally, based on the these conceptual understanding of money, we have successfully classified complicated monetary theories into four theories: public money, moneyless price theory (commodity money), endogenous debt money by flow approach and stock approach.

Questions for Deeper Understanding

1. When people claim that money is created out of nothing or thin air, what kind of money are they referring to? Explain it by using definitions of money and Table 5.2 (Classification of Money).

2. Creation of functional-money or credits (a source of control) depends on the fractional reserve banking; that is, a reserve ratio between $0 \leq \beta \leq 1$. If $\beta = 1$, what will happen?

3. It will also be affected by a change in currency ratio α. Discuss why the fractional reserve banking system becomes "the chief cause of both booms and depressions (Irving Fisher (Fisher, 1945, p.xviii))."

4. Who owns the central bank in your country?

5. Do we really need the central bank to manage money stock and run the economies? Without the central bank, what problems will arise?

6. If the central bank is owned by the government, what alternative policies could be available against current monetary policies of open market operations etc. by the central bank?

7. (**Challenge**) Table 5.5 presents a complete classification of money stock in Japan. For deeper understanding of the nature of contemporary debt money, the reader is encouraged to create a similar classification table of money stock in his/her country.

Chapter 6

Creation of Money

This chapter[1] continues to explores the nature of money under the current debt money system. Following the analysis of the previous chapter, this chapter construct two types of the ASD monetary models that is, flow approach of banks as intermediaries and stock approach of banks as deposit(credit) creators. Specifically, two simple models of gold standard by these two approaches are constructed and behaviors of money stocks are comparatively analyzed. The models are further expanded to those of discount loans by central bank and government bonds that allow the central bank to exercise a discretionary control over base money through open market operations. Throughout these comparative analyses, behaviors of money creation processes are demonstrated to be identical in essence among these two approaches as if they are heads and tails of the same coin, bringing century-long disputes of economists between flow and stock approach groups to an end.

6.1 Overview of Money Creation Models

This chapter construct monetary creation models step by step, starting gold standard model. To avoid the confusions an overview of these models as well as simulation files names are summarized as Figure 6.1.

[1] This chapter is based on the paper (Yamaguchi, 2004b, 2004): Money Supply and Creation of Deposits – SD Macroeconomic Modeling (1) – in "Proceedings of the 22nd International Conference of the System Dynamics Society", Oxford, U.K. , July 25-29, 2004, ISBN 0-9745329-1-6. It is further revised for the Edition 3.0 on the basis of the paper (Yamaguchi and Yamguchi, 2016, 2016): The Heads and Tails of Money Creation and its System Design Failures – Toward the Alternative System Design – in "Proceedings of the 34th International Conference of the System Dynamics Society", Delft, the Netherlands, July 17-21, 2016.

Creation of Money	Flow Approach Model	Stock Approach Model
(1) Gold Standard (Commodity Money) by the Public	1 Money(Gold).vpmx (t = 1) <Gold Standard (Flow-approach)>	1a Money(Gold-S).vpmx <Gold Standard (Stock)>
(2) Discount Loans to Banks by the Central Bank	2 Money(Loan).vpmx (t = 6) <Discount Loans to Banks (Flow)>	2a Money(Loan-S).vpmx <Discount Loans to Banks (Stock)>
(3) Loans to Government (Debts) (3a) by the Public (3b) by Banks with Reserves (3c) by Banks with Excess Reserves	3 Money(Flow-approach).vpmx (t = 8) <Gov Debs by the Public (Flow)> <Gov Debts with Reserves (Flow)> <Gov Debts with Excess Reserves (Flow)>	3a Money(Stock-approach).vpmx <Gov Debts by the Public (Stock)> <Gov Debts with Reserves (Stock)> <Gov Debts with Excess Reserves (Stock)>
(4) Open Market Operations by the Central Bank (4a) Open Market Purchase (4b) Open Market Sale	3 Money(Flow-approach).vpmx <Open Market Purchase (Flow) (t = 16) <Open Market Sale (Flow) (t = 22)	3a Money(Stock-approach).vpmx <Open Market Purchase (Stock) <Open Market Sale (Stock)

Figure 6.1: Overview of Money Creation Models

6.2 Gold Standard

6.2.1 Flow Approach Simulations

To examine a dynamic process of money and functional-money creation, let us construct a simple money creation model of flow approach [Companion model: 1 Money(Gold).vpmx]. Without losing generality it is assumed from now on that excess reserve ratio is zero, $\beta_e = 0$ so that reserve ratio β becomes equal to the required reserve ratio β_r. Vault cash of commercial banks in the model could be interpreted as excess reserves. The model is then built by assuming that the only currency available in our macroeconomic system is gold, or gold certificates (convertibles) issued by the central bank against the amount of gold. In short, it is constructed under gold standard. By doing so, we could avoid complicated transactions of discount loans by the central bank and government bonds among three sectors, and focus on the essential feature of money stock per se. This assumption will be dropped later and discount loans and government bonds will be introduced into the model.

Figures 6.2 illustrates our simple money creation model under gold standard. In the model, currency outstanding in the central bank and currency in circulation in non-banking public sector are illustrated as two different stocks. Thus, they need not be identically equal as most macroeconomics textbooks treat so. This is one of the features that system dynamics modeling can precisely differentiate itself from traditional macroeconomic modeling. It is interesting to observe how these two differentiated stocks of currency and three expressions of money stock derived from them will behave in the economy.

Base Money vs High-Powered Money

Let us run the model and see how it works. In the model, currency ratio and required reserve ratio are set to be $(\alpha, \beta) = (0.2,\ 0.1)$. Hence, money multiplier becomes $m = (0.2 + 1)/(0.2 + 0.1) = 4$. Meanwhile, from the balance sheet of

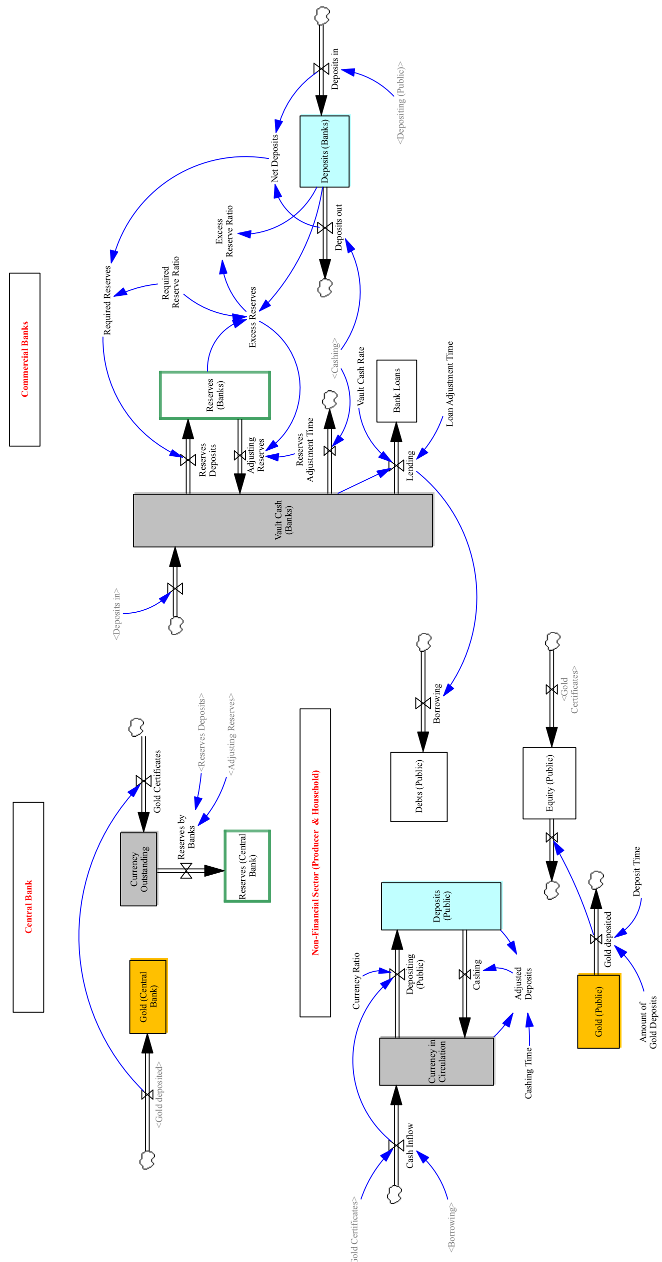

Figure 6.2: Money Creation Model under Gold Standard: Flow Approach

the central bank base money under gold standard is always equal to the fixed amount of gold, the only assets held by the central bank, which is here set to be equal to $200. This amount of gold is also equal to the gold assets by the public. In other words, the central bank is assumed to be trusted to start its banking business with the gold owned by the public and issue gold certificates as banknotes against it.

From the equation (5.20), money stock (base) can be easily calculated as 800 (= 4 * 200) dollars without running the model. Meanwhile, true money stock based on high-powered money in equation (5.19) cannot be obtained without running a simulation.

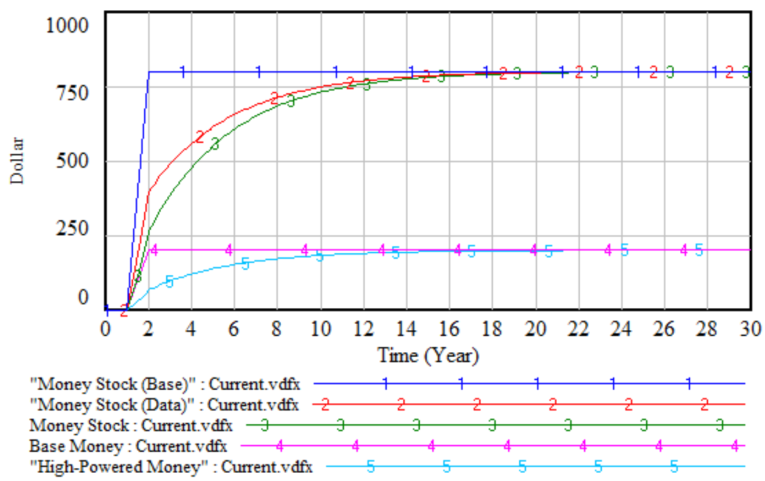

Figure 6.3: Money Stock under Gold Standard

Figure 6.3 illustrates our simulation result in which money stock (base), money stock (data), and money stock are represented by the lines numbered 1, 2 and 3, respectively. Base money and high-powered money are illustrated by the lines 4 and 5.

Two features are easily observed from the Figure. First, three expressions of money stock appear to have the following orderly relation.

$$\text{Money Stock (Base)} > \text{Money Stock (Data)} > \text{Money Stock} \tag{6.1}$$

Latter part of the inequality implies that actual money stock (data) overestimates true money stock. Since money stock (data) is the only figure actually obtained by using real data of the currency outstanding (liabilities of the central bank) and deposits (liabilities of commercial banks), the overestimation of true money stock might mislead economic activities in the real economy.

Second, base money turns out to be greater than high-powered money.

$$\text{Base Money} > \text{High-Powered Money}, \tag{6.2}$$

which then leads to the following inequality from the definitions in equations (5.19) and (5.20):

$$\text{Money Stock (Base)} > \text{Money Stock}. \tag{6.3}$$

It also leads to

$$\text{Currency Outstanding} > \text{Currency in Circulation}, \tag{6.4}$$

which in turn implies

$$\text{Money Stock (Data)} > \text{Money Stock}. \tag{6.5}$$

In other words, actual money stock (data) (line 2) calculated by the central bank always overestimates true money stock (line 3) available in the economy, which, however, tends to approach to the money stock (data) eventually.

Furthermore, under the equation (6.2) it is easily proved that

$$\text{Money Stock (Base)} > \text{Money Stock (Data)}^{2}. \tag{6.6}$$

Hence, the orderly equation (6.1) is proven. All three expressions of money stock are shown to converge as long as vault cash tends to diminish, and overestimation of money stock will be eventually corrected. Furthermore, it is shown as well that the above orderly relation is reversed when the order in equation (6.2) is reversed. This reversed order can be observed in Figures 6.7 and 6.8 below.

To understand the above orderly features from the simulation, specifically the difference between currency outstanding and currency in circulation, let us consider the amount of currency that exists outside the central bank. From the money creation model, it is the sum of cash in circulation among the non-banking public sector such as producers and households and cash held in the vaults of all commercial banks. Hence, the following relation holds:

$$\text{Cash outside Central Bank} = \text{Currency in Circulation} + \text{Vault Cash(Banks)} \tag{6.7}$$

Furthermore, cash outside the central bank should be equal to cash outstanding in the balance sheet of the central bank; that is, the amount of cash that the central bank owes to its outside world (non-banking public sector and commercial banks).

$$\text{Currency Outstanding} = \text{Cash outside Central Bank} \tag{6.8}$$

[2] Money multiplier m in equation (5.18) is rewritted as $m = \frac{C+D}{C+R}$. Then we have

$$\frac{dm}{dC} = \frac{R-D}{(C+R)^2} < 0.$$

Accordingly, under the condition: Currency Outstanding (O) > Currency in Circulation (C), it is easily shown that

$$\text{Money Stock (Base)} = \frac{C+D}{C+R} * (O+R) > O + D = \text{Money Stock (Data)}.$$

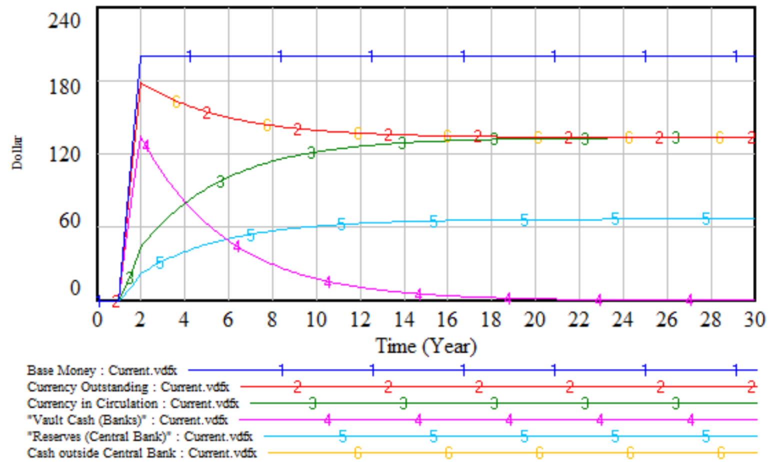

Figure 6.4: Currency Outstanding and Cash outside the Central Bank

Figure 6.4 confirms that currency outstanding (line 2) is equal to the cash outside the central bank (line 6). Hence, we have correctly arrived at the equation:

$$\begin{aligned}
&\text{Vault Cash(Banks)} \\
&\qquad = \text{Currency Outstanding} - \text{Currency in Circulation} \\
&\qquad = \text{Base Money} - \text{High-Powered Money} > 0 \qquad (6.9)
\end{aligned}$$

which in turn leads to the above inequality relations of equation (6.2) so long as vault cash is positive.

Ingredients of Functional-Money Creation

Since currency ratio of 0.2 cannot be controlled, money multiplier can take the range of $6 \geq m \geq 1$. When base money is $200 in our example, this implies that money stock can take the range between $200 and $1,200. Accordingly, let us discuss how money stocks get affected between the range by several ingredients in the money creation processes.

Loan Adjustment Time

There is a case in which a convergence to the money stock (data) becomes very slow and overestimation of money stock remains. In Figure 6.5 loan adjustment time is assumed to triple and become 3 periods. This is a situation in which a speed of bank loans becomes slower, or commercial banks become reluctant to make loans. Accordingly, money stock might converge to money stock (data), but extremely slow. In other words, money stock will not converge to the money

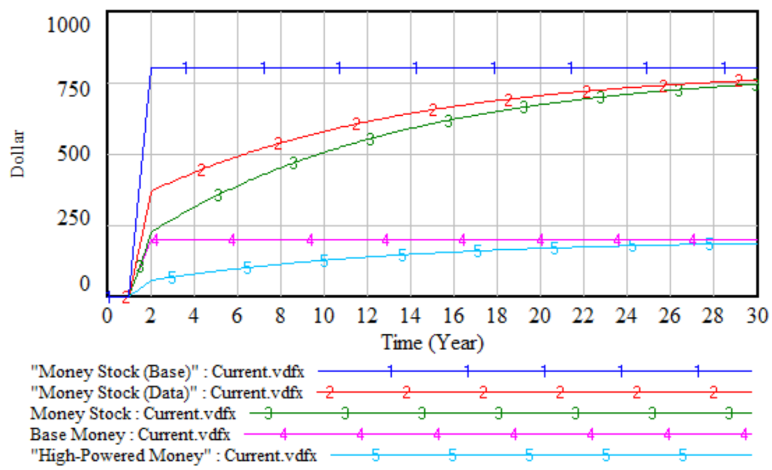

Figure 6.5: Money Stock when Loan Adjustment Time triples.

stock (data) for a foreseeable future and overestimation of money stock remains. Specifically, money stock (data) (line 2) is always greater than money stock (line 3) during the simulation of 24 periods.

Excess Reserves / Vault Cash

How can the amount of money stock be changed or controlled by the central bank? Under the gold standard, base money is always fixed, and the central bank can only influence money stock by changing a required reserve ratio. Even so, money stock may not be under the control of the central bank in a real economy. It could be affected by the following two situations. First, commercial banks may be forced to hold excess reserves in addition to the required reserves due to a reduced opportunity of making loans. Second, depositors in the non-banking public sector may prefer to hold cash or liquidity due to a reduced attractiveness of financial market caused by lower interest rates. Money stock will be reduced under these situations.

Let us consider the situation of excess reserves first. In our model excess reserves are stored as vault cash in the asset of commercial banks. Excess reserves are needed to an imminent demand for liquidity. Thus, commercial banks may additionally need to keep excess reserves as vault cash in their vaults. To see how excess reserves affect money stock, let us increase a vault cash rate to 0.5 from zero, so that 50% of available vault cash is constantly reserved.

As Figure 6.6 illustrates, the effect of keeping a portion of vault cash is similar to the above case of loan adjustment time. That is, three expressions of money stock converges eventually as the amount of vault cash diminishes.

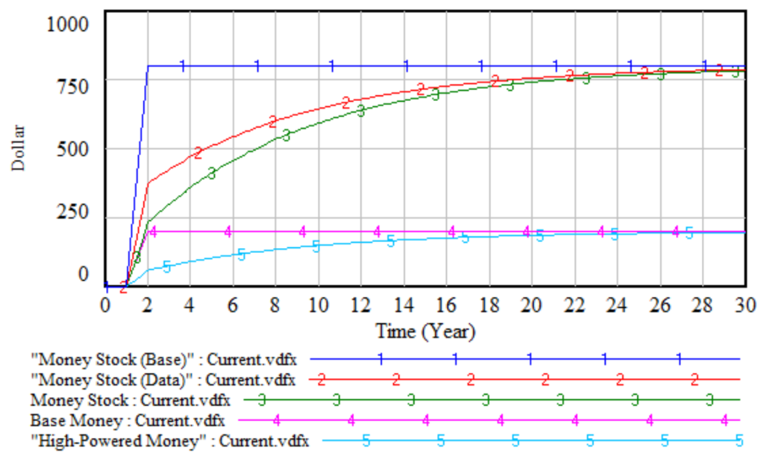

Figure 6.6: Money Stock when Vault Cash Rate is 0.5.

Currency Ratio

Let us now consider the second situation in which non-banking public sector prefers to hold more liquidity. To analyze its effect on money stock, let us assume that at t = 8 consumers suddenly wish to withhold cash by doubling currency rate from 0.2 to 0.4. Money multiplier is now calculated as $m = (0.4 + 1)/(0.4 + 0.1) = 2.8$ and money stock (base) becomes 560 dollars (= 2.8 * 200).

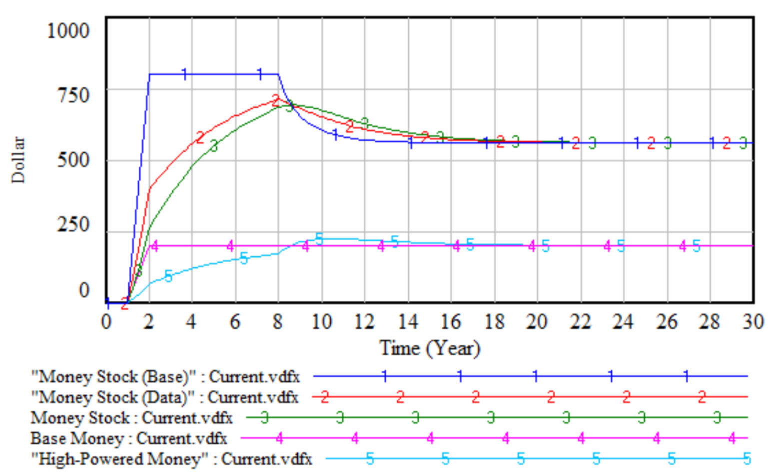

Figure 6.7: Money Stock when Currency Ratio doubles at t = 8

Figure 6.7 illustrates how money stock is reduced due to a sudden increase in liquidity preference in the non-banking public sector. Three expressions of money stock tend to converge again.

Let us emphasize at this early stage of analysis that money stock can be in this way easily crunched under the fractional reserve banking system. This becomes the main cause of monetary and financial instability as pointed out by Irving Fisher (Fisher, 1945, 1935). We'll discuss monetary stability issues in Chapter 14.

Assets, Equity and Money as Debts

When functional-money is created *out of nothing*, non-banking public sector's assets also increase from the original equity (or gold assets) of $200 to $800; that is, assets is increased by $600. Does this mean that non-banking public sector becomes wealthy out of the process of money creation under the *fractional reserve* banking system? Apparently, if 100% fractional reserve is required at t=8; that is, $\beta = 1$, commercial banks have to keep the same amount of deposits as deposited by the non-banking public sector. Accordingly, money stock remains the same as the original gold certificates of $200. Thus, equity, assets and money stock remain the same amount as Figure 6.8 illustrates.

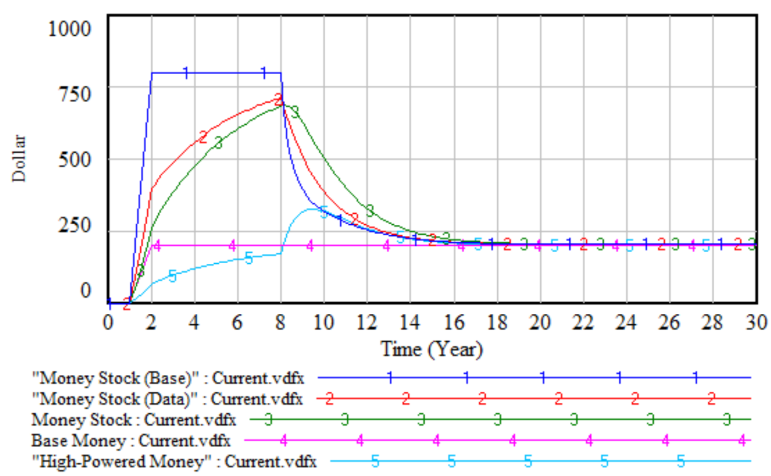

Figure 6.8: 100% Fractional Reserve at t=8

Where does the money of $600 come from when a required reserve ratio is $\beta = 0.1$, then? There is no magic. Nothing cannot be created *out of nothing!* It comes from the non-financial public sector's debt, Debt (Public) of $600, as line 3 of Figure 6.9 indicates, which also becomes equal to Functonal-Money (line 4).

In other words, source of functional-money becomes debts, without which no functional-money creation takes place. non-banking public sector's *wealth* remains the same as its equity of gold assets of $200. It has never been increased

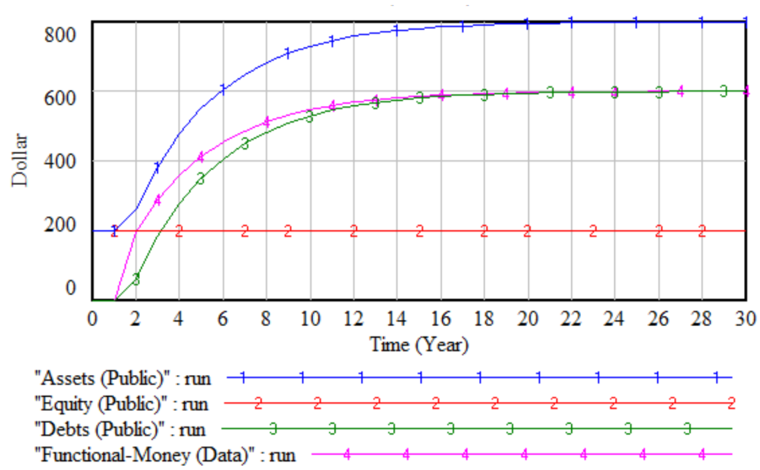

Figure 6.9: Money Stock, Assets, Equity and Debt

through this process of functional-money creation under the fractional reserve banking system.

6.2.2 Stock Approach Simulations

Let us now construct stock approach model of Gold Standard according to the conceptual Figure 5.13. According to the stock approach banking practice, banks first calculate the maximum amount of demand deposits they can create from the amount of reserves, then create "functional-money or deposits" by hitting keyboard and writing digital numbers, as a flow amount of Deposits Creation, into the borrower's Deposits account. This stock approach of money creation [Companion model: 1a Money(Gold-S)] is illustrated in Figure 6.10.

How are money stocks created under stock approach, then? Compared with diversified behaviors of money stocks in Figure 6.3, money stock (base), money stock (data), and money stock now coincide as indicated by lines 1, 2 and 3 in Figure 6.11, because banks are assumed not to hold vault cash under the stock approach here[3]. Accordingly, base money and high-powered money become the same (lines 4 and 5). In other words, orderly relations disclosed in equations (6.1) and (6.2) no longer emerge. The behaviors of money stock become simplified. Yet similar behaviors of various money stocks as in the flow approach will be obtained under the stock approach model if vault cash is held by banks.

[3]By increasing the value of Vault Cash Ratio, the reader can confirm that lines 1,2 and 3 begin to diverge as in the flow approach. Under stock approach, this ratio becomes a banking policy variable of commercial banks.

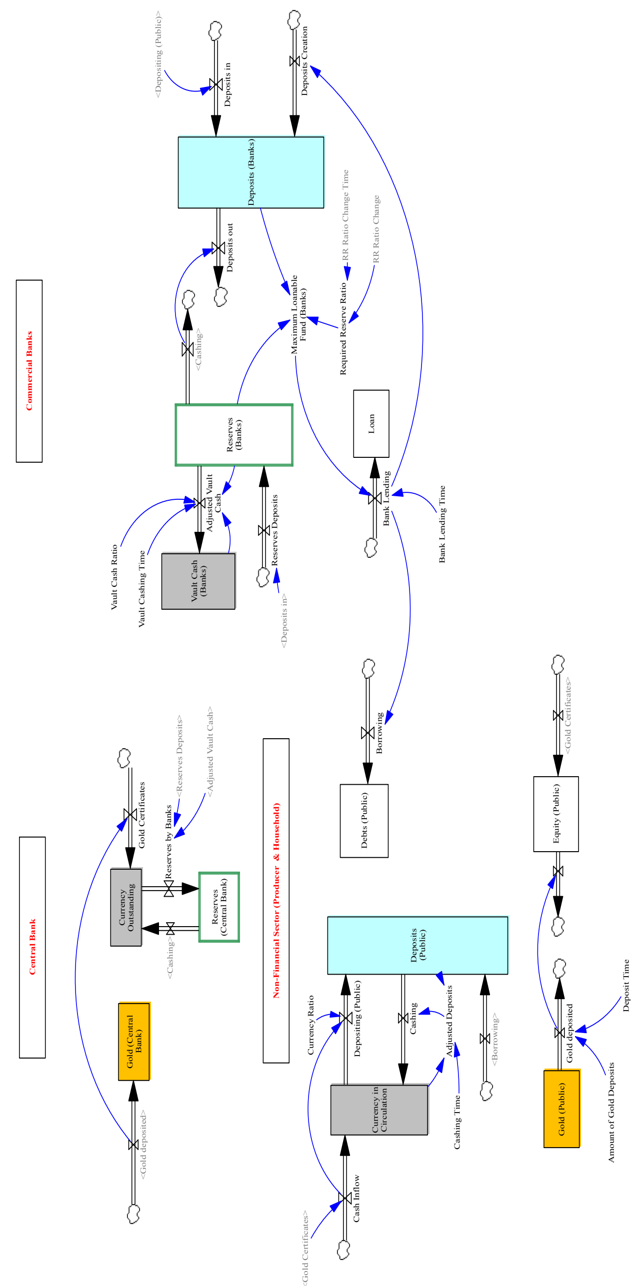

Figure 6.10: Money Creation Model under Gold Standard: Stock Approach

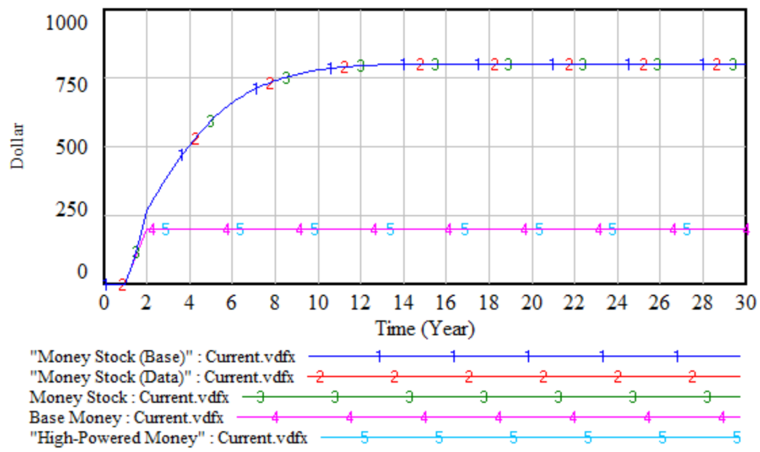

Figure 6.11: Money Stock under Gold Standard: Stock Approach

Functional-Money = Debts (by Non-Banking Public Sector)

This stock approach reveals a true nature of functional-money creation under the fractional reserve banking system more vividly as illustrated in Figure 6.12. It is extended to the 60th year. In the year 1, currency outstanding of \$200 is put into circulation as base money (bold line 1), part of which is held by non-financial public sector as currency in circulation (line 2) according to a currency ratio (=0.2) and the remaining will be deposited (line 3) directly as reserves of the banks with the central bank (line 3). Money Stock (Data) is presented by bold line 4; that is, \$800 at t=30.

Functional-money (bold line 5) is obtained as the amount of money stock that is not backed up by base money as legal tender; that is, the difference between money stock and base money (= \$800 - \$200 = \$600 at t=30). Total debts by the public, Debts (Public), shown by line 6 becomes exactly equal to functional-money (bold line 5). As pointed out in the above flow approach subsection, debts become the source of functional money under the stock approach as well. Hence, the functional-money constitutes a newly created amount of money stock which has "no real physical existence" as pointed out above by Fisher (Fisher, 1945, p.7, 1935). The nature of functional-money created out of nothing as public debts is in this way clearly revealed by the stock approach.

According to the flow-approach textbook definition of money stock, equation (5.21), money stock in a real economy (here \$800) is calculated as a sum of currency outstanding (here \$133.33) and deposits (here \$666.67). Consequently the fact that most deposits are newly created out of nothing (that is, \$600) is entirely hidden in the flow approach of a fractional reserve banking analyses. Our new introduction of functional money M_f as debts by non-banking public sector (producers and households) has revealed this fact. This could be the main reason why almost all macroeconomics textbooks have adopted the

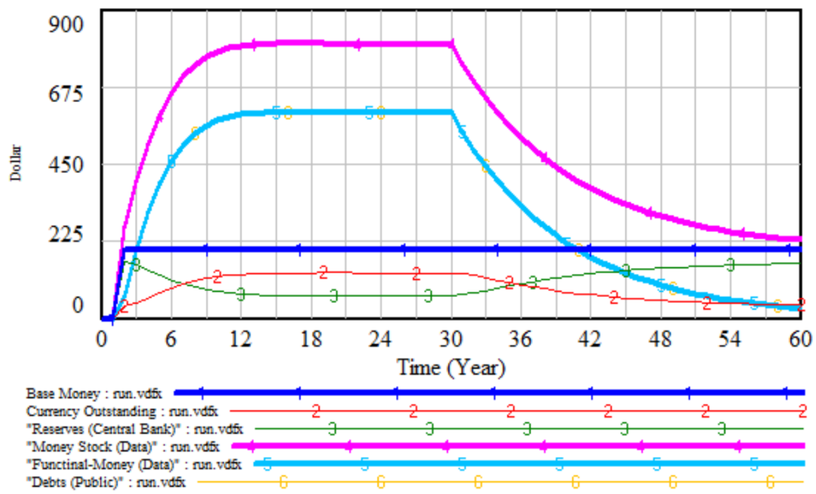

Figure 6.12: Base Money, Deposits and Money Stock: 100% Reserve at t=30

flow approach without introducing M_f, and many economists, including Nobel laureates, have flocked to the flow approach and disguised as if banks are mere intermediaries for the benefits of banking industry.

When a required reserve ratio is increased to 100% at the year 30, functional-money, as well as public debts, begins to shrink to zero as illustrated by lines 5 and 6 in Figure 6.12, and money stock tends to become the original amount of base money ($200). In other words, money stock tends to approach to base money; that is, 100% money. Fluctuations of a currency ratio, say, caused by the withdrawal of deposits due to recessions, only affect functional-money and loans, but do not affect the base money as the reader can easily confirm by running the companion model. This is the main reason why Irving Fisher advocated that 100% money attains monetary and financial stability in (Fisher, 1945, 1935). This issue will be further investigated in Chapter 14.

6.2.3 Limit to the Gold Standard System

If base money backed by gold is fixed under gold standard, how can we increase money stock to meet the need for increasing transactions as our economy continues to grow? Let us ask differently. What's the maximum amount of money stock the gold standard system can provide?

From the equation (5.20), under the fixed amount of base money, only money multiplier can change the money stock (base), and money stock accordingly. Since currency ratio is not under the direct control of the central bank, the only discretionary policy the central bank can exercise is a change in the required reserve ratio, as already shown above. Hence, money multiplier could be maximized if the required reserve ratio is set to be zero (!), and commercial banks are allowed to fully make loans out of all deposits. In this case, money multiplier becomes $m = (0.2 + 1)/0.2 = 6$ and the maximum money stock (base) increases from 800 to 1,200.

Historically, base money backed by gold had been increased in two different ways: (i) Gold mining and (ii) Appreciation of gold price.

(i) Gold mining. Well-known story is the California Gold Rush (1848 - 1855). On January 24, 1848 gold was found by James W. Marshall at Sutter's Mill in Coloma, California, which brought approximately 300,000 people to California from the rest of the US and abroad. Private banking business flourished in California and the West, and commercial banks there began to issue their own coins and banknotes backed by the newly mined gold, like Miners Bank of San Francisco in1849, and Bank of D. O. Mills, Sacramento, California, in 1853.

(ii) Appreciation of gold price. A de facto gold standard was adopted by England in 1717 when the Master of the Mint, Sir Isaac Newton (a founder of differential equations), produced a report "On the State of the Gold and Silver Coin" and fixed the value of the guinea (approximately one-quarter ounce of gold) at twenty-one shillings. A century later in 1819 the gold standard was formally adopted. In 1834 the United States, formally under a bimetallic (gold and silver) standard, switched to gold de facto, and fixed the price of gold at \$20.67 per ounce.

This rate was maintained for a century long until 1933 when, after the Great Depressions in 1929, the newly-elected President Franklin D. Roosevelt closed the banks to stop bank runs on the gold reserves at the Federal Reserves Bank of New York. That is, FDR increased the price of gold from \$20.67 to \$35 per ounce according to the Gold Reserve Act (established on January 30, 1934) that authorized him to devalue the gold dollar by 40%, As a result, the government's gold reserves increased in value from \$4,033 billion to \$7,348 billion; 82% increase in gold reserves. In our simulation models above, this is the same as to appreciate the value of gold certificates from \$200 to \$364, increasing money stock from \$800 to \$1,456.

To maintain the gold standard, the Bretton Woods agreement was created in 1944 by all of the Allied nations during the World War II in Bretton Woods, New Hampshire. In those days, the United States held the majority of the world's gold and dollar exchange was set at \$35 per ounce. Under this agreement, its member countries are obliged to convert their currencies into gold only through dollars indirectly at their pegged currency values to dollar. In this sense, this is not a genuine gold standard but a gold-dollar standard. Yet, the pressure of appreciating gold price continued due to the growing demand for gold, because the deficits of US balance-of-payments steadily reduced her gold reserves, and confidence of redeeming gold by the US continued to decline. On August 15, 1971, President Richard M. Nixon announced that the United States would no longer redeem currency for gold. In those days, the United States didn't have political and economic power to appreciate gold price once again as FDR did in 1934, say from \$35 to \$70 per ounce, against the growing demand for gold as a means of payments. The final step of abandoning the gold standard historically took place in 1971. The gold standard lasted only for 255 years since the first adoption of de facto gold standard by Sir Isaac Newton in 1717, a short period over a long monetary history.

How can central banks, then, increase money stocks under a fractional reserve banking by abandoning the historical gold standard system? Our analysis of debt money system continues.

Collaspse of Gold Standard (Commodity Money)

History has proved that there exist no general equilibrium in this (N+1) market economy with money. It is the collapse of the gold standard that uses gold as commodity money. Under the gold standard, gold coins have been used as *legal tender* separately from gold as material. The gold standard, however, did not last long either. There was a shortage of gold material as the Nth good, and it became impossible to cast gold coins as the (N+1)st commodity money. That is, US President Nixon made a historical proof in 1971 that the gold (commodity) money economy based on the monetary general equilibrium theory failed to survive.

So let's take a brief look at the history leading up to the collapse of the gold standard. In Britain, the de facto gold standard started when a quarter ounce of gold was decided to be 21 shillings in 1717 by Sir Isaac Newton (then Master of the Royal Mint) who established classical mechanics and calculus. A century later, in 1819, it became the official gold standard. In the United States, in 1834, 1 ounce = \$20.67 became the de facto gold standard. This gold price was used for a century until 1933. In order to calm the bank run immediately following the Great Depression in 1929, President Roosevelt raised gold prices, under the Gold Reserve Act of 1934, to 1 ounce = \$35, yet the gold standard began to collapse globally around this time.

In order to protect the gold standard, the Bretton Woods system of 1944, by maintaining the conventional 1 ounce = \$35, has shifted to a gold-dollar standard system in which gold can only be exchanged for dollars. However, gold production could not keep up with the growth of the international economy and trade volumes, and the price of gold began to rise due to the increase in demand for gold. And the outflow of gold from the United States to Europe has not stopped. Under such situations, President Nixon was forced to stop the dollar-gold convertibility in August 1971. The so-called "Nixon shock" announcement has historically put to an end the gold standard. Since then, to this day, the world's monetary system has transitioned to a managed monetary system that is no longer backed by gold. From these historical events, there exists at present no monetary system in which commodity such as gold is used as money. Commodity money theory based on the gold standard is no longer the analytical subject of monetary theory.

6.3 Discount Loans to Banks

6.3.1 Discount Loans: Flow Approach Simulations

Let us assume that a growing economy has to meet an increasing demand for money from non-banking public sector (producers and households). Under the circumstances without gold standard, commercial banks are now entitled to freely borrow from central bank at a discount (lower) interest rate. Then they make loans to a non-banking public sector at a higher interest rate to make arbitrage profits.

This process of money creation is easily modeled as an expansion to the gold standard model by adding a stock of discount loan in the assets account of the central bank, and that of debts in the liabilities account of commercial banks, as illustrated in Figure 6.13 [Companion model: 2 Money(Loan).vpmx].

Under the gold standard in the above model, the maximum amount of money stock to be created is limited to $800 when $\beta = 0.1$. Suppose the demand for money from the economic activities is $1,200. To meet this additional demand for money of $400, the amount of $100 worth of gold is further needed under the gold standard, since the economy's money multiplier is 4. Line 1 and 2 in Figure 6.14 illustrates how money stock is increased by the increase in the amount of gold by $100; that is, the amount of gold deposited increases to $300 from $200.

Due to the limitation of gold standard, it eventually becomes impossible to meet a growing demand for money by increasing more gold to the gold standard system. In this way, historically, gold standard has been repeatedly suspended in 1930s and finally abandoned in 1971 as briefly discussed above.

Instead of increasing gold, the central bank now just prints its banknotes (legal tender) worth of $100 and make loans to commercial banks, which in turn make loans to non-banking public sector. Line 3 in Figure 6.14 illustrates how money stock is increased to $1,200 when the central bank makes discount loans of $100 at the period of 6. Vice versa, money stock is contracted when the central bank retrieves discount loans from commercial banks.

Thanks to this increase in money stock, non-banking public sector's assets also increases to $1,200, as illustrated by line 1 in in Figure 6.15. Yet its equity or wealth remains the same as the initial Gold Certificates; that is, $200 (line 2). As already examined under the gold standard, the increased amount of $1,000 is made available by the same amount of increase in debts by $1,000 (line 3) in non-financial public sector. In other words, the increase in money stock is always followed by the increase in debts. This point will be further examined in the next chapter.

By abandoning the gold standard, central bank can exercise its almighty power to create money by just making discount loans to commercial banks; a process of functional-money creation as debts by commercial banks. According to Richard A. Werner (Werner, 2003, 2003), for instance, the Bank of Japan used to exercise the so-called *window guidance* - a hidden monetary policy, through which previous governors of the BoJ intentionally assigned discount loans to the

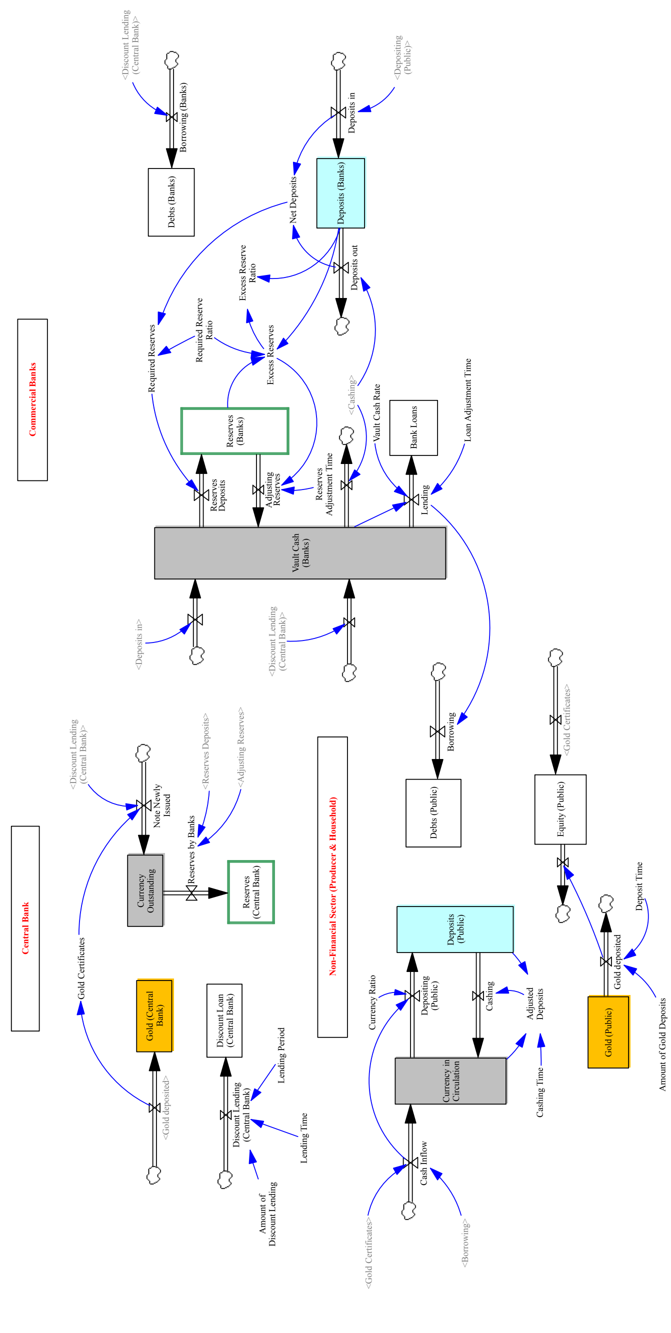

Figure 6.13: Money Creation Model out of Discount Loans to Banks

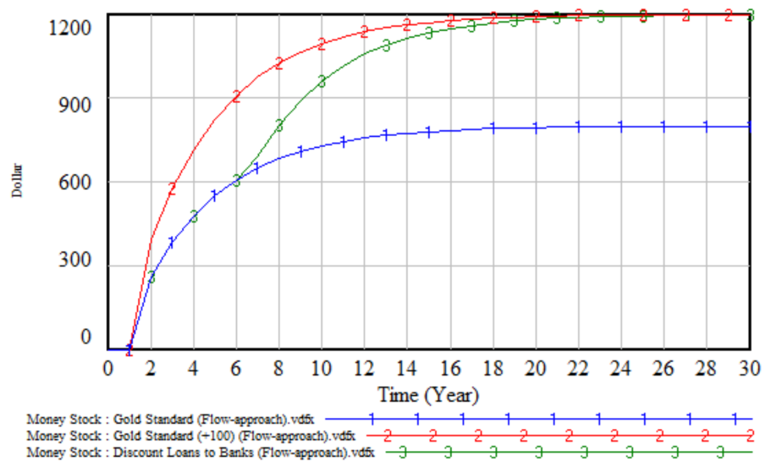

Figure 6.14: Money Stock Creation out of Discount Loans to Banks

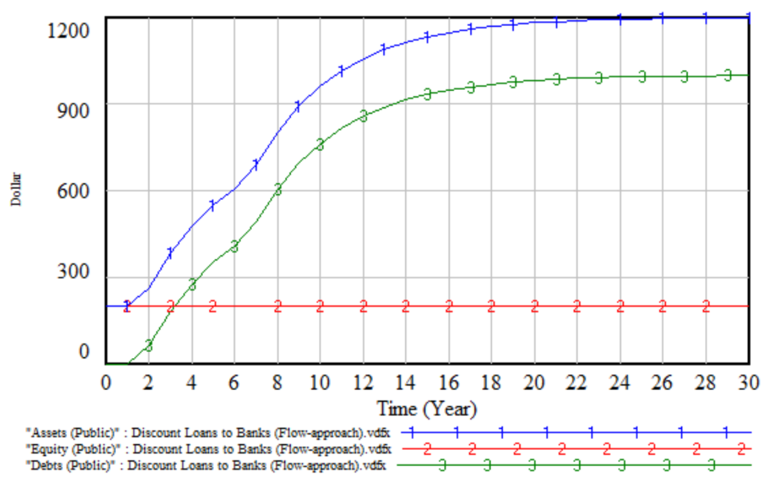

Figure 6.15: Assets, Equity and Debts

commercial banks according to their own preferences. Moreover, functional-money thus created by commercial banks can buy anything such as military weapons, economic hit men, drugs, and information of media for controlling political and economic activities in favor for those who control money stock. That is, a free-hand control of the economy is endowed to the central bank through the power of issuing its banknotes out of nothing. To restrict its power, central bank has to be, indeed, placed under the management of democratic government and people.

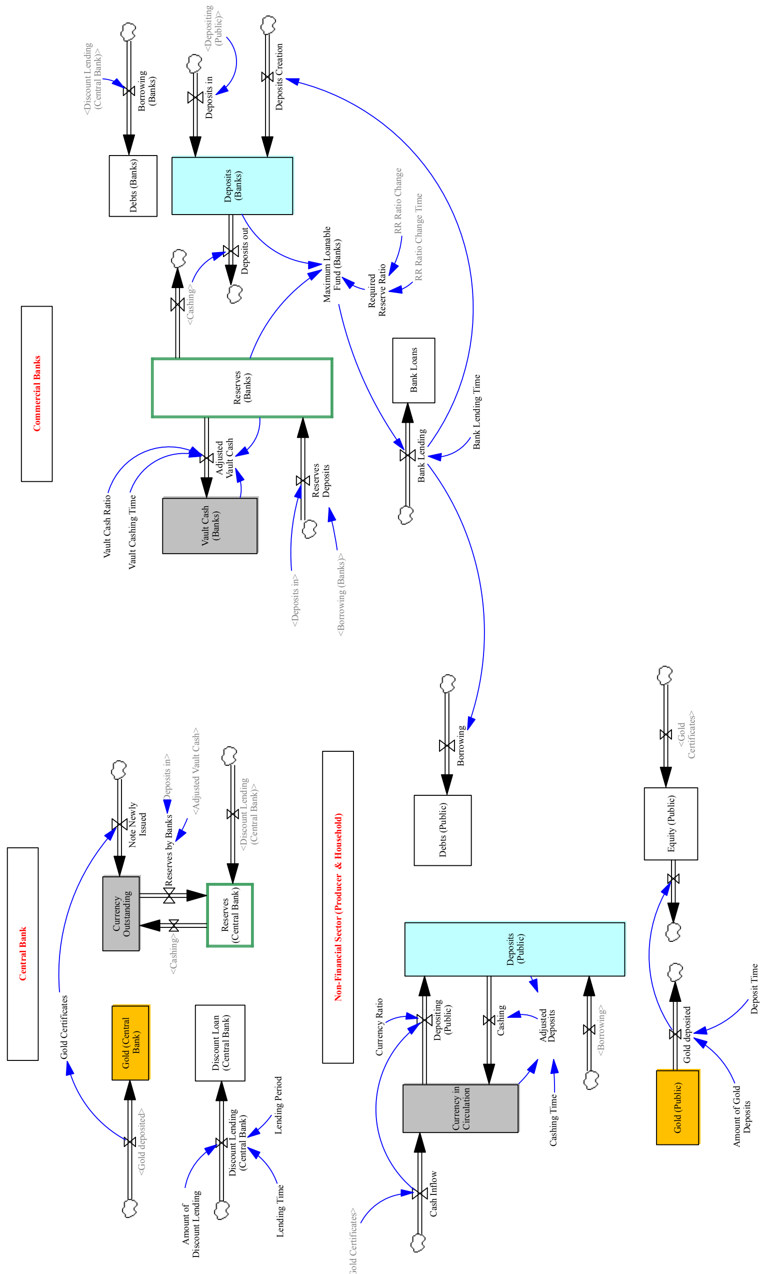

Figure 6.16: Money Creation Model out of Loan to Banks: Stock Approach

6.3.2 Discount Loans: Stock Approach Simulations

Stock approach to the money creation model out of discount loans to banks is easily built by applying a similar method to the stock approach as in the gold standard model. Figure 6.16 is the stock approach model, thus built, of the fractional reserve banking [Companion model: 2a Money(Loan-S).vpmx].

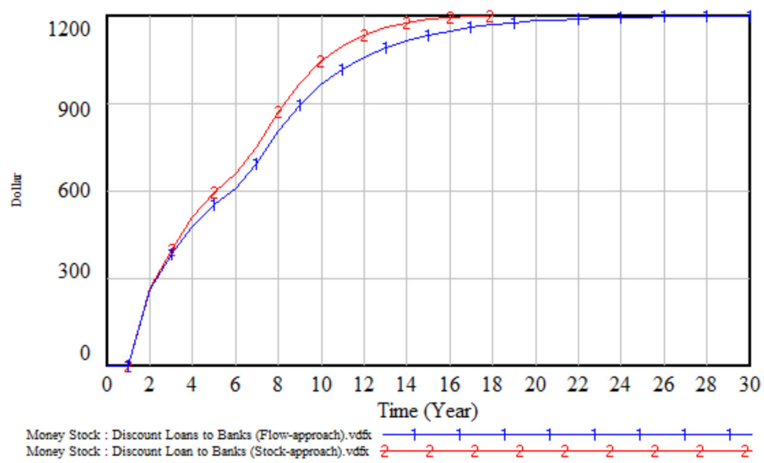

Figure 6.17: Money Stock Creation out of Loans to Banks: Comparison

Figure 6.17 compares how money stock behaves between flow and stock approaches when commercial banks borrow the amount of $100 from central bank. Line 1 indicates money stock under flow approach and line 2 under stock approach. Money stock under stock approach converges to the equilibrium level slightly faster than that under flow approach. Except these, two approaches behave in a similar fashion.

6.4 Loans to Government

6.4.1 A Complete Money Creation Model: Flow Approach

Let us now expand our money creation model to a further complete model of money creation in which government bonds are introduced and central bank can purchase them as assets and issue its banknotes for their payments as liabilities [Companion model: 3 Money(Flow-approach).vpmx]. The model consists of four sectors such as non-banking public sector (producers and households), government, commercial banks and central bank. With the introduction of government bonds, our expanded money creation model becomes a little bit complicated. To avoid a further complication the model is explained as four sub-models.

Non-Banking Public Sector (Producers and Households)

Non-banking public sector consists of producers and households (non-banking financials are excluded here). It is simply called public sector. With the introduction of government, a stock of government bonds (public) is newly added as assets. A balance sheet of non-banking public sector is illustrated in Figure **??**.

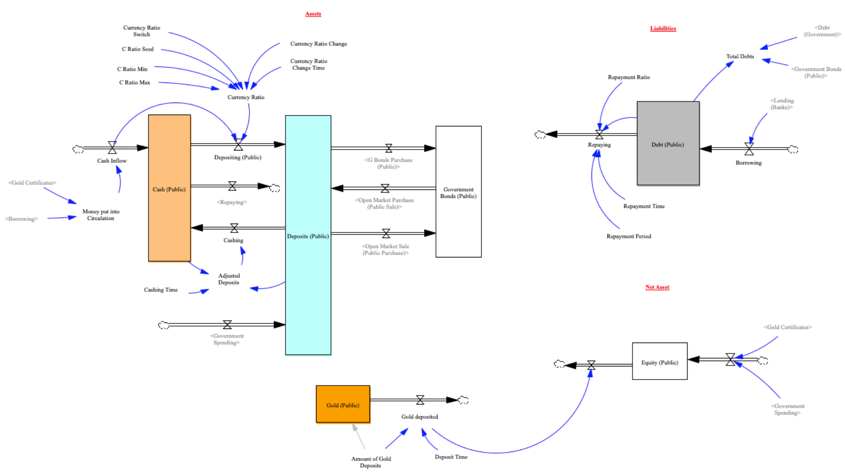

Figure 6.18: A Complete Money Creation Model: Non-Banking Public Sector

Government

Figure 6.19 illustrates a balance sheet of government, in which a stock of government deposit is added to the assets side, and stocks of its debts and its equity are added to its liabilities and net asset side, respectively.

Apparently money stock is not affected by the introduction of government bonds so long as they are purchased by households and producers and government spends the amount it borrowed within the public sector, as shown below.

Commercial Banks

A stock of government bonds held by commercial banks has to be newly added to the assets side of the balance sheet of commercial banks. Now commercial banks have a portfolio choice of investment between loans and investment on government bonds. Government bonds are paid out of required (or excess) reserves account of commercial banks with the central bank. Figure 6.20 illustrates the sector of commercial banks.

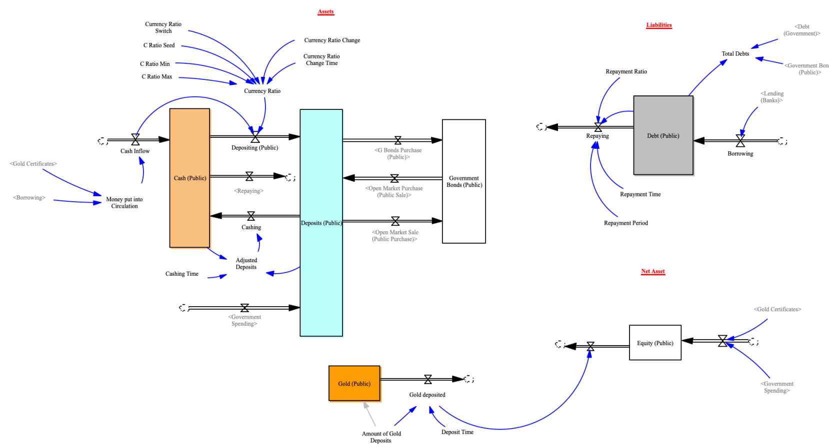

Figure 6.19: Government Sector

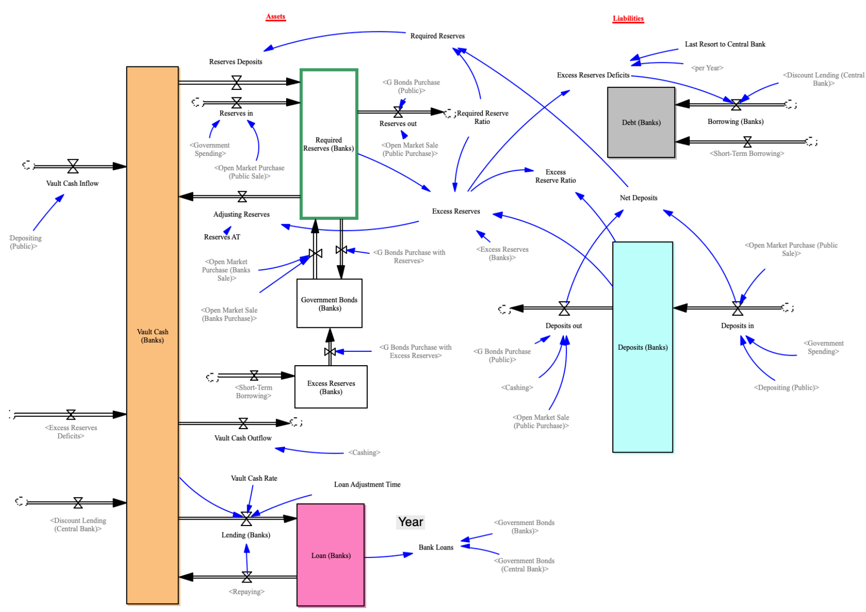

Figure 6.20: A Complete Money Creation Model: Commercial Banks

Central Bank

A stock of government bonds held by the central bank has to be newly added to the assets side of the balance sheet of the central bank. In addition, the central bank opens deposits account of government, and plays a role of government's bank. Now, the central bank can purchase government bonds (known as *open* *market purchase*), and their payments are handled through reserves account of commercial banks[4]. These transactions increase the same amount of the central bank's liabilities such as reserves, and accordingly base money.

If the central bank sells government bonds to the public sector and commercial banks (known as *open market sale*), these payments are withdrawn from reserves account of commercial banks, decreasing reserves of commercial banks by the same amount, and hence base money as a whole. Purchases and sales of government bonds by the central bank are known as *open market operations*.[5] Figure 6.21 illustrates these operations of the central bank. In this way, with the

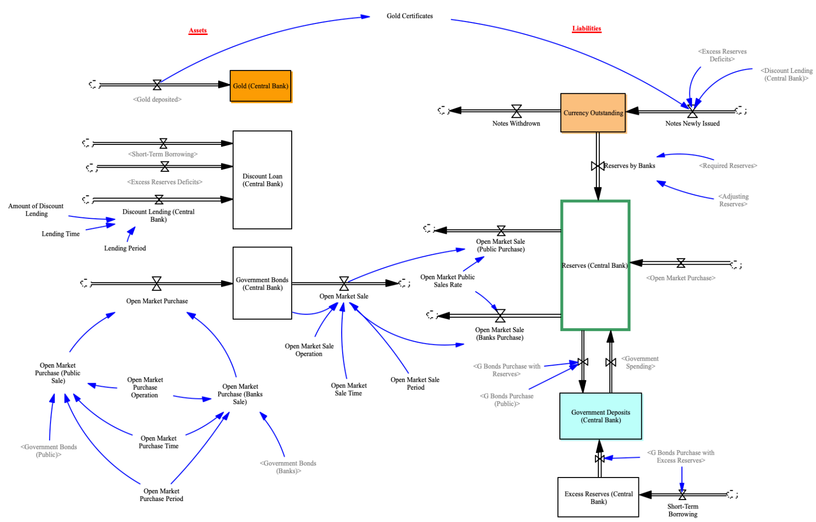

Figure 6.21: A Complete Money Creation Model: Central Bank

introduction of government bonds, the central bank has a discretionary control of base money, which, however, does not imply its direct control over money stock as generally assumed in the textbooks.

Do the Government Debts increase Money Stock?

The flow approach model of money creation under loans to government is complete. We have now to pose a question: do the government debts by newly issuing bonds increase money stock? Recently due to the influence of MMT (Modern Money Theory) such as (Wray, 2012, 2012), misperception spreads such that whenever government borrows money by issuing bonds, money stock

[4]Direct purchase of government bonds, or direct loans to government by the central bank is prohibited in Japan. Therefore, such purchases has to be indirectly performed through markets.

[5]Recently, purchases of government bonds and private bonds held by commercial banks and non-banking financials are known as *quantitative easing (QE)* policies

increases, simply because government transfers the borrowed money to the deposits account of the public, which by definition increases money stock M_1. This argument is inadequate. To answer our question, we have to consider in detail who purchases government bonds, and with which account the purchase of bonds is paid.

Purchase of Gov Bonds	with Required Reserves (Switch=0)	with Excess Reserves (Switch=1)
by the Public (Holding Ratio(Banks)=0)	M_1 no increase	M_1 no increase
by Banks (Holding Ratio(Banks)=1)	M_1 no increase	M_1 increase

Table 6.1: Money Creation by Government Bonds

From Table 6.1, it may be enough for the analysis of money creation by the government bonds to consider the following three cases.

Case 1 This is a case in which all bonds issued by the government are purchased by the public (households and producers). This case is obtained in the model by setting the parameter value at "Holding Ratio (Banks)=0". When government borrows money directly from the public, its debts move from the deposits account of the public to the government account, then go back to the public account. Hence, total amount of money stock in circulation does not increase. This is a well-known case of mainstream theory which causes *crowing-out* effect, causing only interest rate to go up. Left diagram of Figure 6.22 illustrate base money (line 4) and three money stocks (lines 1-3).

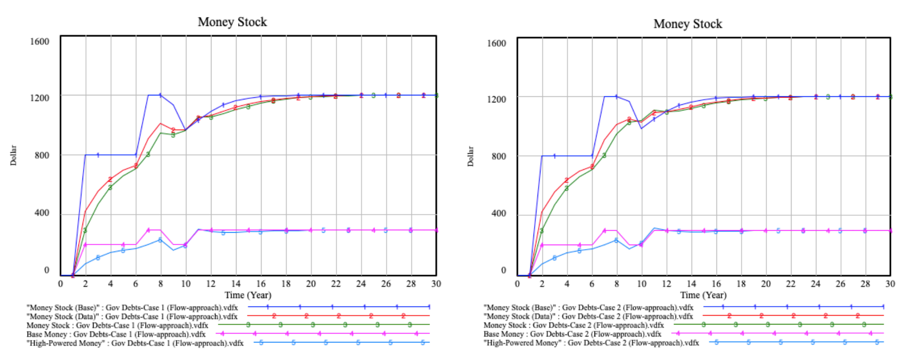

Figure 6.22: Money by Gov Debts (Flow approach): Case 1 and Case 2

Case 2 This is a case in which government borrows money directly from commercial banks, but banks purchase bonds out of their required reserve accounts. This case is obtained in the model by setting "Switch (Excess Reserves= 0". In this case base money decreases by the same amount of bonds payments, which is, however, recovered when the government spends its debts via reserves account. Temporal drops of money stocks are caused by a time lag of borrowing at t=8 and spending by government at t=10. Money stock, which is temporarily reduced due to the decrease in base money, will be eventually recovered. In this case, furthermore, a partial holding of the government bonds by the public does not eventually affect money stock; that is, any Holding Ratio (Banks) between 0 and 1 does not affect money stock at all, Right diagram of Figure 6.22 illustrates base money (line 4) and three money stocks (lines 1-3) for the case in which all bonds are held by banks; that is, "Holding Ratio (Banks)=1".

Case 3 This is a case in which commercial banks purchase all bonds from the government and pay them out of their excess reserves. The existence of excess reserves implies that banks are not making full amount of loans available under a fractional reserve banking. Hence, government debts play a role of filling in this gap of loans. MMT inaccurately seems to assume only this recessionary case. In case banks do not have excess reserves, it is assumed in the model that they make a short-term borrowing from the central bank. This case is obtained when the switch is set to be "Switch (Excess Reserves)=1" (by default). Figure 6.23 illustrates

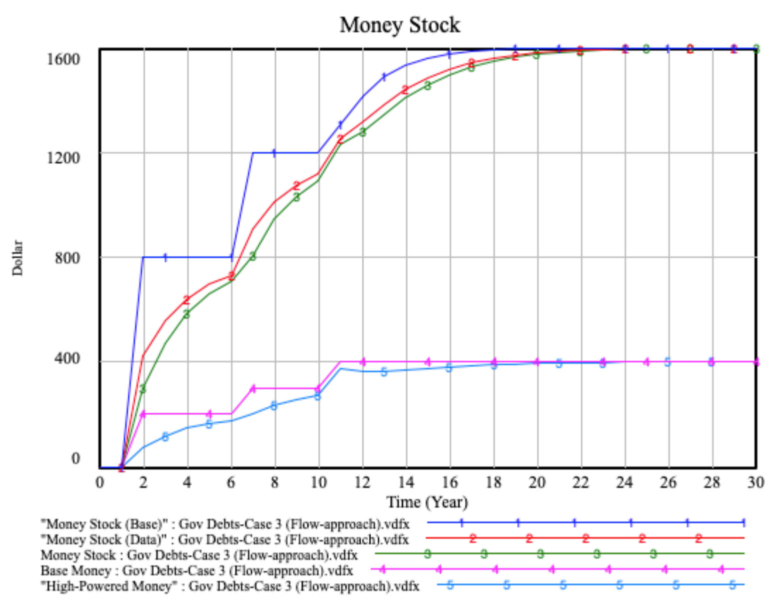

Figure 6.23: Money Creation by Government Debts (Flow approach): Case 3

this case of base money (line 4) and three money stocks (lines 1-3). It shows that base money increases from \$300 to \$400 at t=10[6] due to the issuance of bonds by \$100. Accordingly, three money stocks converge to \$1,600 (=\$400 x 4 (money multiplier)). The amount of money stocks ranges between \$1,200 and \$1,600, depending on the parameter value of the "Holding Ratio (Banks)" between 0 and 1. In conclusion, money stock can be increased by the new issuance of government bonds only in this case 3.

6.4.2 A Complete Money Creation Model: Stock Approach

A complete money creation model by stock approach is demonstrated in Figure 6.24 [Companion model: 3a Money(Stock-approach).vpmx]. The reader can run it to obtain similar simulations as in the above flow approach, then confirm the similar results.

6.5 Open Market Operations

6.5.1 Open Market Purchase: Flow Approach

Let us continue to explore how our complete functional-money creation model works under open market operations. Our simulation continues by following the above case 3; that is, banks purchase all government bonds with their excess reserves.

Figure 6.25 illustrates how open market operations affect the behavior of money stock. At the period t=16 the central bank purchases 50% of government bonds held by the public and commercial banks through open market purchase operations. Accordingly, base money (line 4) is now increased from the previous \$400 to \$440. Money stock (base) (line 1) begins to increase from 1,576.4(t=16) to 1,750.3 (t=22), while money stock (data) and money stock (lines 2 & 3) also continue to increase toward the same level.

At the period t=22 the central bank sells 50% of the government bonds it holds, and base money decreases from \$440 to \$424 next year (t=23). Money stock (base) (line 1) begins to decrease from \$1,750.3 (t=22) to \$1,697.5 (t=30). Eventually three expressions of money stock converge to this level as shown in Figure 6.25.

In this way, the central bank can increase or decrease money stock by its discretionary monetary policy of open market operations so long as commercial banks make maximum loans, as assumed in this model, under the fractional reserve banking practice. In this way, theoretically there exists no ceiling or upper boundary of money stock to be created under the current debt money system.

Even so, there is a case in which the central bank cannot control money stock. Figure 6.26 illustrates the case in which a currency ratio is additionally

[6] It is assumed here that bonds are issued at t=8, but government spent them at t=10.

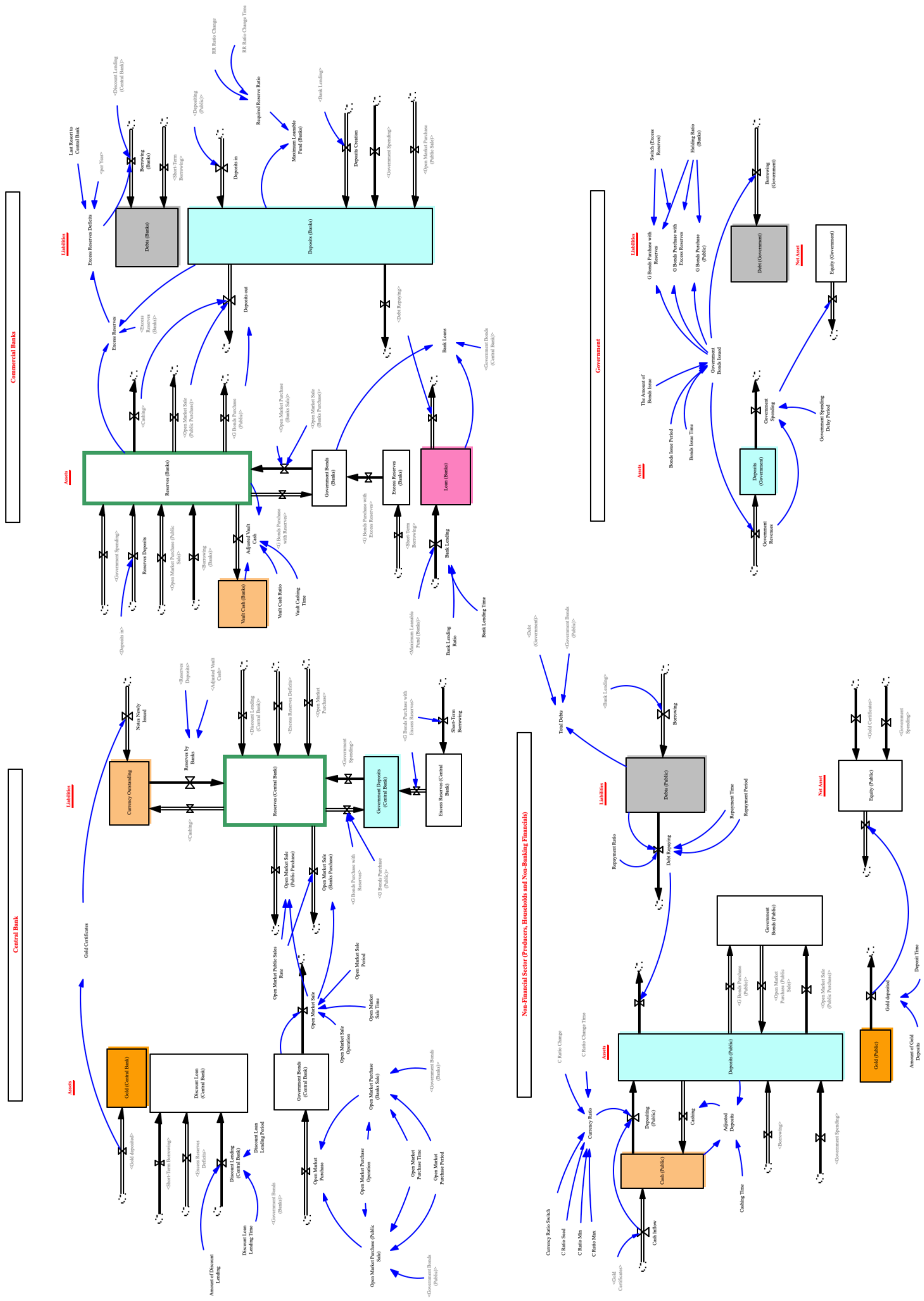

Figure 6.24: A Complete Money Creation Model: Stock Approach

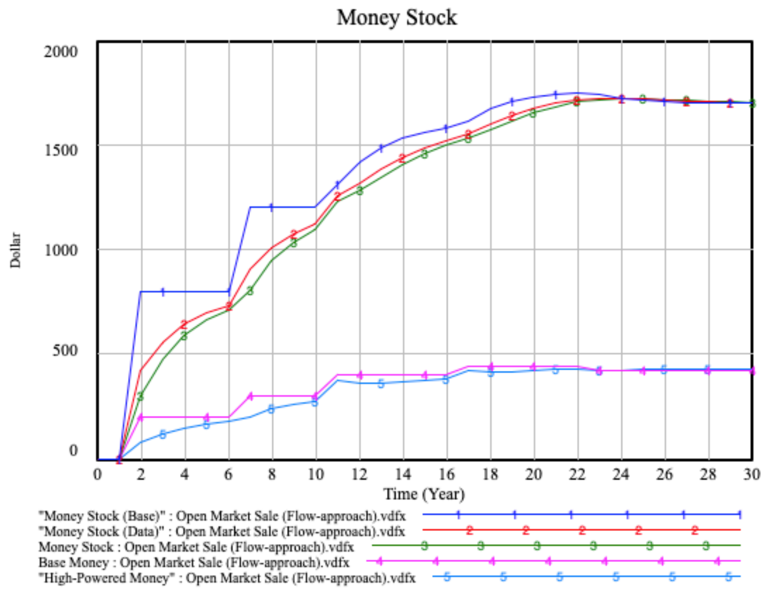

Figure 6.25: Simulation of Open Market Purchase and Sale Operations

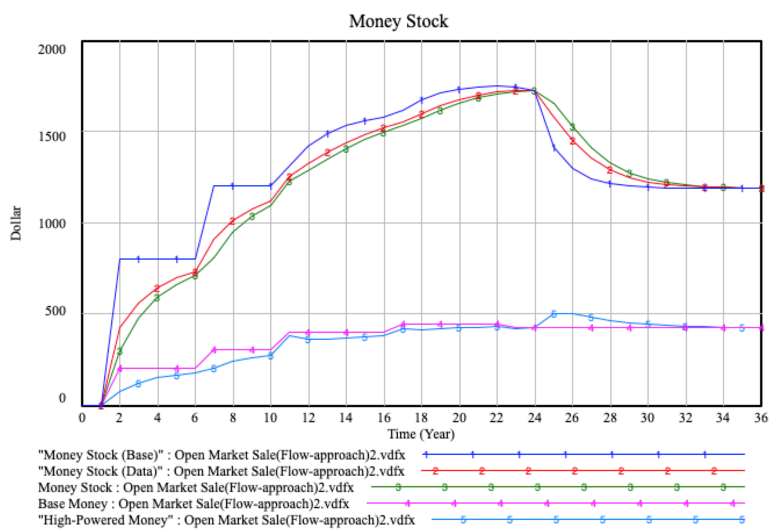

Figure 6.26: Open Market Operation with Currency Ratio Doubled

doubled from 0.2 to 0.4 at t=24, due to the economic recessions, followed by the increase in liquidity preferences. Money stock (base) tends to decrease from \$1,722.3 (t=24) to \$1,194.3 (t=30), then further to \$1,187.5 at the extended final time of t=36; that is a reduction of money stock by \$534.8. Three expressions of money stock all converge to this reduced amount at t=36.

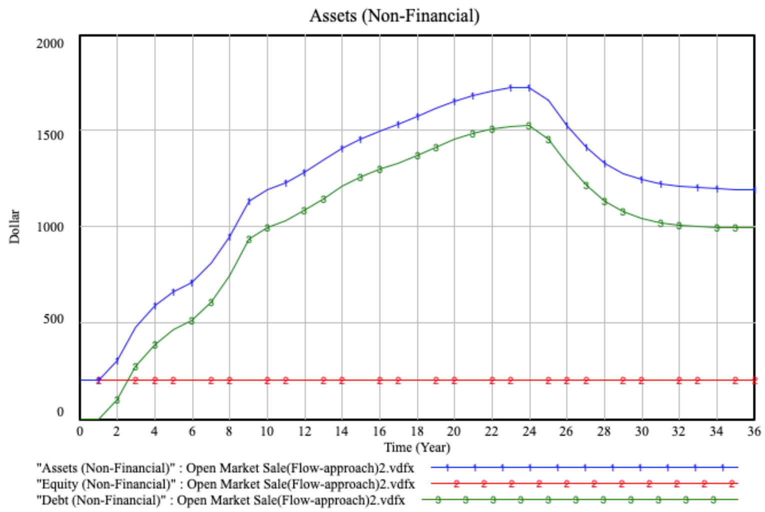

Figure 6.27: Assets, Equity and Debt of Non-Financial Sector

Finally, let us examine how the above open market operations and a change in currency ratio affect assets (line 1), equity (line 2) and debt (line 3) of non-financial sector, consisting of households, producers and government. As expected from the above analyses, it is again confirmed that the equity or wealth of non-financial sector is not affected at all as illustrated in Figure 6.27. All changes in assets are balanced by debts.

Open Market Purchase: Stock Approach

Open market behaviors of stock approach are confirmed in Figure 6.28 under the same parametric conditions, as in the open market behaviors of flow approach illustrated in Figure 6.25. The only difference is that here three different behaviors of money stock (base), money stock (data) and money stock are all merged. Furthermore, for comparison money stock behavior of flow approach is added as dotted line 6. Obviously money stocks of both approaches (line 3 and line 6) behaves similarly and all converge at t=30. Now we have completed the comparative analyses of flow and the stock approaches of money stock.

6.6 Identical Creations of Money

So far we have observed, step by step, how money stocks are increased in response to the increases in base money due to the discount loans to banks and loans to the government (bonds purchase). Our simulation results have indicated that both flow and stock approaches of functional-money creation entail

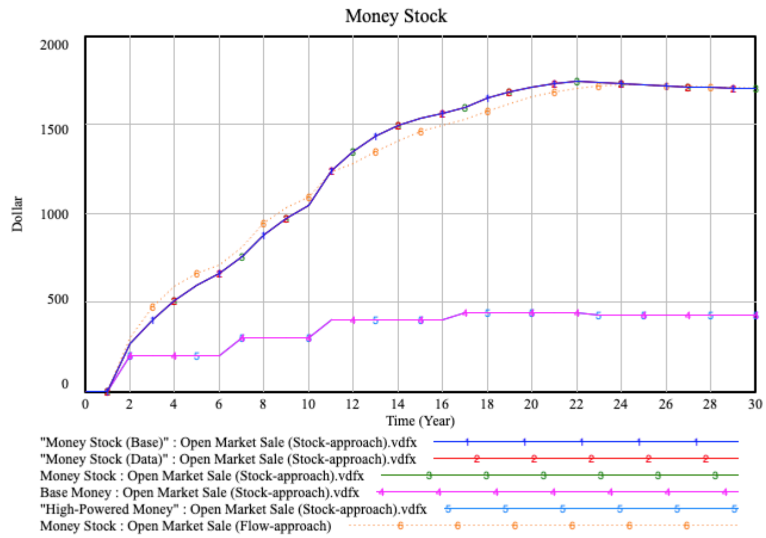

Figure 6.28: Simulation of Open Market Operation

similar behaviors of money creation. We are now in a position to compare flow and stock approaches simultaneously in terms of base money and money stock according to the following simulations.

(1) Gold Standard: \$200 by default.

(2) Discount Loans to Banks: \$100 at t=6.

(3) Government Debts: \$100 (Case 3) at t=8.

(4) Open Market Purchase: 50% purchase of existing Gov Bonds at t=16.

(5) Open Market Sale: 50% sale of Gov Bonds held by Central Bank at t=22.

Figure 6.29 illustrates the flow approach behaviors of Base Money (left-hand diagram) and Money Stock (right-hand diagram) under five different simulations; gold standard (line 1), discount loans to commercial banks (line 2), government debt (loans to the government-Case 3) (line 3), open market purchase of government bonds (line 4), and open market sale of government bonds (line 5).

To be more specific, first, base money of \$200 is assumed under the gold standard. Second, discount loans to banks is made with \$100 at t=6, which increases money stock to \$1,200. Third, government borrows \$100 (by issuing bonds of \$100) at t=8, which, increases money stock to \$1,600. Fourth, central bank exercises open market purchase of 50% of outstanding bonds (\$50) at t=16, which surely increases money stock to a new level of \$1,759 at t=30. Fifth, central bank exercises open market sale of 50% of its holding bonds at t=22, which decreases money stock to \$1,702 at t=30.

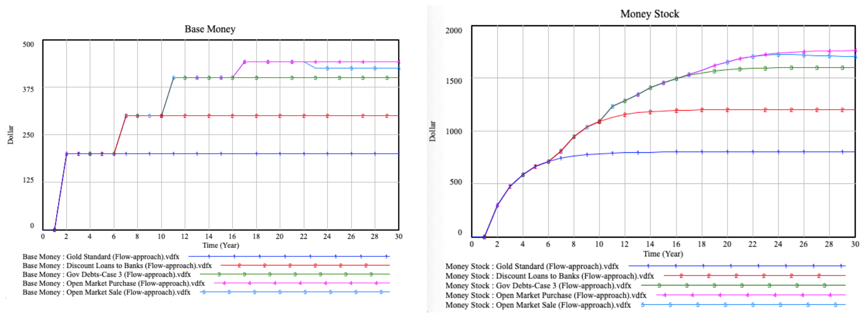

Figure 6.29: Behaviors of Base Money and Money Stock: Flow Approach

Figure 6.30 illustrates the stock approach behaviors of Base Money and Money Stock under the same simulations as in the flow approach. To be more specific, first, base money of $200 is assumed under the gold standard. Second, discount loans to banks is made with $100 at t=6, which increases money stock to $1,200. Third, government borrows $100 (by issuing bonds of $100)

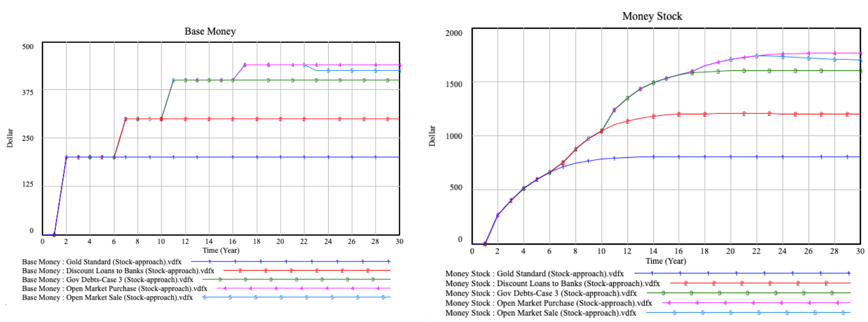

Figure 6.30: Behaviors of Base Money and Money Stock: Stock Approach

at t=8, which increases money stock to $1,600. Fourth, central bank exercises open market purchase of 50% of outstanding bonds ($50) at t=16, which surely increases money stock to a new level of $1,762 at t=30. Fifth, central bank exercises open market sale of 50% of its holding bonds at t=22, which decreases money stock to 1,700 at t=30. Except minor differences of money stock for open market purchase and sale operations, flow approach and stock approach indeed indicate similar behaviors. Consequently, the comparison of these two figures confirms that the behaviors of flow and stock approaches are almost identical, as if they are heads and tails of the identical coin. This is our mail conclusion on the flow and stock approaches of money creation in this chapter. Our simulation results here may put an end to century-long disputes among economists on the creation of money.

Inseparable Heads and Tails in Banking Practices

If flow and stock approaches are identical, which one of modeling should be used for the analysis of economic behaviors? For the macroeconomic analysis of aggregate banking sector, either approach works well.

At the microeconomic level of individual banks, however, the answer depends on the target sectors of economic analysis. In the non-banking public sector, producers and non-banking financial institutions are constantly in a state of liquidity deficiency and need to borrow from banks, while consumers tend to make deposits.

Under the circumstances, if consumers are main clients of banks, these banks tend to hold excess reserves, out of which loans are made first to derive arbitrage interest incomes between deposits and loans. Hence, for the analysis of such banking practices, the flow approach of banks (say, the heads of the coin) that masquerade as intermediaries may be appropriate.

If producers and non-banking financial institutions are main clients of banks, the stock approach of functional-money creation (say, the tails of the coin) may be appropriate for analyzing their banking practices. These banks make large amount of loans first, then adjust to their reserve requirements later through interbank call-money market, etc. Hence, the selection between flow and stock approaches depends on target sector of analysis so long as the analysis objectives are at a microeconomic level.

In real banking transactions at the microeconomic level, however, both practices of flow and stock approach coexist and become impractical to distinguish one from another. This coexistence might have confusingly misled economists into either or tails camp, or "three main theories of banking" according to the classification of Werner (Werner, 2016, 2015), as already discussed above. Under these confusions, bankers who wish to hide away their practice of functional-money (or deposits) creation out of nothing tended laboriously to support flow approach of "banks as intermediaries".

Our ASD macroeconomic modeling analyses have successfully revealed the equivalence of flow and stock approaches as the heads and tails of the identical coin. Even so, it's worth drawing attention to the reader that significant differences in banking practices exist at the individual banking level. Let us continue our journey.

Conclusion

We have started this chapter by defining money as legal tender according to the definition by the Greek philosopher Aristotle. Under the current debt money system legal tender is created by the privately-owned central bank as base money. Commercial banks then create deposits as functional-money out of nothing under the fractional reserve banking. Deposits thus created only function as money so long as they are accepted for transactions.

Concerning this functional-money creation process, two or three different theories have been presented in the history of economics. They are called flow and stock approaches in this chapter according to our accounting system dynamics modeling method.

For the analysis of functional-money creation, six sectors in the previous chapter are rearranged to three sectors: central bank, commercial banks and non-banking public sector. This modeling process inevitably requires a distinction between currency in circulation and currency outstanding, and accordingly high-powered money and base money that have been traditionally treated equivalently in macroeconomics. These distinctions lead to three different concepts of money stock; that is, money stock (base), money stock (data) and money stock.

Our comparative analysis is carried out first under gold standard. It is shown that, in the flow approach, money stock (data) obtained from actual economic data tends to overestimate true money stock based on high-powered money. It is also shown that three expressions of money stock tend to converge one another as long as vault cash held by commercial banks diminishes. It turned out that these different behaviors of money stock are fully merged in the stock approach.

These comparative analyses continue to the models in which functional-money is created out of loans to commercial banks and government by introducing the central bank's discount loans and purchase of government bonds. Then we have obtained that behaviors of money stock are approximately identical between the flow and stock approaches as if they are the heads and tails of the same coin.

Throughout the functional-money creation processes, it is also demonstrated that the increased assets in non-banking public sector due to functional-money creation are always balanced by the same increased amount of debts. In consequence, the equity or wealth of non-banking public sector is not affected, and remains the same under three models such as gold standard, discount loans to commercial banks and loans to the government.

Our simulation results of functional-money creation may put an end to century-long disputes among economists on the creation of money.

Questions for Deeper Understanding

1. Discuss how the money you analyzed above is indeed created out of nothing, or thin air under the following four cases by running flow-approach models:

Case 1 Central bank issues gold certificates of 100 (million) dollars against the gold deposited by the public (Run *1 Money(Gold).vpmx*).

Case 2 Central bank makes loans of 100 (million) dollars by newly issuing its banknotes to commercial banks, which in turn use them to make loans to the public, that is, non-banking public sector such as producers and households (Run *2 Money(Loan).vpmx*).

Case 3 Government newly issues its bonds of 100 (million) dollars, and commercial banks purchase them by borrowing money from the central bank. In other words, both government and commercial banks borrow. Additionally discuss how the balance sheet accounts of the central bank and commercial banks are affected by these transactions. Moreover discuss how debts and equity accounts of the government are affected by them (Run *3 Money(Flow-approach).vpmx*).

Case 4 Under the situation of the above case 3, the central bank now purchases 50% of the government bonds trough Open Market Purchase Operations (Run *3 Money(Flow-approach).vpmx*).

2. In a history of economic thoughts, two different approaches to the money creation process out of nothing have been provided. The stock approach was dominant till 1935, then this approach completely disappeared, as if it is a taboo subject, from the economic teaching till around 2014. On the other hand, flow approach has dominated since Hayek (1929) and Keynes (1936) till recently, simply because this approach misguides banks as mere intermediaries of money in circulation. These two approaches are fully discussed in this chapter. Considering a recent popularity of stock approach of money creation, it is essential to fully comprehend the nature of money with the model of stock approach.

   Run the comprehensive money creation model of stock approach:
   3a Money(Stock-approach).vpmx. Then, perform the following simulations:

   (1) Gold Standard: \$200 by default.

   (2) Discount Loan to Banks: \$100 at t=6.

   (3) Government Debt: \$100 at t=8.

   (4) Open Market Purchase: 50% purchase of existing Gov Bonds at t=16.

   (5) Open Market Sale: 50% sale of Gov Bonds held by Central Bank at t=22.

   Save these simulation results and answer the following questions.

(a) Draw a diagram that compares how Money Stock gets increased or decreased under these simulations.

(b) Draw a diagram that compares how Assets and Debts of non-banking public sector get affected under these simulations.

(c) Draw a diagram that compares Base Money and Money Stock, and discuss the relations among Base Money, Money Stock and Money Multiplier.

(d) Discuss how government debt (by issuing bonds) affects Money Stock.

Chapter 7

Money as Debts

Following the previous chapter that has focused on the back face of money in our classification table of money, this chapter[1] continues to explore the nature of money from the front face of money. That is, money stock is considered here as the sum of public money and debt money. Then, debt money is shown to be equal to total debts. Since public money is negligible under the the current debt money system, it is asserted that money stock is determined by the amount of total debts. This assertion is confirmed as a case study in Japan.

Accordingly, this chapter tries to analyze how total debts are endogenously determined by the behaviors of those who come to banks to borrow such as producers, households and government, and attitudes of banks to make loans to them. We have focused on the destruction of money stock, and identified three main causes of monetary destruction. Then simulations are carried on to find out how these causes destroys money stock. Failures of quantitative easing policies are shown to be produced by the combination of these causes, as well as monetary instability. Finally monetary instability is shown to be subdued by introducing 100% required reserve ratio.

7.1 Money Stock $\simeq$ Total Debts

Front Face of Money: Public vs Debt Money

We have explored in the previous chapter how functional money is created out of nothing under the fractional reserve banking system by focusing on base money as legal tender. Our analysis there was based on the back face of money in our classification tables of money such as Tables 5.2 and 5.5. Consequently our

[1]This chapter is partly based on the paper (Yamaguchi and Yamguchi, 2016, 2016): The Heads and Tails of Money Creation and its System Design Failures – Toward the Alternative System Design – in "Proceedings of the 34th International Conference of the System Dynamics Society", Delft, the Netherlands, July 17-21, 2016.

analysis has been carried out by following the monetary equation such that

$$\text{Money Stock } = \text{Legal Tender } (M_0) + \text{Functional Money } (M_f) \tag{7.1}$$

More specifically, only the maximum amount of money stock that is allowed by a fractional reserve has been analyzed. In this sense, our analysis constituted the *supply side* of money creation.

In the same classification tables, money is, as its front face, classified as

$$\text{Money Stock } = \text{Public Money } + \text{Debt Money} \tag{7.2}$$

Public money is referred to as the money that is issued by public (sovereign) authorities *at interest-free*, while debt money as the one issued by private banks *at interest*. Figure 7.1 is conceptually the same as Tables 5.2 and 5.5 in the previous chapter except that it emphasizes a creation process of functional-money M_f out of nothing from base money M_0 as legal tender. In addition,

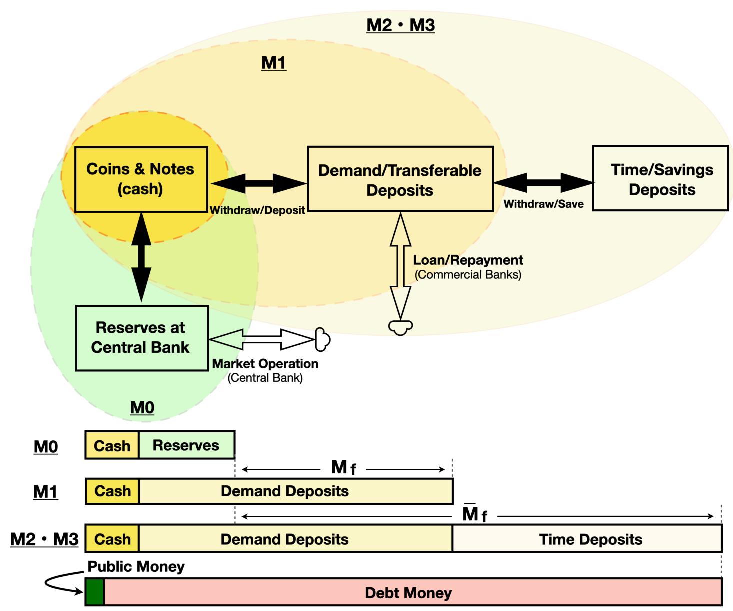

Figure 7.1: Money Stock = Public Money + Debt Money

debt money is illustrated to dominate the whole money stock. In fact, public money is shown in Table 5.5 to occupy only 0.3% in Japan. Accordingly, this chapter explores the nature of money from a front face of mostly *debt money* such as who borrowed how much; that is, *demand side* of money creation.

Figure 7.2 [Companion model: 4a Money(Stock-Instability).vpmx[2]] illustrates these two different classifications of money, front face and back face, which are represented by the equations (7.1) and (7.2), respectively. Equation

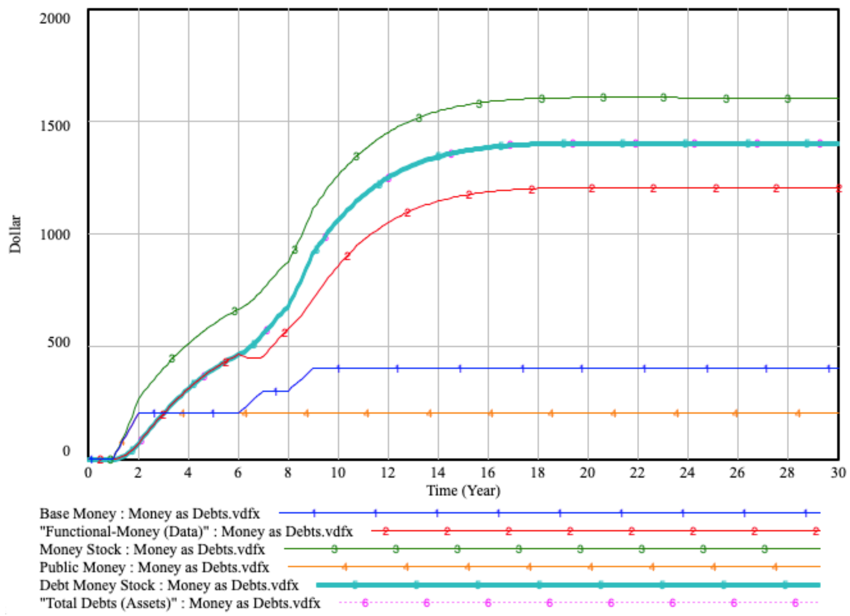

Figure 7.2: Debt Money = Total Debts

(7.1), back face, is illustrated as

Money Stock (line 3) = Base Money (line 1) + Functional Money (line 2).

In the model, money stock is \$1,600 and functional money is \$1,200, while base money consists of gold certificates (\$200), discount loans to commercial banks (\$100) issued at t=6, and government securities (\$100) issued at t=8.

Equation (7.2), front face, is illustrated as

Money Stock (line 3) = Public Money (line 4) + Debt Money (line 5).

Public money here only amounts to gold (certificates) of \$200, and debt money is \$1,400.

Debt Money ≃ Total Debts

Historically, public money has been the only money widely used as a means of transactions and payments as legal tender. In this sense, from the beginning of

[2]In this chapter due to the heads-tails nature of money creation we exclusively use a slightly extended stock-approach model of 3a Money(Stock-approach) used in the previous chapter. Its package model is available from the author's web site.

our monetary history money has been treated as

$$\text{Money Stock } = \text{Public Money } = \text{Legal Tender} \tag{7.3}$$

as indicated by the quotation of Greek philosopher Aristotle (384-322 BC) in the previous chapter.

When transaction and payment businesses were taken over by private banks and a fractional reserve banking system was introduced under the control of central banks, the entity of money stock had drastically changed such that functional money as bank deposits began to be created out of nothing by commercial banks as shown in the following relation:

$$\text{Money Stock } = \text{Public Money (Gold)} + \text{Functional Money} \tag{7.4}$$

Under the gold standard, gold has been public money. Accordingly our gold standard model in the previous chanter is constructed to reflect this monetary history, and our analysis of money creation started with the gold standard.

After the abandonment of global gold standard in 1971, only metallic coins of governments have survived as public money. Aa a result, base money as legal tender has become a mixture of public money and debts money such that

$$\text{Legal Tender} = \text{Public Money (Coins)} + \text{Debt Money (Banknotes \& Reserves)} \tag{7.5}$$

In this way, debt money has become nowadays

$$\text{Debt Money} = \text{Debt Money (Banknotes \& Reserves)} + \text{Functional Money} \tag{7.6}$$

Where does debt money come from, and how is it determined, then? In the previous chapter only functional money was demonstrated to be created as bank deposits by commercial banks out of nothing. Where does a remaining portion of debt money (bank notes and reserves) come from? To answer these questions, let us define total debts as the sum of these two types of debt money; that is, bank notes, reserves and functional money. Then our question becomes where do total debts come from? We can answer it in two different ways.

Assets approach of loans by banks and central bank

Total debts can be calculated as total assets of loans by banks and government securities held by banks and central bank. This is,

$$\begin{aligned} \text{Total Debts} &= \text{Loans (Banks)} \\ &+ \text{Government Securities (Banks)} \\ &+ \text{Government Securities (Central Bank)} \end{aligned} \tag{7.7}$$

Liabilities approach of debts by the public sector and government

Another way to obtain total debts is to calculate total liabilities as the sum of debts that non-banking sectors, such as the *public sector* (producers and households) owe to the banks and government debts.

$$\text{Total Debts} = \text{Public Debts} + \text{Government Debts} \tag{7.8}$$

where Government Debt is defined in the model as

$$\text{Government Debts} = \text{Debt (Government)} - \text{Government Securities (Public)} \tag{7.9}$$

That is, securities held by the public sector (households and producers) are excluded from the government debt because the government does not borrow from the banks. Total debts thus obtained in two different ways become identical as our model in this chapter demonstrates.

From Figure 7.2, we can easily observe that

$$\text{Debt Money (line 5)} = \text{Total Debts (line 6)} \tag{7.10}$$

We have confirmed this equality under all simulations we have carried out in the previous chapter. This implies that debt money as part of our money stock is always determined by the total amount of debts producers, households and government borrow from banks as a whole. Banknotes and reserves as a part of debt money are also determined by the amount of total debts by non-banking sectors. This answers the question posed above. In this way, demand for debts by non-banking sectors determines the amount of debt money.

Money Stock ≃ Total Debts

From the case analysis of Japan, Table 5.5 in the previous chapter, public money (coins) constitutes only 0.3% of money stock M_3, almost negligible. Nowadays, this situation of public money is comparable in many countries where central banks issue banknotes as legal tender. Hence, from equations (7.2) and (7.10) we have

$$\text{Money Stock} \simeq \text{Debt Money} = \text{Total Debts} \tag{7.11}$$

Moreover, this also implies, from equation (7.1), that

$$\text{Debt Money} \simeq \text{Legal Tender } (M_0) + \text{Functional Money } (M_f) \tag{7.12}$$

Figure 7.3 is produced to analyze the case in which gold as public money becomes negligible. That is, gold deposits of \$200 is replaced with the same amount of discount loans to banks, which now adds up to \$300 at t=6.

This figure also confirms equation (7.11) as

$$\text{Money Stock (line 3)} = \text{Debt Money (line 5)} = \text{Total Debts (line 6)}$$

where money stock etc. are all \$1,600.

Equation (7.12) is similarly confirmed as

$$\text{Debt Money (line 5)} = \text{Base Money (line 1)} + \text{Functional Money (line 2)}$$

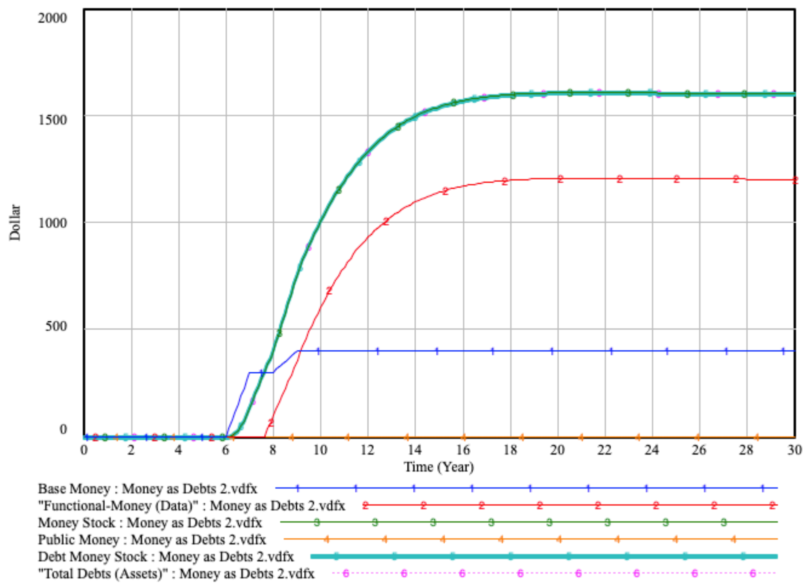

Figure 7.3: Money Stock = Debt Money = Total Debts = $M_0 + M_f$

where debt money is \$1,600, base money is \$400 and functional money is \$1,200.

This relation implies that base money consisting of discount loans to banks could be created by central banks as legal tender (M_0) out of nothing only when someone comes to central banks to borrow. Someone in this case are commercial banks. Then, debts by commercial banks are passed on to those of non-banking sectors later, because debt money equals their total debts. The reader can easily confirm that someone could also be government when central banks purchase government securities as their open market purchase operations.[3]

In addition to functional money (M_f) that is created out of nothing, we have now revealed that almost all money stock (more then 99%) are created only when non-banking sectors come to banks to borrow. Under the modern debt money system, money stock is created out of nothing as two stages. First, by central banks as creation of legal tender or base money, then by commercial banks as creation of functional money or bank deposits. In this way all money stock is issued at interest under a debt money system, and interest incomes thus raised from debt money issuance are shared within central banks and commercial banks. We will explore this issue of income distribution among banking and non-banking sectors in the next chapter.

[3] In this model, government securities are assumed to be purchased the banks out of their excess reserves that are made available through the discount loans to banks.

7.2 Balance Sheet Analysis of Money Stock as Total Debts

7.2.1 Macroeconomic Cosmos of Six Sectors

In order to understand that money stock is endogenously created by the demand side of total debts, it is effectual to look at our economy from the highest level of its aggregation conceptually.[4] Figure 7.4 illustrates balance sheets of six macroeconomic sectors: central bank, commercial banks, the government, producers (non-financial corporations), households and overseas. By looking at

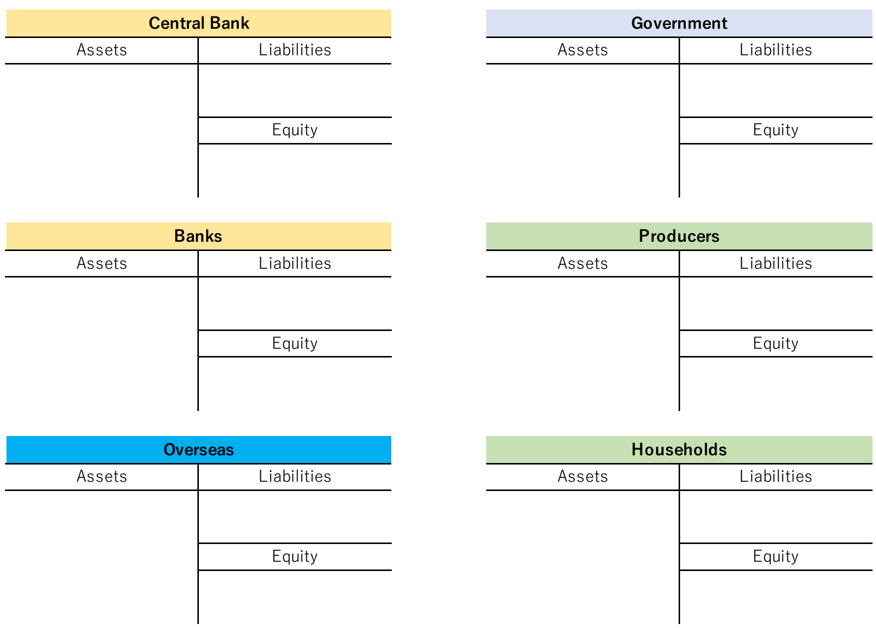

Figure 7.4: Balance sheets of Six Sectors as Worksheet of Macroeconomy

changes in their balance sheets, Flow of Funds approach adopted by the central banks attempts to inclusively look at our national economy by describing inter-sector transactions among these six aggregate sectors. Therefore, Flow of Funds in our economy can be thought of as transactions between institutions within and across sectors. In other words, these six sectors constitute the simplest cosmos of macroeconomy in which behaviors of economic system emerge. In this way, demand processes of money creation in our macroeconomy can be

[4]This section is excerpted from the paper: Money Stock Equals Total Debts by Banks, presented in the Parallel Session: Money and Finance (14:30 - 15:20) on Tuesday, July 23, 2019, at the 37th International Conference of the System Dynamics Society, Albuquerque, New Mexico, USA.

described in its simplest form by using the worksheet format shown in Figure 7.4.

Quadruple-Entry Bookkeeping

In accounting system each transactions are recorded with double-entry bookkeeping rules for financial reporting and business management as discussed in Chapter 3. Similarly, for any transaction in macroeconomic analysis, each transaction reflects changes in respective accounts of at least two or four involved sectors due to the need for tracing flow of funds between sectors. This is known as *double double-entry* or *quadruple-entry bookkeeping*, which theoretically ensures balances in accounts of all sectors involved in every transaction in the economy, and equality in the amount of transaction items appearing in asset and liability sides. The former rule is referred to as *balance sheet test* and the latter as *flow of funds test*, respectively. These tests are incessantly applied to validate our ASD macroeconomic models constructed in this book. They are similarly applied to our numerical examples of the following worksheets.

Payments through Deposits Transfer

All inter-sector transactions represents flows of funds in the national economy. Payments are made through transfer of deposits from one sector to another. Therefore, existing deposits are decreased from payers account while corresponding amounts are increased in payees account following the quadruple bookkeeping rule.

7.2.2 Producers going into Debt

Transaction steps of producers are listed as below.

Transactions of Producers

1. Producers request 1,000 million dollars of bank loan as Debts (Producers).
2. Banks approve the loan applications, open deposits account for producers and make loans by crediting 1,000 million dollars. Simultaneously, Producers receive 1,000 million dollars as Demand Deposits (P) as assets.
3. Banks borrow 10 (=1,000 x 0.01) million dollars from Central Bank as CB Debts to meet the required reserve ratio of 1%.
4. Producers pay, out of their Demand Deposits (P) account, wages of 970 million dollars to households and interest of 30 million dollars to banks (3% interest rate per year).
5. Banks process these payment requests from Producers by transferring to households Demand deposits (H) account and to their interest earnings (Equity) respectively.

(Start with Debts (F) of 1,000 million yen)

Central Bank

Assets		Liabilities	
		Reserves	10
G Bonds			
		G Deposits	
CB Loans	10		
		Equity	

Government

Assets		Liabilities	
G Deposits		Debts (G)	
		Equity	
		G Expenditures	
		Interest	

Banks

Assets		Liabilities	
Reserves	10	CB Debts	10
		Demand Deposits (P)	1,000
Bank Loans	1,000		-970
			-30
G Bonds			
		Demand Deposits (H)	970
		(of Bankers)	30
		Time Deposits	
		Equity	
		Interest	30
		Dividends	-30

Producers

Assets		Liabilities	
Demand Deposits (P)	1,000	Debts (P)	1,000
	-970		
	-30		
		Equity	
		Income	
		Costs (Wage	-970
		Interest	-30

Households

Assets		Liabilities	
Demand Deposits (H)	970	Debts (H)	
(of Bankers)	30		
Time Deposits		**Equity**	
		Income (Wages)	970
		Interest	
		Dividends (Bankers)	30

Figure 7.5: Money Creation by Bank Loans - Producers

6. Banks pay dividends to shareholders. Shareholders of banks are called bankers and also belong to households sector. Demand Deposits (of Bankers) account.

In step 1, producers incur debts by taking loans while corresponding amount of deposits are credited to their bank account, thereby increasing the balance-sheets of banks. Figure 7.5 illustrates change in balance-sheets as a result of these transactions.

7.2.3 Households going into Debt

Transaction steps of households are listed as below. Figure 7.6 illustrates the balance sheets from these transactions.

(Start with Debts (H) of 1,000 million yen)

Central Bank

Assets		Liabilities	
		Reserves	10
G Bonds			
		G Deposits	
CB Loans	10		
		Equity	

Government

Assets		Liabilities	
G Deposits		Debts (G)	
		Equity	
		G Expenditures	
		Interest	

Banks

Assets		Liabilities	
Reserves	10	CB Debts	10
		Demand Deposits (P)	970
Bank Loans	1,000		
		Demand Deposits (H)	1,000
G Bonds			-970
			-30
		(of Bankers)	30
		Time Deposits	
		Equity	
		Interest	30
		Dividends	-30

Producers

Assets		Liabilities	
Demand Dep	970	Debts (P)	
		Equity	
		Income	970
		Costs (Wages)	
		Interest	

Households

Assets		Liabilities	
Demand Deposits (H)	1,000	Debts (H)	1,000
	-970		
	-30		
(of Bankers)	30	**Equity**	
Time Deposits		Income (Interest)	-30
Houses	970	Dividends (Bankers)	30

Figure 7.6: Money Creation by Bank Loans - Households

Transactions of Households

1. Households decide to purchase houses and request 1,000 million dollars of Loans from Banks as Debts (Households)
2. Banks approve the applications, open Demand Deposits account for households, then make loans of 1,000 million dollars.
3. Banks borrow 10 (=1,000 x 0.01) million dollars from Central Bank to meet the required reserve ratio of 1%.
4. Households can now readily use Demand Deposits account for payments and pay 970 million dollars to producers.
5. Households incur debt obligation and pay interests of 30 million dollars on their loans to banks (interest rate of 3% per year).
6. Banks process these requests for payments by Households by transferring to producers' deposits account and interest earnings to their Equity.
7. Banks pay dividends out of their Equity to bankers (households)'s demand deposits account.

7.2.4 Government going into Debt

Transaction steps of the government are listed as below. Figure 7.7 illustrates the balance sheets from these transactions.

Transactions of Government

1. Government issues Bonds worth of 1,000 million dollars as Debts (G) in Liability in order to finance its deficits.
2. Banks underwrite those newly issued Bonds of 1,000 million dollars out of their Reserves at Central Bank.
3. Central Bank processes the payment request by transfering 1,000 million dollars from Bank's Reserves to G Deposits accounts at the central bank.
4. Government is ready to use Deposits at the central bank for its expenditure. Specifically it pays welfare subsidies of 970 million dollars to households and interest of 30 million dollars on the bonds held by banks (3% interest rate).
5. Central Bank and Banks transfer subsidies from the Government to households deposits account through Reserves account, and interest to their Equity.
6. Banks borrow 10 (=1,000x0.01) million dollars from Central Bank to meet the required reserve ratio of 1%.
7. Banks pay dividends out of their Equity to bankers (households)'s demand deposits account.

(Start with Debts (G) of 1,000 million yen)

Central Bank

Assets		Liabilities	
		Reserves	-1,000
G Bonds			970
			30
			10
		G Deposits	1,000
CB Loans	10		-970
			-30
		Equity	

Government

Assets		Liabilities	
G Deposits	1,000	Debts (G)	1,000
	-970		
	-30		
		Equity	
		G Expenditur	-970
		Interest	-30

Banks

Assets		Liabilities	
Reserves	-1,000	CB Debts	10
	970		
	30	Demand Deposits (P)	
	10		
Bank Loans			
		Demand Deposits (H)	970
G Bonds	1,000	(of Bankers)	30
		Time Deposits	
		Equity	
		Interest	30
		Dividends	-30

Producers

Assets		Liabilities	
Demand Deposits (P)		Debts (P)	
		Equity	
		Income	
		Costs (Wages)	
		Interest	

Households

Assets		Liabilities	
Demand Deposits (H)	970	Debts (H)	
(of Bankers)	30		
Time Deposits		Equity	
		Income	970
		Interest	
		Dividends (Bank	30

Figure 7.7: Money Creation by Bank Loans - Government

Observations

Reserves of banks decreased as a result of investment in government bonds at transaction step 3. All of these payment transactions are reflected in the liability side of central bank's balance sheet. Hence, no money creation occurs when bank *lend* their money to the government in the form of investment in government bonds.

However, as in cases of bank loans to producers and households, bank lending to the government will eventually lead to creation of new deposits once the government spend back as its expenditures to producers and households (transaction step 5 above). Money stock, or more precisely M1 in Figure 7.1, increases at this stage.

7.2.5 Central Bank's Operation of Purchasing Assets

Central Bank

Assets		Liabilities	
		Reserves	-1,000
G Bonds	600		970
			600
			12
		(Dividends payment)	18
			10
		G Deposits	1,000
CB Loans	10		-970
			-12
			-18
		Equity	
		Interest	18
		Dividends	-18

Government

Assets		Liabilities	
G Deposits	1,000	Debts (G)	1,000
	-970		
	-12		
	-18	**Equity**	
		G Expenditur	-970
		Interest (Bar	-12
		Interest (CB	-18

Producers

Assets		Liabilities	
Demand Deposits (P)		Debts (F)	
		Equity	
		Income	
		Costs (Wages)	
		Interest	

Banks

Assets		Liabilities	
Reserves	-1,000	CB Debts	10
	970		
	12	Demand Deposits (P)	
	18		
	10		
	600	Demand Deposits (H)	970
Bank Loans		(of Bankers)	12
		(of C Banker	18
G Bonds	1,000		
	-600	Time Deposits	
		Equity	
		Interest	12
		Dividends	-12

Households

Assets		Liabilities	
Demand Deposits (H)	970	Debts (H)	
(of Bankers)	12		
(of C Banker	18		
Time Deposits		**Equity**	
		Income	970
		Interest	
		Dividends (Bankers)	12
		Dividends (C Bankers)	18

Figure 7.8: Money Creation by Purchase Operation of Assets

Let us now consider a case where central bank perceives the need for monetary easing and conducts market purchase operation. Market operations by central bank essentially purchase existing financial assets held by financial institutions such as banks. This results in injection of additional liquidity into bank's reserve accounts at the central bank. Transaction steps of central bank are listed as below.

Transactions of Central Bank

1. Central Bank purchases G Bonds of 600 million dollars from banks.

2. Government divides interest payment of 30 million dollars on its bonds according to its holding ratio: 12 million dollars goes to banks and 18 million dollars goes to central banks respectively.

3. Eventually those interest earnings are payed out as dividends to shareholders. 18 million dollars goes to Central Bankers' demand deposits out of central bank's Equity.

4. 12 million dollars goes to Bankers' demand deposits out of banks' Equity.

Figure 7.8 illustrates all changes in balance-sheets as a result of these transactions.

Observations

Only the Bank's Reserves held at the central bank increase as a result of purchase operation by 600 million dollars while money stock remained unaffected in step 1. Therefore purchase/withdrawal operation by the central bank directly affects base money shown in Figure 7.1. Only after step 3 and 4 did money stock increase slightly as independent from market operations.

7.2.6 Money Stock equals Total Debts

By considering numerical transactions, we have looked at how money stock increases as non-banking sectors going into debt with banks. Figure 7.9 summarizes final values aggregated from each sectors to analyze relationship between debts and money stock. It is shown that total debts in the economy, 3,000 million dollars, equals the sum of money in the economy, that is, money stock of 3,000 million dollars. As explained at the beginning of this Section, demand deposits are first created as bank loans, and held by different sectors as a result of inter-sector transactions.

Debts (Loans)		Money Stock (M1) = Demand Deposits			
		Producers (Assets)		Households (Assets)	
Producers	1,000			Demand Depoists (H) (Bankers)	970 30
Households	1,000	Demand Deposits	970	Demand Deposits (Bankers)	30
Government	1,000			Demand Deposits (H) (Bankers)	970 30
CB/Government (QE)	(Sales of G Bonds only)			(Bankers) (CB Owners)	(12) (18)
Total Debts	3,000	Total Deposits			3,000
		(Details)			
		Demand Deposits (P)	970	Demand Deposits (H) (Bankers)	1,940 90

Figure 7.9: Money Stock equals Total Debts

7.3 Money Stock ≃ Total Debts: A Case in Japan

This section continues our analysis of money creation in Japan from our previous study in Chapter 5: Base Money and Money Stock: A Case in Japan.[5] We have already presented all types of money stock such as M_0, M_1, M_f, M_T and M_3 in the previous case study. For this case study, we also use the same Flow of Funds Account (FFA) statistics by the Bank of Japan. Transaction items of FFA consist of top-level domain items such as Currency and deposits (A), Deposits with Fiscal Loan Funds (B), Loans (C), Debt securities (D), and sub-items under each corresponding items in the top-level such as Currency (A-a), Deposits with the Bank of Japan (A-b), Government deposits (A-c), Bank of Japan loans (C-a), Loans by private financial institutions (C-c), Treasury discount bills (D-a),

[5]This section is based on the paper (Yamaguchi and Yamaguchi, 2019, 2019): Money Stock ≃ Total Domestic Debts – Theory of Debt Money. Its original version was presented in the Session T3009: Monetary Policy and Finance (15:30 - 17:10) on Thursday, Sept. 5, 2019, at the International Conference on Economics (EconTR2019@Ankara, Başkent University, Ankara, Turkey, organized jointly by the Econ. Dept. of Başkent University and Economics Literature Journal of World Economic Research Institute (WERI).

Central government bonds (D-b), Local government securities (D-c), etc.

Using these transaction items and following assets approach discussed in the above section, let us define Total Debts as follows.

$$\begin{aligned} \text{Total Debts} &= \text{Loans by Banks (C-c)} \\ &+ \text{Government Debts (D-a, D-b and D-c)}, \end{aligned} \tag{7.13}$$

where

$$\begin{aligned} &\text{Government Debts} \\ &= \text{Treasury Bills (D-a) (held by Banks and Central Bank)} \\ &+ \text{Central Government Bonds (D-b) (held by Banks and Central Bank)} \\ &+ \text{Local Government Secutires (D-c) (held by Banks)} \end{aligned} \tag{7.14}$$

To deepen our understanding of money creation among these amounts, we have carried out correlation analysis by applying Python's big data analysis method, and obtained their correlation coefficients in Figure 7.10. Total Debts, Loans by Banks and Government Debts defined above are denoted in the Figure by Debts, Loans (B) and Debts (G), respectively. GDP is also added to this calculation for our expanded analysis below.

	M3	MT	M1	Mf	M0	Debts
M3	1.000000	0.677165	0.908333	0.813254	0.767185	0.987053
MT	0.677165	1.000000	0.307332	0.326299	0.209650	0.630637
M1	0.908333	0.307332	1.000000	0.866260	0.872985	0.918036
Mf	0.813254	0.326299	0.866260	1.000000	0.512556	0.770464
M0	0.767185	0.209650	0.872985	0.512556	1.000000	0.825638
Debts	0.987053	0.630637	0.918036	0.770464	0.825638	1.000000
Loans (B)	0.774520	0.927800	0.474273	0.368614	0.455261	0.776685
Debts (G)	0.891453	0.282253	0.992425	0.852418	0.873479	0.908451
GDP	0.903101	0.887429	0.663505	0.666639	0.489537	0.862140

	Loans (B)	Debts (G)	GDP
M3	0.774520	0.891453	0.903101
MT	0.927800	0.282253	0.887429
M1	0.474273	0.992425	0.663505
Mf	0.368614	0.852418	0.666639
M0	0.455261	0.873479	0.489537
Debts	0.776685	0.908451	0.862140
Loans (B)	1.000000	0.442293	0.909193
Debts (G)	0.442293	1.000000	0.624227
GDP	0.909193	0.624227	1.000000

Figure 7.10: Correlation Coefficients of All Money Stocks and Debts

Additionally, Figure 7.11 illustrates heatmaps of these correlation coefficients, which indicates scales of coefficient between 0 (black color) and 1 (white color). This figure helps identify close correlations on the spot.

From these two Figure, we have identified a close correlation between M_3 and Total Debts, whose correlation coefficient is 0.987 as expected from our dis-

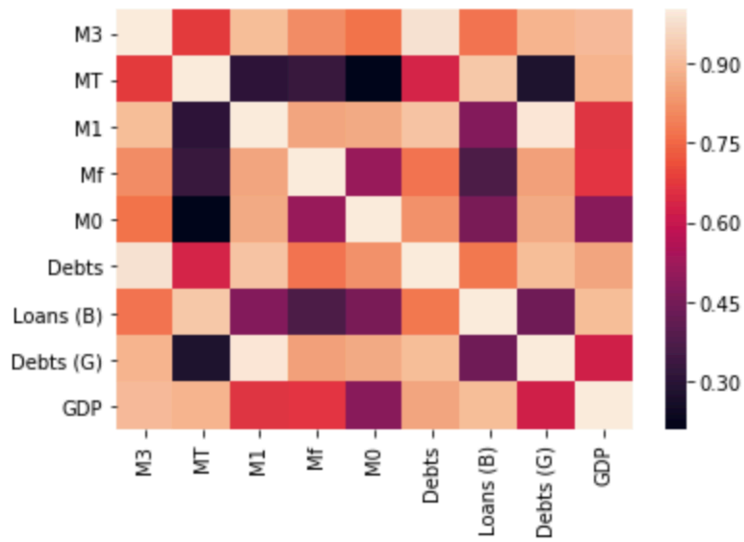

Figure 7.11: Heatmap of Correlation Coefficients of All Money Stocks and Debts

cussions above.[6] Unexpectedly, in the Japanese economy between 1980 through 2019 we have also identified two more close correlations; (1) Government Debts and M_1 with correlation coefficient of 0.992, and (2) Loans by Banks and M_T (Time Deposits) with correlation coefficient of 0.928.

Figure 7.12 illustrates time-series behaviors of these highly correlated six variables. Specifically, we have observed the following three findings.

1. Money Stock M_3 (line 1) $\simeq$ Total Debts (line 2).
   This is our main observation attained in Japan; that is, money stock M_3 is approximately equal to the total debts in Japan.[7] Moreover, we claim that this approximate relation universally holds under the debt money

[6] M_3 and Government Domestic Loans also indicate a high correlation of 0.891, which implies, as we discuss below, that a large portion of M_3 has been created by the huge amount of government debts between 1995 and 2019.

[7] A divergence is observed between money stock M_3 and the total debts, starting from around the year 1993 until 2014 - a chaotic period after her bubble burst in early 1990's through financial crisis in 2008. Our hypotheses of this divergence made in (Cavana et al., 2021, Chapter 4, 2021) are the following:

- H1 Missing transaction items that must be included in the proxy data series for total debts by banks, thereby underestimating total debts that affect money stock M_3.
- H2 Potential overlaps in one of data components in M_3 calculated from FFA statistics, thereby overestimating true value for M_3.
- H3 Inaccuracy in one of data source are included in one of components in the two proxy data series.

True causes of this divergence under debt money system must be further explored.

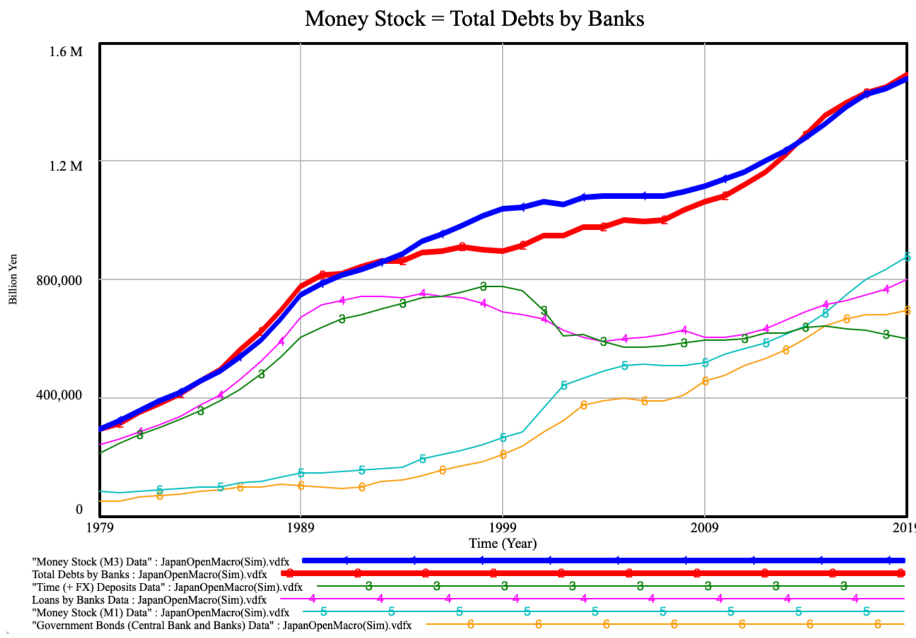

Figure 7.12: Money Stock $M_3 \simeq$ Total Domestic Debts (1980-2018)

system so that *money stock M_3 is endogenously created out of nothing by the borrowings of non-banking sectors.*

2. Time Deposits (line 3) $\simeq$ Loans by Bank (line 4).
   Time deposits in Japan are shown to be approximately equal to the sum of loans by households as housing loans and by producers as capital investment. This observation supports macroeconomic textbook explanation that savings (time deposits) are used for housing and capital investment through bank loans.

   Yet, it is essential to understand from our discussions above that a textbook causal relation of saving to investment is reversed; that is
   Loans by Banks $\Rightarrow$ Investment $\Rightarrow$ Savings (Time Deposits), not *vice versa*.

3. Money Stock M_1 (line 5) $\simeq$ Government Debts (line 6).
   Money stock M_1 used for our daily transaction payments are shown in Japan to be approximately equal to government debts.

More compactly, we have observed the following three high correlations in the Japanese economy.

$$M_3\ (\equiv M_T + M_1) \quad \simeq \quad \text{Total Debts (corr.coef } = 0.987) \tag{7.15}$$

$$M_T \quad \simeq \quad \text{Loans by Banks (corr.coef } = 0.928) \tag{7.16}$$

$$M_1 \quad \simeq \quad \text{Government Debts (corr.coef } = 0.992) \tag{7.17}$$

Equation (7.15) holds true in any economy under debt money system, meanwhile, equations (7.16) and (7.17) may be specific to Japan.

We have now confirmed the above section's argument that almost all money stock are created only when non-banking sectors (such as producers, households and government) come to banks to borrow in the case of Japanese economy. Additionally, we have found highly correlated relation of time deposits and loans by banks (to producers and households), and that of M_1 and government debts.

Causal Relations of Money Stock and Debts

Generally speaking, causal relations cannot be derived from the analysis of correlations. Yet, from our analysis of correlations based on the creation processes of money stock we could unquestionably derive the following three causal relations as equations of linear regression. First, our main finding of equation (7.15) is now illustrated in Figure 7.13. Coefficient of total domestic debts in this linear equation is 1.0166, which means that M_3 is increased almost by the same amount of total debts. In other words, money stock M_3 is created endogenously by the total debts of private sectors (producers and households) and government.

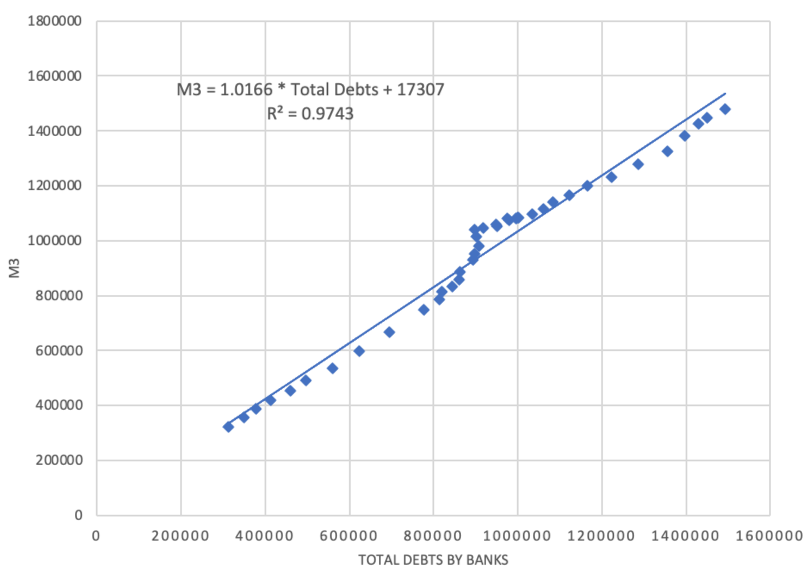

Figure 7.13: Linear Regression of M_3 as Total Domestic Debts (1980-2019)

$$M_3 = 17,307 + 1.0166 * \text{Total Debts} \quad (R^2 = 0.9743) \tag{7.18}$$

To understand our second and third findings observed above, let us further consider how bank loans are put into circulation and end up with stocks such as Demand Deposits and Time Deposits by using stock-flow diagram of system dynamics modeling of Figure 7.14. It illustrates a simplified balance sheet of banks

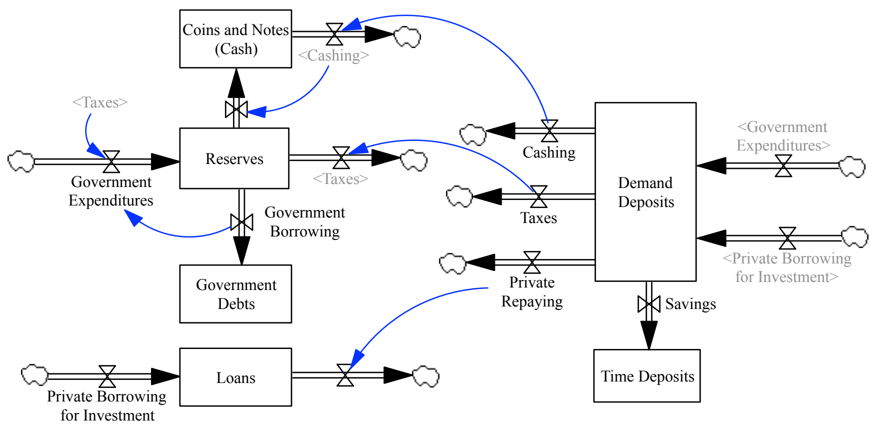

Figure 7.14: Loans ⇒ Time Deposits, and Government Debts ⇒ M1

in which money flows from banks to borrowers in terms of stocks. Specifically the following flows of payments in our economic activities are observed.

Loans ⇒ Demand Deposits ⇒ Time Deposits. Banks make loans to private sectors (producers and households) and the amount of loans becomes their assets of Loans. The amount of loans are put into Demand Deposits of private sectors, out of which some amount leaks to their Time Deposits.

Government Debts ⇒ Reserves ⇒ M_1. Banks purchase government bonds out of their Reserves. Now government spend these amounts as government expenditures through banks' Reserves to Demand Deposits (M_1) of recipients. Some amount leaks to Time Deposits.

Figure 7.15 illustrates linear regressions of our second and third findings. Their linear regression equations are obtained as follows.

$$M_T = 30,092 + 0.9012 * \text{Loans by Banks} \quad (R^2 = 0.8608) \tag{7.19}$$

$$M_1 = 26,173 + 1.1254 * \text{Government Debts} \quad (R^2 = 0.9849) \tag{7.20}$$

Equation (7.19) indicates that the increased amount of bank loans to producers and households ends up with time deposits by the factor of 0.9012. Equation

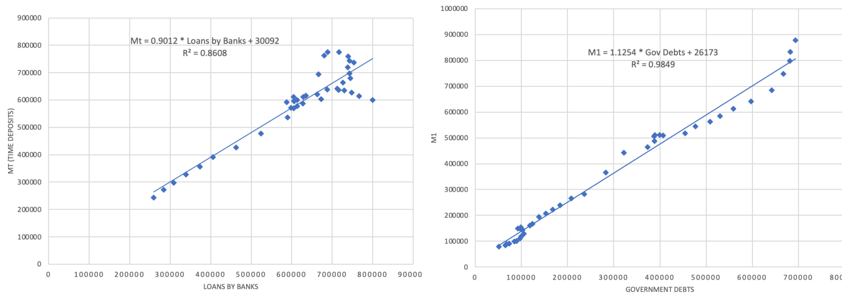

Figure 7.15: Linear Regressions of M_T and M_1 as Private and Gov. Debts

(7.20) indicates the increased amount of government debts ends up with demand deposits by the factor of 1.1254. These causal equations may be specific to the case of Japanese economy.

How M_1 (and M_3) are Created by Debts ?

Before we discuss endogenous destruction of money stock in the next section, let us briefly summarize how M_1 (and ultimately M_3) are created by debts in Japan from the borrowings of private and government sectors as Figure 7.16[8].

Debtors	Creditors	M0 (Reserves)	Mf (Deposits)	M1	GDP
Private Sectors (Producers & Households)	Banks	0	+	+	+
Governmement	Central Bank	+	-	+	0
	Banks	0	+	+	0
	Private Sector	0	0	0	0
Quantitative Easing (QE) Banks	Central Bank	+	-	0	0

(M0 + Mf = M1)

Figure 7.16: How M_1 is created by Debts?

1. Debts by private sectors such as producers and households end with the increases in M_f and M_1. They do not increase M_0.
2. Government bonds (debts) purchased directly by the central bank end with the increases in M_0 and M_1, but M_f does not increase.

[8]Impacts of debts on GDP in Japan is added in the last column as a reference to the reader. QE is briefly discussed in Section 7.5. See (Yamaguchi and Yamaguchi, 2019, 2019) for our analysis of the failures of QE in Japan.

3. Government bonds (debts) purchased by banks end with the increases in M_f and M_1, but M_0 does not increase.

4. Government bonds (debts) purchased by private sectors do not increase M_0, M_f and M_1.

5. Existing government bonds (debts) purchased by the central bank from banks (this operation is called *Quantitative Easing or QE*) end with the increases in M_0, but M_f may decrease. As a result, M_1 may not increase as expected (to be discussed below).

7.4 Endogenous Destruction of Money Stock

So far we have analyzed how money stock can be endogenously created by the demand for debts by non-banking sectors such as households, producers and government. In a similar fashion, money stock could also be endogenously destructed, causing economic instability and recessions to our economy. In this section, let us examine how endogenous destruction of money stock takes place under our debt money system.

7.4.1 Causes of Monetary Destruction

Loans Cutbacks

Debts (Public) in our model as a part of total debts is a stock amount whose stock level is determined by its inflow and outflow. Its inflow is determined by the borrowing behaviors of the public and lending attitudes of the banks.
(a) Borrowing by Producers. In Chapter 4 we have analyzed that "in a capitalist market economy producers are all the time in a state of cash deficiency". Accordingly, borrowing from banks for real investment becomes one of their options to raise fund for running their corporate economic activities. This tends to increase money stock constantly so long as the economy continues to grow. In the days of bubbles they additionally tend to borrow as much as their financial investments (such as financial securities and bonds) make quick profits. Once bubbles pop, values of their financial assets begin to plummet, which forces producers as financial investors to sell these financial assets for cash, followed by the sudden plunges of their borrowings.
(b) Borrowing by Households. Most households are also in a state of cash deficiency to buy durable goods such as automobiles and houses for better lives. Therefore, their borrowing demand constitutes a relatively large amount of demand for debts. In the days of bubbles real estates and financial securities also become their targets of financial investments. When bubbles burst, their demand for borrowing as a whole all of sudden get subdued due to an immediate decline in their expected incomes in the future.
(c) Lending by Banks. Generally speaking banks are ready to make loans so long as they can secure sound collaterals or expect higher returns from such

loans. Banks are in this way always in a position to make loans so long as there exists borrowing demand from producers and households under the debt money system. In Japan real estates have been the most favored collaterals for bank loans. As a result, so long as the prices of real estates continued to hike in the days of bubbles in late 1980's, Japanese banks made loans almost in an unlimited fashion. Once bubbles pop, their lending attitudes were quickly reversed and tried to restrict their lending.

Repayments of Debts

Now let us consider the outflow side of Debts (Public) in our models that affects total debts and money stock. Borrowers have to repay their debts, which constantly reduces the amount of debts and money stock as well. At a microeconomic level, some borrow and some repay daily, so that money stock increases or decreases daily as well. Yet money stock has to continue to be provided to sustain an economic growth. That is to say, at a macroeconomic level, borrowings as inflows of debts has to constantly exceed outflows of repayments in a growing economy. This is the essence of stock-flow analysis of system dynamics. Consequently, commercial banks continue to prosper as well under the debt money system.

Once this "inflow > outflow" relation of system dynamics breaks, money stock begins to decline, causing economic recessions and depressions. This happens when bubbles pop and all of sudden prices of financial assets begin to plummet. Under such circumstances, banks, being afraid of losing their loans, compel borrowers to make unusually earlier repayments. On the other hand, borrowers, specifically producers, find their balance sheets are sinking under water due to the depreciation of financial assets they purchased during the days of bubbles. To restore good shapes of their balance sheets, they are also forced to repay theirs debts out of the profits they earned from their normal business operations. In this way forced repayments trend take place from both sides of banks and producers (as financial investors). These unusual behaviors of forced repayments tend to decrease money stock, which is claimed to have caused decades-long prolonged recessions in Japan. Richard Koo called this type of recession *Balance Sheet Recession*(Koo, 2009, 2009).

Liquidity Preferences

Producers and households want to keep more cash or currency at hand in the days of recessions, partly because of lower interest rates and partly because of fears of losing their bank deposits. Such unstable states of their mind rush them to the banks once they receive rumors of bankruptcies; so-called *bank runs* take place any time during recessions or immediately after the bubble burst. This type of destruction of money stock really happened during the Great Depression between 1929 and 1933 in the United States, as Irving Fisher described more metaphorically as follows.

> The shrinkage of 8 billions in the nations's check-book money[9] reflects the increase of 1 billion (i.e. from 4 to 5) in pocket-book money. The public withdrew this billion of cash from the banks and the banks, to provide it, had to destroy the 8 billions of credit.
>
> This loss or destruction, of 8 billions of check-book money has been realized by few and seldom mentioned. There would have been big newspaper headlines if 8 thousand miles out of ever 23 thousand miles of railway had been destroyed. Yet such a disaster would have been a small one compared with the destruction of 8 billions out of 23 billions of our main monetary highway. That destruction of 8 billion dollars of what the public counted on as their money was the chief sinister fact in the depression from which followed the two chief tragedies, unemployment and bankruptcies. Irving Fisher(Fisher, 1945, pp. 6 - 7, 1935).

As we have analyzed in the previous chapter, liquidity preferences are represented by Currency Ratio in our models. Though it influentially affects money stock, monetary authorities such as central banks cannot control such liquidity preferences, causing endogenous instability of money stock in our economies.

7.4.2 How Destruction of Money Stock Takes Place?

We have now discussed how money stock as total debts are endogenously destroyed by the causes such as Loans Cutbacks, Repayments of Debts and Liquidity Preferences. Figure 7.17 illustrates how these three causes destroy money stocks. Line 1 indicates the maximum money stock created by the discount loans to banks, that is the same as line 3 in Figure 7.2. Destruction of money stock caused by Loans Cutbacks, Liquidity Preferences (Bank runs) and Repayments of Debts are assumed to take place simultaneously at t=10 as shown by lines 2, 3, and 4, respectively. Liquidity preferences (line 3) and repayments of debts (line 4) end up at the same level of monetary destruction in our simulation.

Historically, the Great Depression in 1929 was caused by the destruction of money stock, specifically by the Liquidity Preferences (line 3) as demonstrated by the above quotation from Irving Fisher. Financial crises in 2008, followed by the lost decades of economic recessions in Japan as balance sheet recessions, might have been caused by the Repayments of Debts (line 4). More generally, we have discussed in Chapter 4 how money stock could affect Goodwin Growth model. In this way, we could easily predict that endogenous destruction of money stock is deeply correlated with economic recessions. Therefore, understanding the causes of monetary destruction per se must be our prime concern in this chapter for further economic analyses under a debt money system.

From our discussion above, it may be more generally stated that destruction of money stock takes place by a composite mixture of Loans Cutbacks, Repayments and Liquidity Preferences. In this sense, it becomes essential to analyze

[9]Check-book money here means demand deposits or functional-money in our terminology. Meanwhile, pocket-book money here implies cash or currency.

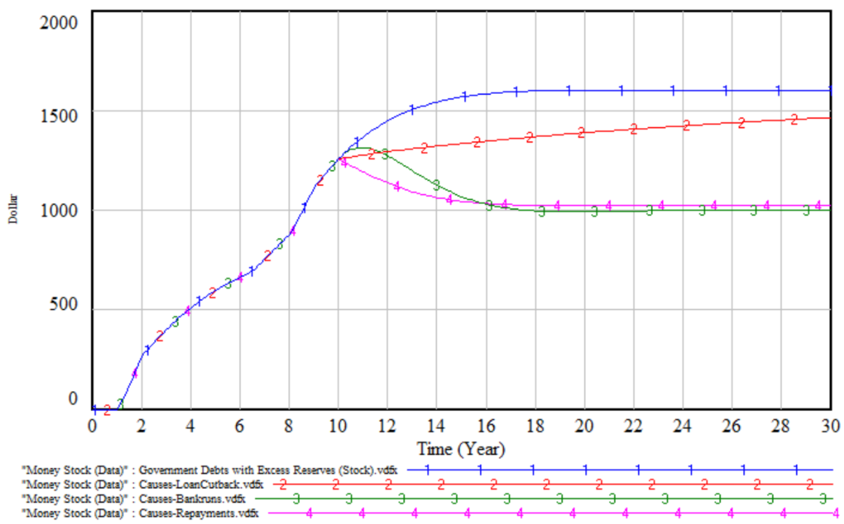

Figure 7.17: Causes of Money Stock Destruction

how money stock is endogenously destroyed by the composite combination of these three causes. Let us first start with the following composite combination of causes in order.

(1) Loans Cutbacks at t=10. Destruction of money stock starts by cutting back bank loans such that Lending Ratio = 0.3 → 0.1, and Lending Period = 3 → 6.

(2) Liquidity Preferences at t=15. Following the loans cutbacks, we now assume people prefer cash or currency, followed likely by bank runs such that Currency Ratio = 0.2 → 0.5.

(3) Repayments of Debts at t=20. Finally, forced repayments start taking place such that Repayment Ratio = 0 → 0.2.

Left-hand diagram of Figure 7.18 illustrates how destruction of money stock takes place as a composite behavior along with the order specified above; that is, lines 2, 3 and 4 against the original level of money stock (line 1).

What will happen if the composite combination of three causes takes place in a reversed order as follows?

(a) Repayments of Debts at t=10. That is, Repayment Ratio = 0 → 0.2.

(b) Liquidity Preferences: Bank runs at t=15. That is, Currency Ratio = 0.2 → 0.5.

(c) Loans Cutbacks at t=20. That is, Lending Ratio = 0.3 → 0.1, and Lending Period = 3→6.

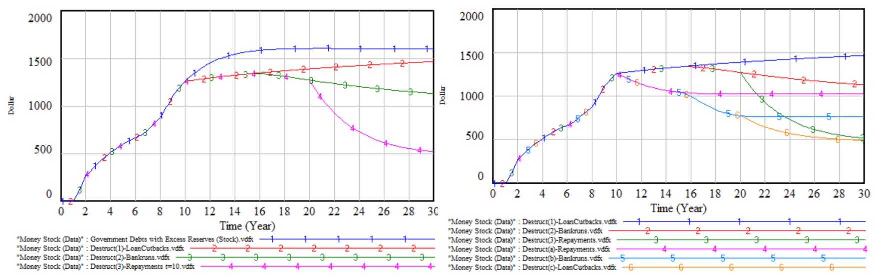

Figure 7.18: Destruction of Money Stock Compared

Right-hand diagram of Figure 7.18 illustrates how money destruction takes place in a reversed order; that is, lines 4, 5 and 6, respectively. The first simulation of destruction processes is shown by lines 1, 2 and 3, respectively in the same right-hand diagram. We can easily observe that the reversed order of causal appearances destroy money stock faster than the first original order. In this way, the order of causal appearances can be said to affect the destruction speed of money stock, and the levels of economic recessions. Theoretically speaking, there are 6 combinations of composite order appearances. Our insight obtained here will be of practical help for empirical researches of economic recessions.

7.5 Open Market Operations as QE

After bubble burst in 1990s Japan has been suffering from decades-long recessions. Traditional Keynesian monetary and fiscal policies all failed. Under such circumstances, the Bank of Japan took an abnormal policy called Quantitative Easing (QE). It is an expanded version of open market operations. That is, the BoJ purchaseed government securities intensively and increased bank reserves (base money) with an expectation that this rapid increase in base money sends a signal of expected inflation (target of 2%) to the markets so that it stimulates bank lending, which eventually lead to the increase in money stock, and economic growth. After the financial crises in 2008, many OECD countries are obliged to follow the BoJ's QE policies. Yet, all such policies failed.

What went wrong with QE policies? Using the above analytical reasonings we try to investigate here root causes of these failures. Let us first trigger recessions at t=10 as balance sheet recessions such that repayments of debts increases from 0 to 20%. Left-hand diagram of Figure 7.19 illustrates a prolonged destruction of money stock to $1,025.

To rescue from this shortage of money stock, and following recessions, government now implements Keynesian fiscal policies by issuing securities (second time) of $100 at t=15. Simultaneously at t=18, central bank enacts its QE policy by purchasing 50% of the government securities for 2 years. The QE policy increases base money from $500 to $628; that is, 25.6% increase. This increased base money successfully restores money stock from $1,044 at t=15 to $1,582

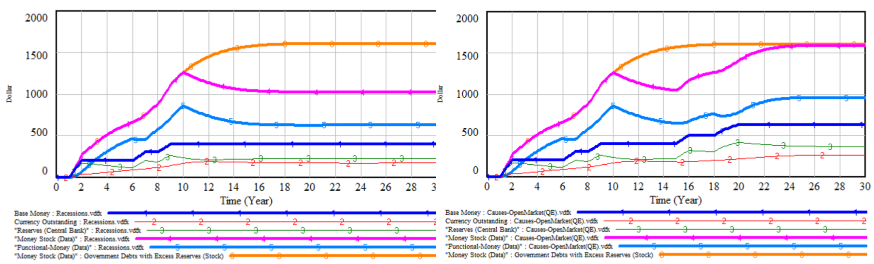

Figure 7.19: Recessions and Open Market QE policy

(close to the original level of \$1,600) at t=30; that is, 51.5% increase. In this way, the QE policy seems to have successfully expanded money stock thanks to government debts followed by the QE policy of the central bank as illustrated by the right-hand diagram of Figure 7.19. This is the so-called *reflationary theory* proposed by mainstream economists. In other words, they claim that central bank can control money stock as if it is exogenously manipulated by the amount of base money. Their claims seem to work under *ceteris paribus* conditions.

In reality, the QE policies didn't work as predicted by the reflationary theory.[10] That is, money stock failed to increase as base money increases. Let us continue our simulation to reproduce this failure. One such failure may be produced if we can trigger a cause of Loans Cutbacks simultaneously at t=20 when QE policy is introduced such that Lending Ratio = 0.3 → 0.2. This assumption may be justified because bank loans are still being discouraged when QE policies are introduced.

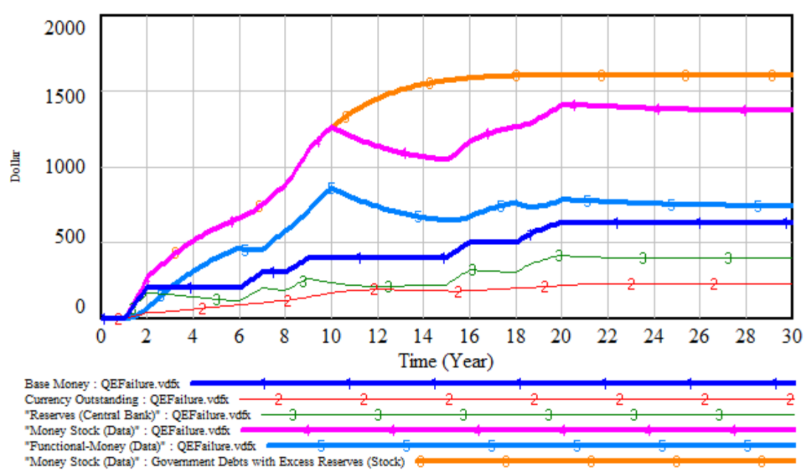

Figure 7.20: Failure of QE policy

[10]For the case of QE failure in Japan, see our paper (Yamaguchi and Yamaguchi, 2019, 2019): Money Stock ≃ Total Domestic Debts – Theory of Debt Money, Section 7.5: Implication 3: Failures of QE Policies.

Figure 7.20 indicates how money stock failed to increase after t=18 against the increase in base money. Money stock increased from $1,260 at t=18 only to $1,369 at t=30; that is, only 8.6% increase against the base money increase in 25.6%. This simulation suggests that the QE policy in this simulation failed to stimulate bank loans. Our ASD model is successful to refute the mainstream reflationary theory such that expected inflation with lowered interest rate will increase bank loans, and eventually stimulate economic growth.

7.6 Monetary Instability

So far we have discussed how money stock can be endogenously created and destroyed, and showed even central bank cannot stabilize money stock. We now examine how monetary instability could take place in our model.

Cyclical Random Walk of Liquidity Preferences

For this purpose Currency Ratio is now assumed to be determined by the following cyclical random walk behaviors. That is, Liquidity Preferences of households are governed by business cycles and random walks as follows.

$$\begin{aligned} \text{Currency Ratio} = 0.2 & \\ & + (\text{SIN}(2*\text{Pi}*\text{Time}/\text{Business Cycle Period})*\text{Business Cycle Scale} \\ & + \text{RANDOM NORMAL}(\text{Min, Max, C Ratio Mean, C Ratio SD, Seed}) \end{aligned} \tag{7.21}$$

where SIN is a trigonometric sine function and RANDOM NORMAL is a random normal distribution with minimum and maximum ranges of tails. Parameter values of these functions are assigned as follows: Pi = 3.14159, Business Cycle Period = 8 years, Business Cycle Scale = 0.07, Min = -0.2, Max = 0.2, C Ratio Mean = 0, C Ratio SD (Standard Deviation) = 0.2, and Random Walk Seed = 10. As a period of business cycle, we have assumed Juglar cylce of 8 years. Figure 7.21 illustrates two separate behaviors of business cycle and random normal distribution of currency ratio.

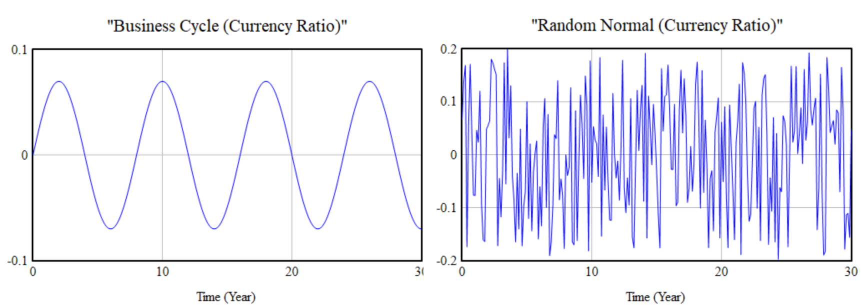

Figure 7.21: Business Cycle and Random Normal Distribution

In addition to a composite behavior of these two cyclical random walk, we have assumed a bullish lending attitude of loans by banks from the beginning of t=1 such that Lending Ratio=0.3→0.6, and Lending Period=3→1. As a result we have obtained an extremely volatile behaviors of money stock as illustrated in Figure 7.22. Line 1 indicates a very stable base money, within which composition of currency outstanding (line 2) and reserves (line 3) fluctuates. These inner fluctuation produces extremely unstable money stock (line 4) as well as functional money (line 5). Between the year 6 and 30, money stock fluctuates with minimum value of \$961 and maximum value of \$2,021 with mean value of \$1,531. If currency ratio is stable and could be governed by central bank, money stock would have behaved very steadily as line 6 indicates (\$1,600 at t=30).

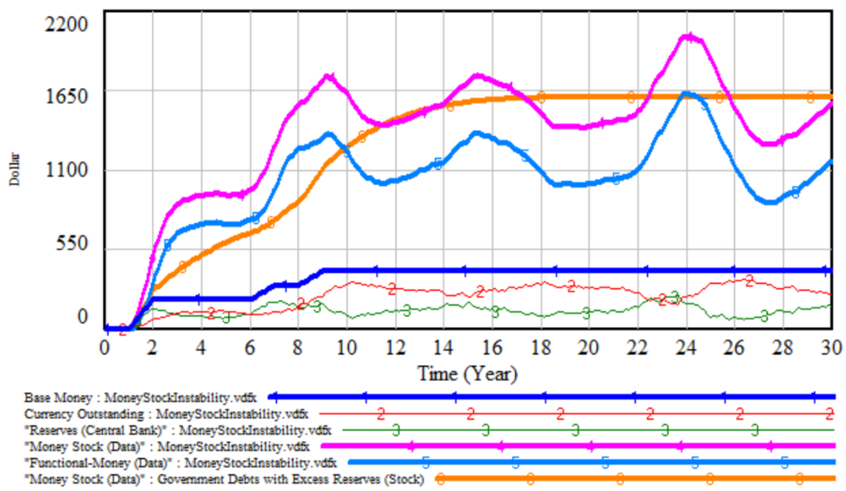

Figure 7.22: Instability of Money Stock

This amplified behaviors of the system reminds us of "Bullwhip Effect" in supply chain; that is, roaring production in upper stream caused by relatively stable downstream demand. Even at this stage of investigation, system dynamics researchers would unanimously say that this debt money system of money creation and destruction is another example of *system design failure!*

7.7 "100% Money" for Monetary Stability

Is there a way to stabilize this roaring behaviors of money stock? Yes, there is. From our discussions so far on the nature of money creation, it can be comprehensively understood that monetary instability is caused by a fractional reserve banking system. To prove this, let us increase the current required reserve ratio of 10% in the model to 100% such that RR ratio: 0.1 → 1 at t=10. From the left-hand diagram of Figure 7.23 we can easily observe that money stock (line 4) converges to base money (line 1).

Simultaneously, functional money (line 5) tends to be eliminated from the circulation: $M_f \to 0$, so that from equation (7.1), we have

$$\text{Money Stock } = \text{Legal Tender } (M_0) \tag{7.22}$$

Under such circumstances, unstable fluctuation of money stock has fully died out, and currency ratio or liquidity preferences stopped affecting money stock. In this way 100% or full reserve requirement becomes an important condition to overcome instability of money stock under a debt money system. This is a state of "100% Money" proposed by Irving Fisher (Fisher, 1945, 1945).

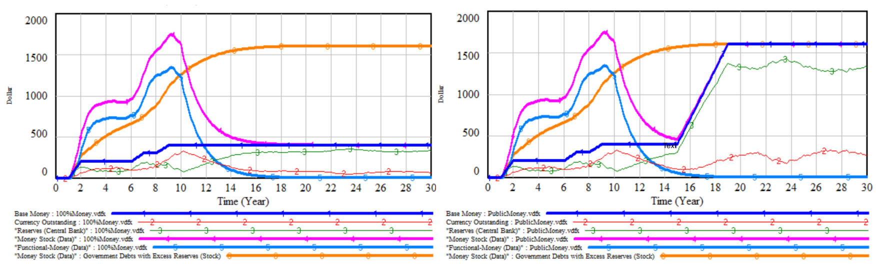

Figure 7.23: From 100% Money Stock to Public Money Stock

As a result, money stock now is severely decreased from the peak of \$1,744 (at t=9) to the base money level of \$400. How can we restore the original level of money stock, then? It can be increased by issuing public money at interest-free. Specifically, at t=15 we issue Public Money \$300 for 4 years (= \$1,200). Money Stock then increases to \$1,600 from the original level: \$454 at t=15, as illustrated by the right-hand diagram of Figure 7.23. By putting public money into circulation we have successfully restored the original level to money stock with a stable monetary condition such that base money = money stock (= \$1,600).

Yet even under this stable situation we still have, from the equation (7.2),

$$\text{Legal Tender}(M_0 = \$1,600) = \text{Public Money } (\$1,400) \ + \text{Debt Money } (\$200) \tag{7.23}$$

That is, the original debt money of \$200 (issued as discount loans to banks and excess reserves loans to banks for the purchase fo government bonds) still remains in the base money. This relation can be easily confirmed from Figure 7.1. To transform the current debt money system fully to the public money system, we have to remove this remaining debt money issued at interest.

Public Money System

It is now clear from the above analysis that monetary stability can be attained only when the following two conditions are met:

a. Elimination of debt money: Front-face transformation.

b. Elimination of functional-money ($M_f \to 0$): Back-face transformation.

Classification table of money presented in the previous chapter Table 5.2 that reflects these two eliminations are now revised as Table 7.1 below.

Debt Money System

Front: Issuance	Public Money	Debt Money (at interest)
Back: Fiat Status	Money as Legal Tender	Functional-Money (M_f)

⇓ ⇓ ⇓

Public Money System

Front: Issuance	Public Money	(Debt Money) → Public Money
Back: Fiat Status	Money as Legal Tender	(M_f) → Legal Tender

Table 7.1: From Debt Money System to Public Money System

This indeed becomes our graphical presentation of public money system: the main theme of this book. These issues of transition from debt money to public money system will be discussed in detail in Part V: Macroeconomic Systems of Public Money.

Conclusion

We have started this chapter by defining money stock as the sum of public money and debt money; that is, a front face of money. Under the current debt money system it is shown that money stock is almost equal to total debts. This has lead to the analysis of demand side of money stock; that is, money stock is endogenously determined by the behaviors of those who come to banks to borrow such as producers, households and government as well as attitudes of banks to make loans to them. We have identified three causes of monetary destructions and analyzed how they affect monetary destruction as well as monetary instability. Finally it is posed that such destruction and instability can be fixed by introducing 100% money with graphical presentation of transition from debt money to public money system.

Questions for Deeper Understanding

1. This chapter showed that "money stock is equal to total debts" under a fractional reserve banking system. Total debs are sum of the debts of non-banking sectors such as producers, households and government. This implies that money stock in our economy is endogenously determined by the behaviors of those who come to banks to borrow and attitudes of banks to make loans to them. Specifically, we have identified three major causes that determine total debts as the causes of monetary destruction and run simulations according to the following order.

    (1) Loans Cutbacks at t=10 in which Lending Ratio = 0.3 → 0.1, and Lending Period = 3 → 6.

    (2) Liquidity Preferences at t=15 in which Currency Ratio = 0.2 → 0.5.

    (3) Repayments of Debts at t=20 in which Repayment Ratio = 0 → 0.2.

    We have also run simulations for the case in which the above order is reversed to take place. There still remain four more different orders that cause destruction of money stock. Run in total 6 simulations and compare their behaviors graphically by focusing on the speed and level of monetary destruction.

2. Figure 7.22 analyzed how Jugular business cycle of 8 years gets amplified and produces fluctuating behaviors that look like "Bullwhip Effect" in supply chain. Obtain similar business cycles of 4 years and 16 years under the same amplified conditions in the model, and compare three business cycles of 4, 8 and 16 years. How are money stocks affected under these 3 business cycles? For your comparative analysis you may use "Statistics" tool in the left-side Analysis Tools of Vensim Model Reader.

3. (**Challenge**) Figure 7.12 presents the correlation of Money Stock M_3 and Total Domestic Debts in Japan. For deeper understanding of the nature of contemporary debt money system, the reader is encouraged to create a similar correlation diagram in his/her country. How about correlations between Time Deposits M_T and Debts of Private Sectors as well as between Money Stock M_1 and Government Debts as shown in Japan?

Chapter 8

Interest and Equity

In the previous two chapters we have analyzed how money stock is created (supply side) under a fractional reserve banking system and how it is endogenously determined (demand side) by the borrowing behaviors of producers, households and government, and lending attitudes of banks. This chapter analyzes how money stock is affected by the introduction of interest. It is assumed that bank loans, deposits and discount loans are no longer interest-free, and different interest rates are applied to them. As a result, money stocks turn out to be changed due to the changes in currency in circulation, money multipliers, etc. More importantly, it is found that equity tends to be distributed in favor of commercial banks and the central bank. This chapter completes our trilogy of Chapters 6, 7 and 8 on monetary modeling.

8.1 What is Interest?

In the previous two chapters, it is argued that money is created as debts by non-financial sectors such as public (producers and households) and government, and commercial banks under a fractional reserve banking system. If money is created this way to meet the growing demand for economic transactions as a medium of exchange, the banking system becomes essential sector for economic activities.

Debts are, however, not free in our economy. When non-financial sector borrows money from commercial banks, they have to pay interest. In other words, commercial banks charge interest for making loans. What is interest, then? According to a typical macroeconomic textbook, "Interest is the price for the use of money. It is the price that borrowers need to pay lenders for transferring purchasing power to the future (259 page in McConnell and Bruce (2008)).

If extra money is sitting idle at hand without a specific plan to be used in the near future, why can't we let someone who are in need for medium of exchange use it free of charge? As a matter of fact, usury has been historically prohibited. Yet greedy bankers began to charge interest when loans were made.

Eventually, to secure more fund for loans from those who have extra money in non-financial sector, bankers began to attract those extra money at interest. And in a capitalist market economy, as the above quotation of the textbook justifies, no one now doubts that "interest is the price for the use of money."

Since system dynamics is a method for designing a better system, it's worth while to consider whether it's possible to design an economy that is free from interest charge. To examine this question, let us expand our models of money creation in the previous chapter 5 one by one to the models with interest payments.

Analytical Framework

Our analysis of money and interest in this chapter starts along with the framework of flow and stock approaches presented in the chapter 6. However, instead of analyzing behaviors of money creation one by one separately as done in the chapter, we explore the impact of interest on equity as the accumulated behaviors of money creation on the previous creation processes. Specifically, processes of money creation are assumed to take place as integrated phases as follows.

(0) Gold Standard 0: Base run of the gold standard model in the previous chapter 5 with the initial amount of gold $200 by default.

(1) Gold Standard: Our economy starts with the initial amount of gold held by the public with the introduction of interest rate and prime rate.

(2) Discount Loans to Banks: $100 at t = 6.
To increase money stock furthermore to meet the increased economic activities and payments, central bank makes discount loans additionally to commercial banks.

(3) Government Debt: $100 at t = 8.
Government is further forced to issue its bonds to meet its budget deficits, or implement Keynesian fiscal policies to stimulate economic activities.[1]

(4) Open Market Purchase: 50% purchase of existing government bonds at t = 16.
Central bank exercises open market purchase operations to buy existing government bonds in the market in order to increase base money, and money stock.

(5) Open Market Sale: 50% sale of government bonds held by the central bank at t = 22. Central bank now tries to reduce money stock in circulation to curb inflation through its open market sale operations that only decrease base money (not money stock directly).

[1]It is assumed here that banks purchase all amount of government bonds with short-term borrowing from the central bank as if purchased with excess reserves. That is, Holding Ratio (Banks) = 1 by default in the models of this chapter.

Simulation file names used for these simulations are the same as phase title names. For instance, in the case of (1) Gold Standard, its simulation file names for flow and stock approaches are Gold Standard (Flow-approach) and Gold Standard (Stock-approach), respectively. In this way, five phases of money creation out of nothing by loans are analyzed under both flow and stock approaches in a unified and integrated fashion.

8.2 Money and Interest under Gold Standard

8.2.1 (1) Flow Approach

Let us start with the interest model of flow approach [Companion model: 1 Money-Interest(Gold).vpmx]. In this model two types of interest rates are introduced. When commercial banks receive deposits, they apply an *interest rate* per dollar deposit to non-financial sector. On the other hand, when they make loans to non-financial sector, they charge a higher interest rate called a *prime rate* per dollar loan. The difference is called *spread* here and becomes a major source of income by the commercial banks. In this way, two different prices of interest rates begin to be introduced for commercial banks. Interest rate and prime rate are set here to be 2% and 3%, respectively

The receipts of interest become interest incomes and are treated as inflows to the equity, while its payments become interest expenses and booked as outflows from the equity. Figure 8.1 reflects these transactions and becomes a revised model of money and interest under gold standard.

Under the introduction of interest, base money is not affected since gold held by the central bank does not change. Currency in circulation drops from \$133 to \$114, and non-financial sector's deposits increases from \$667 to \$788, resulting in the decrease in actual currency ratio from 0.2 to 0.145 at t=30. Actual reserve ratio remains at 0.1. Accordingly, money multiplier increases from 4 to 4.67 at t=30, but high-powered money decreases slightly from \$200 to \$193. Money stock increases from \$800 to \$902 at t= 30 as illustrated by line 2 in the left-hand diagram of Figure 8.2.

In this way, an introduction of interest has a positive effect to increase money stock through the decrease in actual currency ratio.

A more drastic change under the introduction of interest is observed in the distribution of equity between non-financial sector and commercial banks. The amount of equity in the non-financial sector, Equity(Public), begins to decline from \$200 to \$16.6 at t=30, while that of the commercial banks increases from zero to \$183.4 at t=30 as illustrated by lines 2 and 3 in the right-hand diagram of Figure 8.2. Compositions of the equity among the public (line 2) and banks (line 3) become 8.3% and 91.7% at t=30.

Since no production is assumed in this simple economy of gold standard, its entire equity or net assets is the gold of \$200 dollars held by the non-financial public sector, which remains the same through the process of money creation. The introduction of interest causes the economy's equity to be redistributed

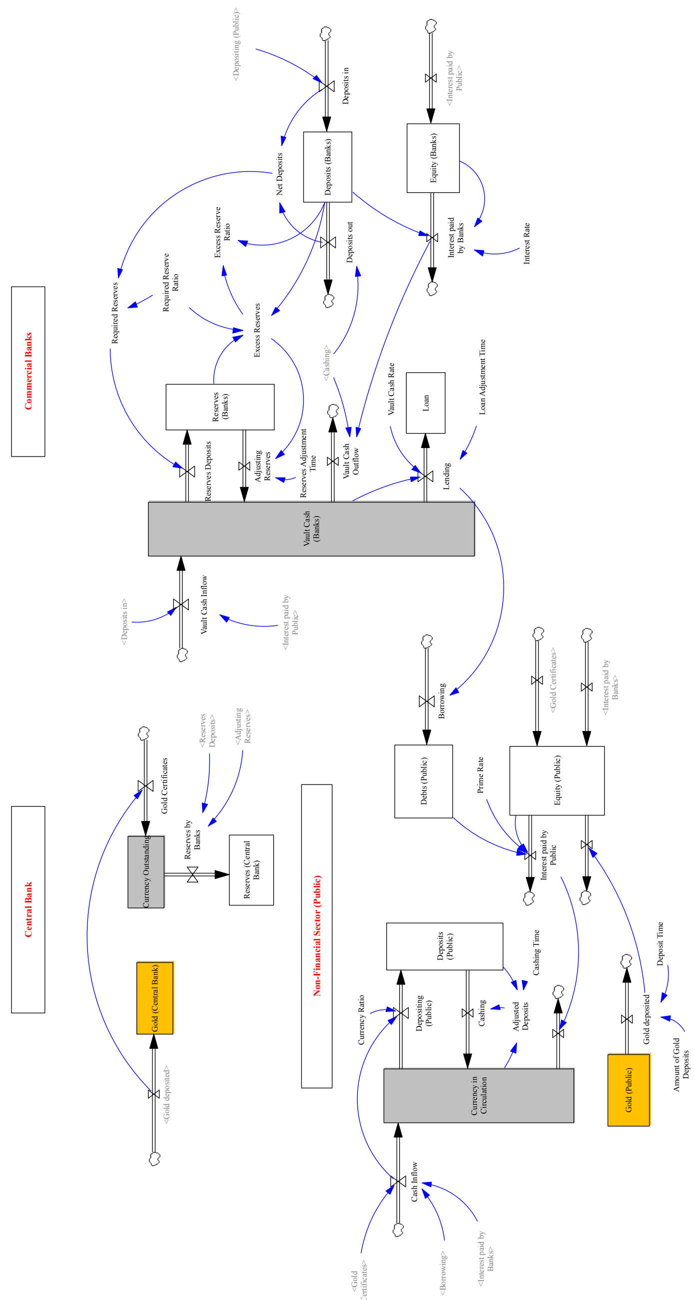

Figure 8.1: Money and Interest under Gold Standard: Flow Approach

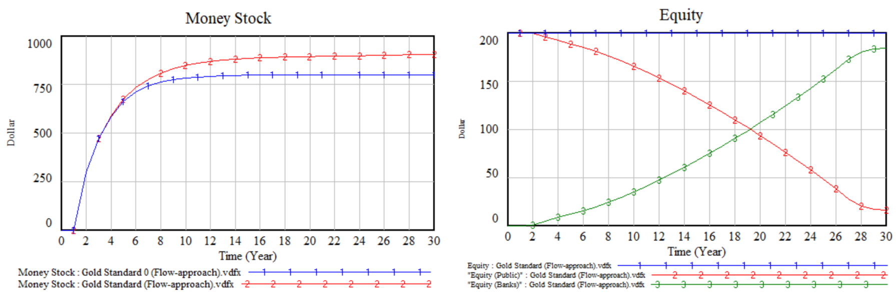

Figure 8.2: Money Stock and Equity under Gold Standard: Flow Approach

between non-financial public sector and commercial banks. In other words, the commercial banks can forcefully exploit non-financial sector's equity as long as the spread value is positive, no matter how positive interest payments (here 2%) please depositors in the non-financial sector. This becomes the essence of the introduction of interest to the monetary economy; that is, a root cause of income inequality under debt money system.

8.2.2 (1) Stock Approach

Stock approach model [Companion model: 1a Money-Interest(Gold-S).vpmx] is illustrated in Figure 8.3. This stock approach model slightly differs from the flow approach model in the sense that the amount of money loaned by commercial banks and interests paid by them are now directly transferred to the deposits account of the non-financial public sector. This method of loan payments indicate straightforwardly that banks creates money out of nothing directly into non-financial sector's deposits account. Interest against this deposits by the public is also paid directly into the public sector's deposits account. Let us now examine how these changes affect money stock and equity or income distribution.

Under the stock approach, base money is not affected since gold held by the central bank does not change. Currency in circulation drops slightly from \$133 to \$128, and non-financial sector's deposits decreases from \$667 to \$640, yet this does not change actual currency ratio around 0.2. On the other hand, actual reserve ratio slightly increases from 0.1 to 0.112 at t = 30. Accordingly, money multiplier decreases from 4 to 3.84 at t=30, but high-powered money remains at \$200. Money stock decreases from \$800 to \$768 at t= 30 as illustrated by line 2 in the left-hand diagram of Figure 8.4.

In this way, an introduction of interest has a negative effect to decrease money stock through the increases in actual reserve ratio. This contrasts with the increase in money stock under the flow approach.

The amount of equity, however, in the non-financial sector, Equity(Public), also begins to decline from \$200 to \$58.3 (instead of \$16.6 under flow approach) at t=30, while that of the commercial banks increases from zero to \$141.7 (in-

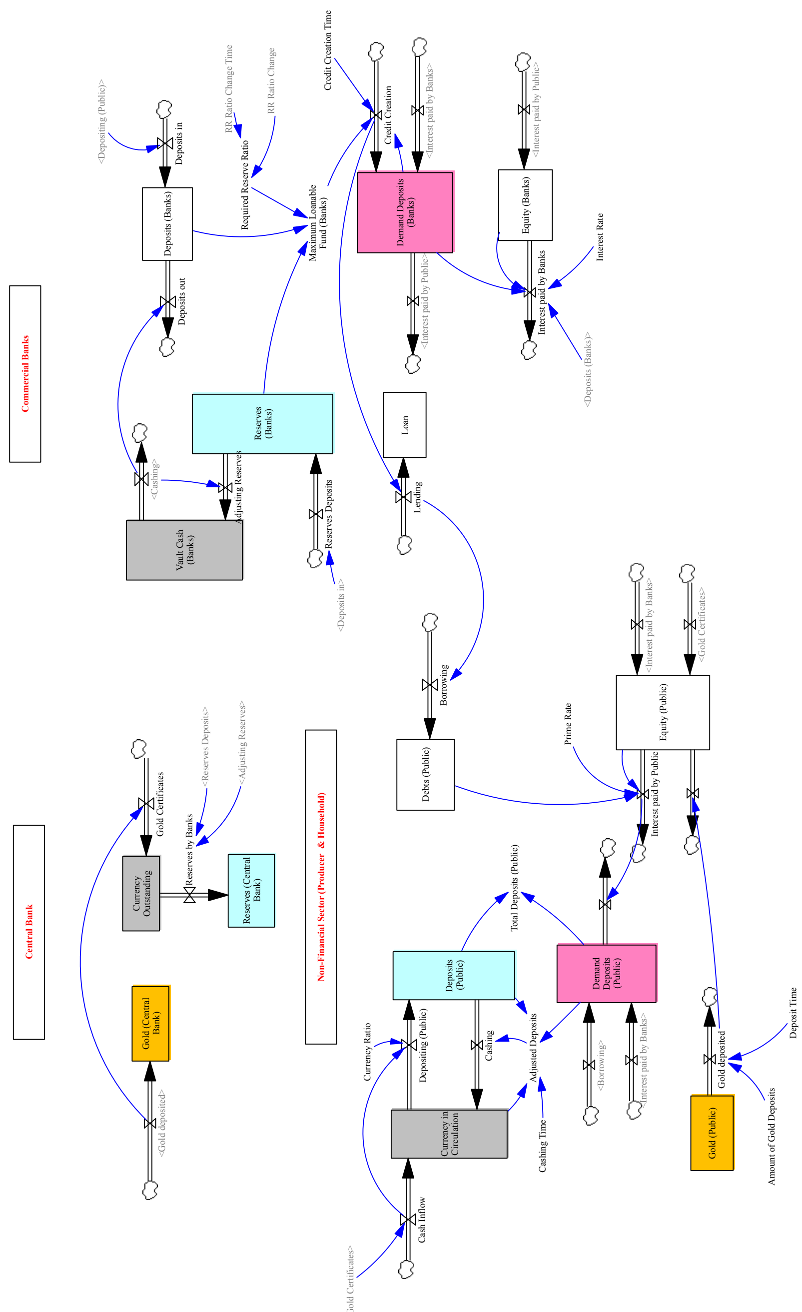

Figure 8.3: Money and Interest under Gold Standard: Stock Approach

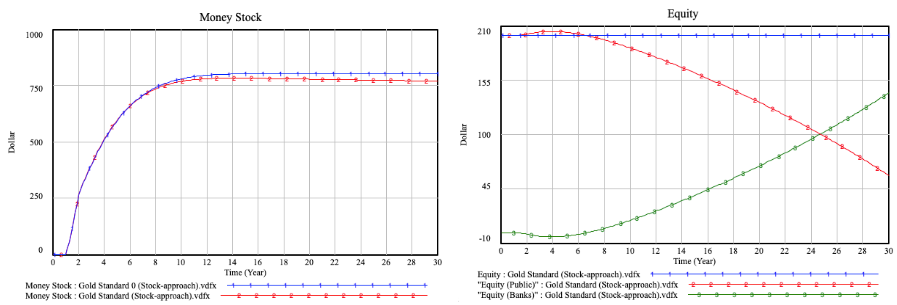

Figure 8.4: Money Stock and Equity under Gold Standard: Stock Approach

stead of $183.4 under flow approach) at t=30 as illustrated by lines 2 and 3 in the right-hand diagram[2] of Figure 8.4. Compositions of the equity among the public (line 2) and banks (line 3) are 29.2% and 70.8% at t=30. Hence, equity(public) or income inequality for non-financial sector shows similar trend as the one under the flow approach. That is to say, the introduction of interest to the monetary economy is shown to become a root cause of income inequality irrespective of our analysis under flow approach or stock approach.

8.3 Money and Interest under Loans to Banks

8.3.1 (2) Flow Approach

What happens if the central bank makes discount loans of $100 to commercial banks to increase base money and hopefully money stock? To examine this effect, let us assume that the discount rate charged by the central bank is 0.01 [Companion model: 2 Money-Interest(Loan).vpmx]. Comparisons in this subsection are made between gold standard and discount loans to banks under the same flow approach. In this case, money multiplier increases slightly from 4.67 to 4.77 at t=30, and high-powered money increases from $193 to $266.5. Accordingly, money stock increases from $902 to $1,272 as illustrated by lines 2 and 3 in the left-hand diagram of Figure 8.5 (in the previous chapter 5 without interest it was $1,200).

The amount of equity in the non-financial sector, Equity(Public), begins to plunge from $16.6 to $-130.2 at t = 30 (line 2),[3] while that of the commercial banks increases from $183.4 to $306.8 (line 3) as illustrated in the right-hand diagram. Moreover, the equity of the central bank increases from zero to $23.4

[2]To be precise, line 2 increases to 203.9 and line 3 decreases to -3.9 around t = 4 due to the small delay of Debts (Public) by the period of 0.125, so that interest payments of banks precede before their interest receipts from the public.

[3]In the real economic model, of course, negative values become unacceptable. Accordingly, this negative value has to be filled in by other incomes such as wages for households, and profits by producers. For the sake of equity analysis per se, negative values are tolerated in this model.

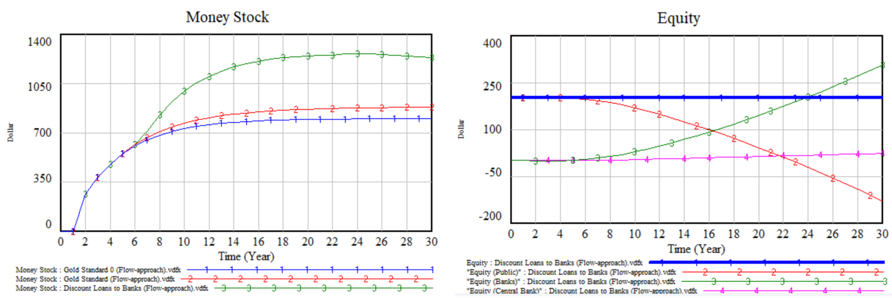

Figure 8.5: Money Stock and Equity under Loans to Banks

(line 4) due to the discount loans to commercial banks. Total equity of the public, banks and central bank remains the same as gold standard; that is, \$200. Whenever central bank makes loans to commercial banks, the total equity is further squeezed to the Equity(Central Bank) so that equity of commercial banks is partly extorted. Compositions of the equity among the public (line 2), banks (line 3) and central bank (line 4) are -65.1%, 153.4% and 11.7% at t=30.

8.3.2 (2) Stock Approach

The effects on money stock and equity under stock approach are obtained with [Companion model: 2a Money-Interest(Loan-S).vpmx]. Comparisons in this subsection are made between gold standard and loans to banks under the stock approach. In this approach, money multiplier stays almost around 3.83 at t=30, and high-powered money increases from \$200 to \$276.6. Accordingly, money stock increases from \$769 to \$1,058 at t =30 as illustrated by lines 2 and 3 in the left-hand diagram of Figure 8.6.

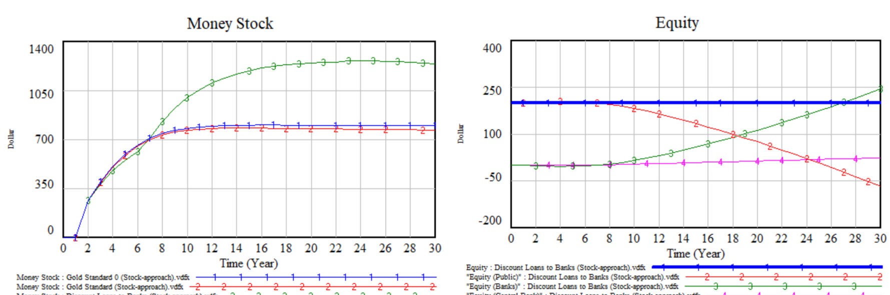

Figure 8.6: Money Stock and Equity under Loans to Banks

The amount of equity in the non-financial sector, Equity (Public), begins to decline from \$58.3 to \$-68.2 at t = 30, while that of the commercial banks increases from \$141.7 to \$244.8 as illustrated by lines 2 and 3 in the right-hand diagram. Moreover, the equity of the central bank increases from zero to \$23.4

(line 4) due to the the discount loans to commercial banks. The total equity of the public, banks and central bank remains the same as gold standard; that is, \$200. Whenever central bank makes loans to commercial banks, equity of \$200 is further squeezed to the Equity(Central Bank) so that non-financial sector's equity as well as commercial banks' equity are extorted. Total equity of the public, banks and central bank remains the same under the gold standard; that is, \$200. Compositions of the equity among the public (line 2), banks (line 3) and central bank (line 4) are -34.1%, 122.4% and 11.7% at t=30. In the case of discount loans to banks, it is observed that money stock of flow approach increases more than that of stock approach, while equity redistribution of flow approach spreads a little bit wider than that of stock approach. Yet in both cases, equity is redistributed in favor of the banks and central bank. That is, the root cause of inequality - payments of interest - remains the same in both cases.

8.4 Money and Interest under Government Debt

8.4.1 (3) Flow Approach

What happens if government borrows by issuing bonds of \$100 at t=8 to meet the demand for money stock due to the limitation of money creation with discount loans to banks. Let us run the flow approach model [Companion model: 3 Money-Interest(Flow-approach).vpmx]. In the chapter 6 it is discussed that when banks purchase all of the government bonds money stock increases. The simulation of money creation up to the phase (3) without interest payments is represented here by the file name "Government Debt 0". With the introduction of interest rate and prime rate as well as bonds rate which is assumed to be the same as the interest rate of 2%, government debt now increases money stock, which represented by the file name "Government Debt". This increase takes place as follows. Currency in circulation drops from \$266.6 to \$218.6, which reduces actual currency ratio from 0.2 to 0.142, which in turn increases money multiplier from 4 to 4.54 at t=30. Simultaneously, high-powered money decreases from \$400 to \$387. These changes increase money stock from \$1,600 to \$1,757.2. Left-hand diagram of Figure 8.7 illustrate these changes in money stock by lines 1 and 2. Right-hand diagram indicates that government equity further drops from \$-100 to \$-153.5.

With these preliminary results in mind, let us continue our analysis of the behaviors of money stock and equity. Comparisons below are made between discount loans to banks (phase 2) and government debt (phase 3). As illustrated in the left-hand diagram of Figure 8.8, money stock becomes \$1,757.2 (line 4) at t=30 as compared with \$1,243.1 (line 3), meanwhile line 1 and 2 are money stocks under gold standard without interest and with interest; that is, \$800, and \$883.7, respectively. This indicates that money stocks increase by the introduction of interest.

Right-hand diagram shows a new distribution of equity among non-financial

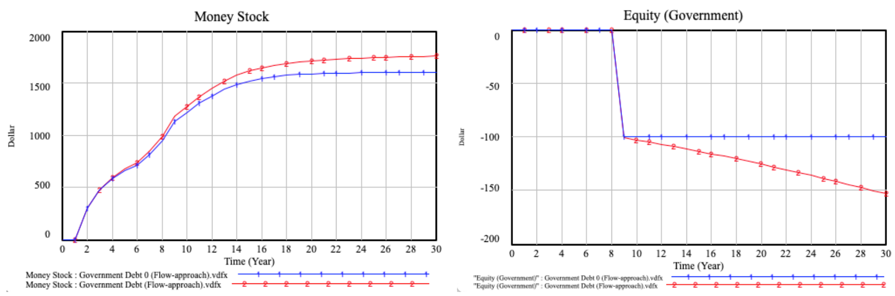

Figure 8.7: Money Stock and Equity under Government Debt Compared

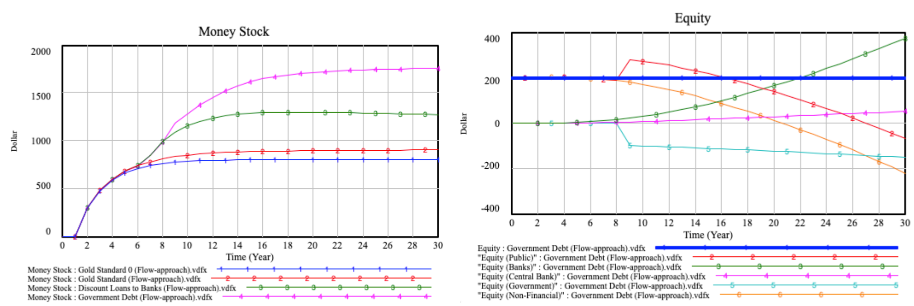

Figure 8.8: Money Stock and Equity under Government Debt

sectors (public and government), commercial banks and central bank. Equity (public) increases to the maximum level at t=9 (line 2) from the original values of \$200 to \$278.8 (139.4% increase!), following the issues of government bonds at t=8. This gives us an impression that government debts increases non-financial public sector's equity, thanks to which we the people become rich. Alas, this temporal increase in public equity is made possible by the negative equity of government (line 5); that is, from zero to \$-100 at t=9. Eventually, equity(public) begins to decline to \$-69.4 and equity (government) to \$-153.5 at t=30. Combined non-financial sector's equity by the public and government (line 6) consequently becomes negative; that is, \$-222.8 at t=30.

On the other hand, equity of banks go beyond the equity of the economy as a whole (\$200) to \$372.6 (line 3) at t=30. Again this extreme inequality of equity in favor of banks is supported by the negative equity value of the public and government. Equity of central bank (line 4) increases from zero to \$50.2%. Total equity at t=30 is the same as gold standard; that is, 200%. In summary, compositions of the equity among the public (line 2), banks (line 3), central bank (line 4) and government (line 5) becomes -34.7%, 186.3%, 25.1% and -76.8% at t=30.

8.4.2 (3) Stock Approach

We now run the stock approach model [Companion model: 3a Money-Interest(Stock-approach).vpmx]. Simulation of money creation up to phase (3) without interest payments is held as "Government Debt 0") file here. Left-hand diagram of Figure 8.9 illustrates money creation under Stock Approach; that is, money stock of \$1,600 (line 1) (without interest rates) and money stock of \$1,530 (line 2). This simulation result shows that money stock decreases slightly under stock approach with the introduction of interest rates. This result complies with the above analyses of phases (1) and (2) on the money stock under flow and stock approaches. Right-hand diagram indicates that government equity further drops

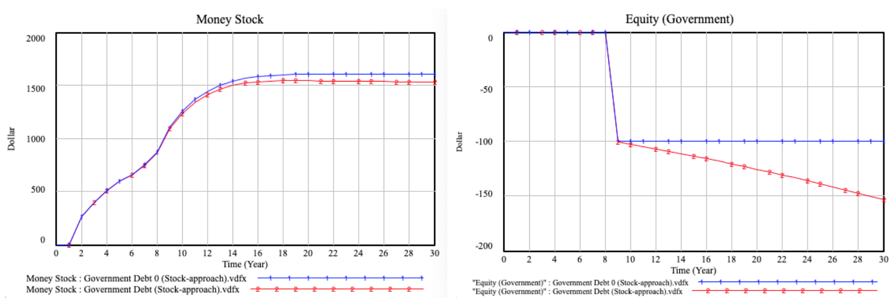

Figure 8.9: Money Stock and Equity Compared (Stock Approach)

from \$-100 (line 1) to \$-153.5 (line 2). This produces the same result of equity distribution under the flow approach.

With these preliminary results in mind, let us continue our analysis of the behaviors for money stock and equity. Comparisons below are made up to phase (3). As illustrated in the left-hand diagram of Figure 8.10, money stock becomes \$1,530 (line 4) at t=30 as compared with \$1,058 (line 3), meanwhile line 1 and 2 are money stocks under gold standard without interest and with interest; that is, \$800 and \$768.7, respectively.

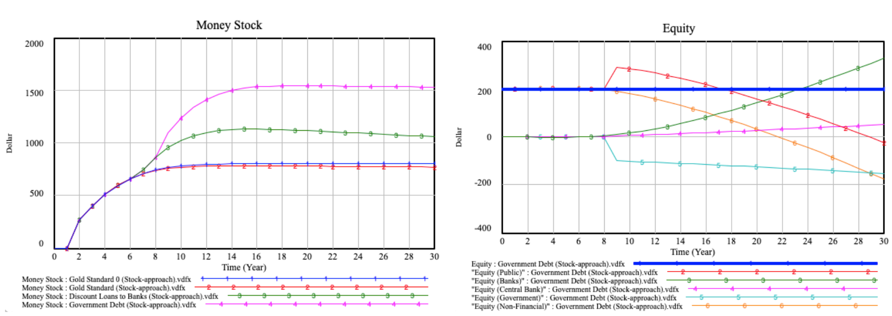

Figure 8.10: Money Stock and Equity under Government Debt: Stock Approach

Right-hand diagram shows a distribution of equity among non-financial sectors (public and government), commercial banks and central bank. Equity (public) (line 2) increases to its maximum level of $289.4 at t=9 from the original values of $200 (144.7% increase compared with 139.4% under flow approach at t=9), following the issues of government bonds at t=8. Again this gives us an impression that government debts increase the public sector's equity as in the flow approach. This temporal increase in the public equity is made possible by the negative equity of government (line 5); that is; from zero to $-100 at t=9, which further drops to $-153.5 at t=30. Eventually, equity(public) begins to decline to $-24.9 at t =30 (compared with $-69.4 under flow approach). Combined non-financial sector's equity (line 6) sooner or later becomes negative; that is, $-178.3 at t=30.

On the other hand, equity of banks go beyond the equity of the economy as a whole ($200) to $306.8 at t=30 (compared with $372.6 under flow approach). Again this extreme inequality of equity in favor of banks is supported by the negative equity value of government. Equity of central bank (line 4) increases from zero to $47.7 at t=30. In summary, compositions of the equity among the public (line 2), banks (line 3), central bank (line 4) and government (line 5) becomes -12.5%, 164.1%, 25.1% and -76.8% at t=30. These simulation results indicate that equity distribution exhibits similar trends as in the flow approach. Equity (public) in both approaches remains negative; -34.7% (flow approach) and -12.5% (stock approach).

8.5 Money and Interest under Open Market Operations

8.5.1 Flow Approach: Phases (4) & (5)

Simulations of open market purchase (phase (4)) and open market sale (phase (5)) are jointly performed in this section, running the same model of flow approach used in phase (3). Left-hand diagram of Figure 8.11 indicates that

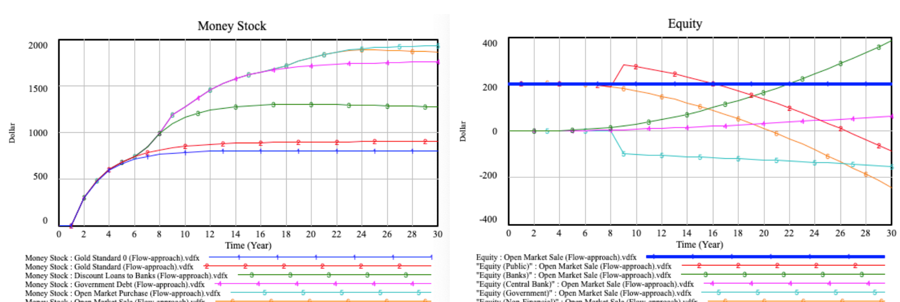

Figure 8.11: Open Market Purchase and Sale Operations: Flow Approach

money stock under open market purchase operation (50% at t=16) increases from \$1,757.2 (line 4) to \$1,925.6 at t=30 (line 5), as expected from our discussions above on the creation of money by government debts. In other words, open market purchase operation increases base money from \$276.6 to \$311.1 as well as high-powered money from \$269.5 to \$303.7, which in turn increases money stock.

On the other hand, whenever central bank carries out open market sale operation (50% at t=22), base money decreases from \$403.3 to \$437.8 as well as high-powered money from \$387 to \$421.1 at t=30, which in turn increases money stock as shown above. Right-hand diagram show a distribution of equity.

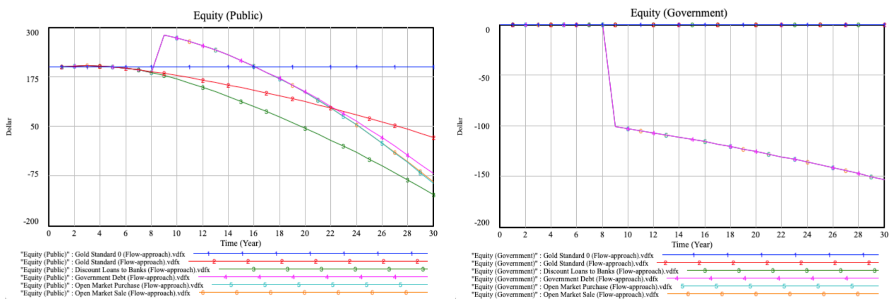

Figure 8.12: Public and Government Equities under Open Market Operations

Let us take a closer look at the equity distribution of non-financial sectors (public and government). Left-hand diagram of Figure 8.12 illustrates the equity of public sector. Lines 4, 5 and 6 are equities of the public under government debts, open market purchase and sale operations, respectively. These values become almost the same. Right-hand diagram illustrates the equity of government. Lines 4, 5 and 6 are equities of the government under government debts, open market purchase and sale operations, respectively. These values become exactly the same; \$-153.5 at t=30. This implies that once government debts are incurred, its equity becomes negative under any situation.

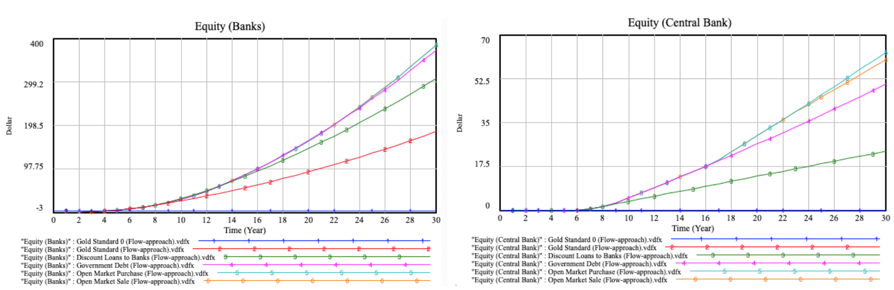

Figure 8.13: Banks and Central Bank Equities under Open Market Operations

Left-hand diagram of Figure 8.13 illustrates the equity of banks. Their equities become \$384.2 under open market purchase at t=30 (line 5), and \$383.7

under open market sale (line 6). In other words, their equities exceed the total equity of the economy; that is, \$200. These extreme distributions in favor of banks, say, under open market purchase, are made possible by negative value of the public equity of \$-93.7 and government equity of \$-153.5 at t=30. Right-hand diagram of Figure 8.13 illustrates the equity of central bank. Its equity becomes \$62.9 (line 5) and \$60.0 (line 6) at t=30 under open market purchase and sale operations, respectively.

Consolidated equity of the public and government, called non-financial equity, becomes \$-247.1 and \$-243.7 under open market purchase and sale operations, respectively. Line 3 in Figure 8.14 illustrates the case of open market purchase operation. On the other hand, consolidated equity of commercial banks and central bank, called financial equity, becomes \$447.1 and \$443.7 under open market purchase and sale operations, respectively. The case of open market purchase is illustrated by line 6 in the Figure. By definition, the sum of non-financial and financial equities should be equal to the total equity of the economy; that is \$200. This is confirmed by our simulation results.

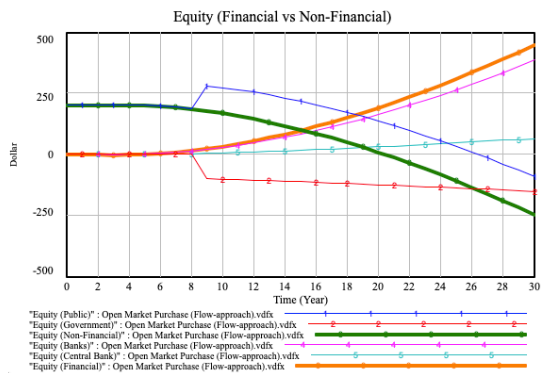

Figure 8.14: Fin. vs Non-Fin. Equity

Our analysis here demonstrates that whenever the public and government borrow at interest, total equity of the economy inevitably gets spreads in favor of financial sectors such as banks and central bank, which in our models exceeds the total equity of the economy. In this way, by creating money stock out of nothing under the debt money system, financial sectors exploit equity non-violently from non-financial sectors such as households, producers and government. Consequently, the introduction of interest rate under debt money system becomes a root cause of income inequality between financial and non-financial sectors; that is, the so-called inequality between 1% vs 99%.

8.5.2 Stock Approach: Phases (4) & (5)

Using stock approach simulation results as a representative model, let us summarize what we have analyzed in this chapter so far in terms of base money, money stock and money multiplier. Left-hand diagram of Figure 8.15 indicates base money under 6 phases of money creation process, including gold standard without interest as line 1. Right-hand diagram indicates corresponding money stock to base money under 6 phases. Though values of money stock are slightly different from the flow approach, their behaviors indicates similar trends.

Left-hand diagram of Figure 8.16 indicates distribution of equity(public)

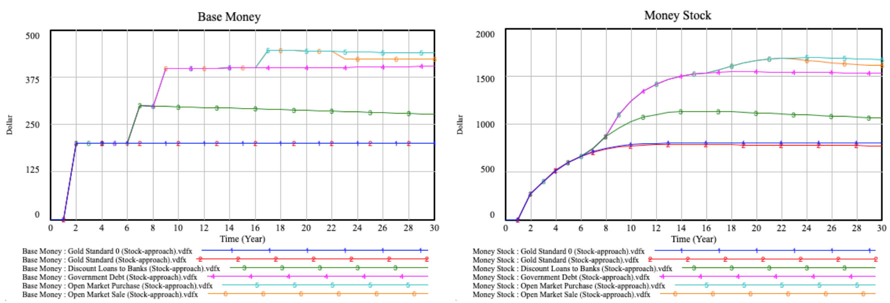

Figure 8.15: Base Money and Money Stock under 6 Phases: Stock Approach

under 6 phases. Right-hand diagram of Figure 8.16 indicates the equity between non-financial sector (line 3) and financial sector (line 6). These behaviors also demonstrate similar trends as those of the flow approach.

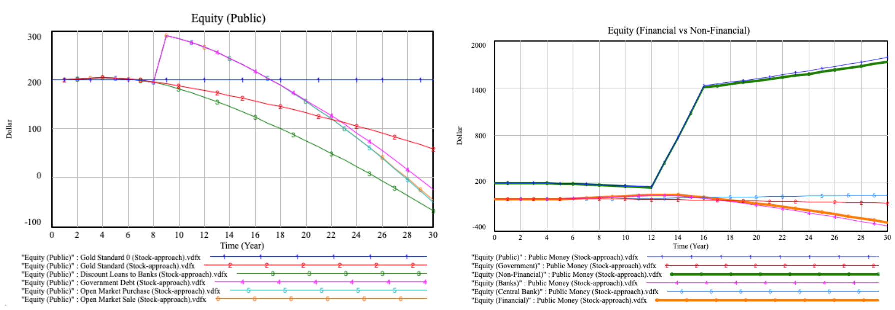

Figure 8.16: Equity Distribution of the Public, and Fin. vs Non-Fin.

Table 8.1 summarizes money creation figures such as base money(M_0), money stock(M), and money multiplier(m) as well as equity distribution figures such as public (producers and households), non-financial sector (public and government) and financial sector (commercial banks and central bank).

	Money Creation			Equity Distribution (= \$200)		
(at t=30)	M_0	M	m	Public	Non-Fin.	Financial
(0) Gold Standard 0	200	800	4.0	200	200	0
(1) Gold Standard	200	768.7	3.844	58.3	58.3	141.7
(2) Discount Loans	276.6	1,058.2	3.826	-68.2	-68.2	268.2
(3) Gov. Debt	403.3	1,530.2	3.794	-24.8	-178.3	378.3
(4) OM Purchase	437.8	1,670.0	3.815	-50.6	-204.1	404.1
(5) OM Sale	421.6	1,607.5	3.813	-46.4	-199.9	399.9

Table 8.1: Summary Table of Open Market Purchase: Stock Approach

Zero-Sum Game of Equity Distribution

This chapter has so far analyzed how money stocks and equity distribution in phases (1) through (5) are affected when various interest rates are introduced. From the table we can easily recognize the trend that, as money stock increases through loans, equity distribution of non-financial sector (producers, households and government) continues to decrease from the original amount of their equity ($200) to negative values due to the introduction of interest payments against borrowers, meanwhile equity of financial sector (commercial banks and central bank) continues to increase beyond the original equity held by the public ($200). Yet this equity distribution does not change the equity of the economy as a whole; that is, the the public equity of $200 held as gold. Hence, the following relation not only holds for all phases (1) through (5) of stock approach from the above table. but also for those of flow approach.

$$\text{Equity } \$200 = \text{Non-Financial Equity} + \text{Financial Equity} \tag{8.1}$$

Under the debt money system, money stock can be endogenously increased when producers, households and government come to borrow at interest from commercial banks, as demonstrated in the previous chapter. Endogenous money creation *at interest* is now shown to be nothing but an endless *zero-sum game* between the non-financial sectors (households, producers and government) and financial sectors (commercial banks and central bank). More specifically, this is one-way distribution game from non-financial sector's equity to financial sector's equity, causing inequality of equity (wealth) distribution between non-financial sector and financial sector. In other words, money creation at interest does not increase net equity, but inequality of equity distribution. This is a design failure of the so-called 1% vs 99% inequality that is built in the current debt money system.

8.6 Equity Distribution under 100% Money

Can we fix this equity inequality, or zero-sum game of equity distribution, then? In the previous chapter we have shown that under "100% money" monetary instability can be fixed. Running [Companion model: 4a Money-Interest(Stock-Instability).vpmx], we can reproduce similar monetary instability under the introduction of interest here. Instead, let us only examine here if "100% money" can fix a system design failure of equity inequality. To run this simulation, let us continue to use same simulation settings of the above stock approach model from phases (1) to (4). To increase the speed of bank lending or borrowing by the public, however, we have assumed a bullish lending attitudes of loans as done in section 7.7 of the previous chapter; that is, Bank Lending Ratio: 0.3→0.6, and Lending Period: 3→1 at t=1. Under such circumstances, let us abolish a fractional reserve ratio of 10% and introduce full reserve ratio of 100% at t=8. Bold line 5 of Figure 8.17 indicates money stock continues to decrease to $442.1, which is approaching to the level of base money; that is, $437.1 at

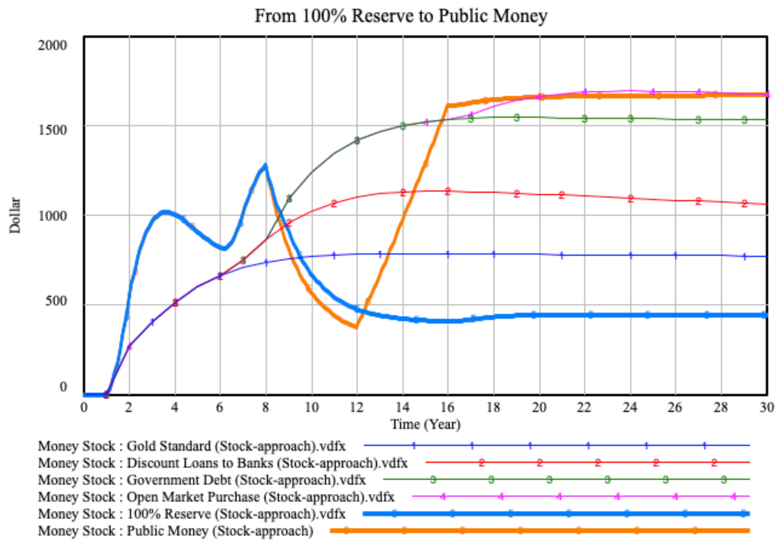

Figure 8.17: From 100% to Public Money System: Stock Approach

t=30. To regain this loss of money stock, public money of 320 dollars is issued for 4 period starting t=12; that is, in total \$1,280. Then, Public Money in circulation increases from the initial amount of \$200 to \$1,670.1 at t = 30 (bold line 6), which becomes almost the same level as money stock under Open Market Purchase; that is, \$1,666.7 at t = 30. In this way, debt money created out of nothing at interest is replaced with public money at interest-free.

Figure 8.18 illustrates the equity distribution under 100% public money. Total equity (bold line 1) becomes \$1,480; that is, the initial equity of \$200 and newly issued public money of \$1,280. This indicates that public money issued by the government[4] directly increases the equity of the economy as a whole. This contrasts with the government debts of issuing bonds which only constitutes its liability but does not increase the total equity at all. In other words,

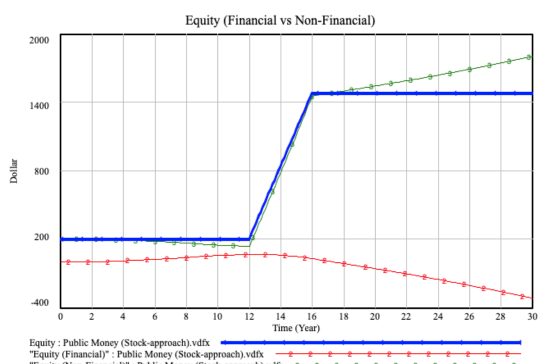

Figure 8.18: Equity Distribution under Public Money: Stock Approach

[4]More precisely, public money is issued by the public money administration under the legislative branch of the government such as Congress, Parliament or Diet as discussed in Part V.

public money system eliminates zero-sum game of the debt money system, and only increases the monetary equity of the economy as a whole. Line 3 represents non-financial equity (public and government) which becomes $1,801 at t=30.[5] This implies that by converting from debt money to pubic money, non-financial equity jumps from $-204.1 (Phase (4)) to $1,801 at t=30 (an increase of factor 9.8!).

On the other hand, line 2 represents financial equity which becomes $-321.3.[6] In this way, financial equity drops from $404.1 (Phase (4)) to $-321.3 (a drop of factor 1.8!). The reader can easily confirm that the sum of financial and non-financial equities is equal to the total equity of $1,480 (= 1,801 - 321).

Under the public money, equity inequality between non-financial and financial sector seems to be thoroughly eliminated. Public money is shown to completely eradicates the root cause of income inequalities. This is the alternative system design we propose in Part V (Public Money System) in place of the current debt money system.

8.7 Interest and Sustainability

The introduction of interest always plays in favor of commercial banks and the central bank in terms of the equity distribution. This is a negative side of debt money creation at interest. Its positive side may be that through a banking system with interest, non-financial sector obtains enough money for productive investment that enables economic growth and eventually an increase in non-financial sector's equity. The model we used here for the analysis of equity distribution does not include production activities. As a result, only the negative side of debt money seems to be revealed.

The fundamental question is whether this increase in the non-financial sector's equity is large enough to compensate the exploitation of its equity by banking system. In system dynamics, this financial (interest) system of deposits and debts can be described by a simple model illustrated in Figure 8.19. That is, this financial system guarantees the infinite inflow of interest to the owner of deposits and lenders.

This is nothing but the example of exponential growth explained in Chapter 1. And the reader can remember its power with a built-in doubling time. In other words, this financial system makes the haves richer and richer. Once we are enslaved with debts, we are forced to work indefinitely to attain endless economic

[5] Equity(public) becomes $1,855 at t=30. The difference of $54 is due to the equity (government) of $-54. In this model, government debts of $100 at t=8 is assumed to remain and its interest is also added to the principal debt, so that government debts continue to increase in a compounded fashion, causing negative equity of the government. In this sense, this model is not well designed for the purpose of this section.

[6] In this model, banks are assumed to pay interest to the public for its deposits and central bank for its discount debts of $100 at t=6, while their loans to the public decline due to the issuance of public money, causing negative equity of banks. In this sense, this model is not well designed for the purpose of this section. Under the public money system, we propose that depositors conversely pay deposits fees to the banks.

growth for the payments of interest if we want to avoid the decline in our equity values.

That is to say, we are not allowed to stop, instead forced to work and grow our economic activities in a world of limited natural resources. Otherwise, as we have seen above, our equity eventually will be totally exploited by bankers. In other words, considering the power of exponential growth, this financial system of distorted equity distribution does not work consistently. Eventually, its resetting needs to be enforced by financial and economic crises and wars as our economic history indicates.

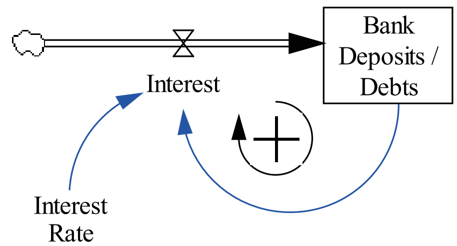

Figure 8.19: Financial (Interest) System of Deposits/ Debts

This may lead to our ultimate question: Can the resetting together with indefinitely forced economic growth work well for attaining a sustainable economy under a finite world of resources? The answer seems to be negative. Accordingly it is always expedient to think about an option of designing an interest-free economy of public money as a system designer. We'll challenge this option in Part V. Until we arrive there, let us continue to model our capitalist market macroeconomy by focusing on the production side in the chapters to follow.

Conclusion

To create money stock out of a limited base money, fractional reserve banking system plays a crucial role. In this chapter we have examined how the introduction of interest rates affect money stock and equity distribution under the systems of gold standard, discount loans to banks and government debt by setting up a uniform analytical framework of phases (1) thorugh (5). In all phases money stocks are shown to be increased.

It is also shown that in the process of money creation equity is always distributed in favor of the commercial banks and the central bank. In other words, non-financial sector's equity will be completely exploited unless economic growth is considered to reverse the trends. Indeed, debt money creation at interest becomes a root cause of equity inequality. Then, it is claimed that this inequality of equity distribution can be completely eradicated under 100% money. Finally, it is posed that interest and sustainability may not be compatible.

Questions for Deeper Understanding

1. Briefly discuss how payments of interest have historically been regarded among world major religions such as Christianity, Islam, Hinduism, Buddhism, Sikhism and Judaism.

2. There are two different calculations of interest; simple and compound interests. Explain how they are different. Then build a simple SD model of these financial systems, and compare the behaviors of these two interests.

3. Left-hand diagram of Figure 1.8 in Chapter 1 introduces a financial system as an example of exponential growth. Discuss the impact of exponential growth on principal or debt. Without exceptions interest system is always introduced as compound financial system in business and economics classes. And interest payments in our real world are based on compound interest system. Discuss why compound interest practice becomes dominant in our economy.

4. In the companion model: 1 Money(Gold).vpmx in Chapter 5, money supply is increased to \$800 from the original gold of \$200 as base money. However, in the model: 1 Money-Interest(Gold).vpmx in this chapter, money stock is further increased to \$903.7 at t=30 due to the introduction of interest rate and prime rate. Discuss why money stock is increased by \$103.7 without a change in base money.

5. Running the Companion model: 4a Money-Interest(Stock-Instability).vpmx by changing Currency Ratio Switch from 0 to 1, reproduce monetary instability, similar to the one in the previous chapter, with the introduction of interest rates. Then examine if this monetary instability can be fixed by the introduction of full reserve (100% reserve ratio).

6. Analyze how the introduction of full reserve affects equity distribution between financial and non-financial sectors under the phases of (1) gold standard and (2) discount loans to banks.

Part III

IS-LM Models of Debt Money System

Chapter 9

Short-Run IS-LM Model

This chapter[1] discusses a dynamic determination processes of GDP, interest rate and price level on the same basis of the principle of accounting system dynamics. For this purpose, a simple Keynesian multiplier model is constructed as a base model for examining a dynamic determination process of GDP. It is then expanded to the short-run IS-LM model by incorporating interest rate, whose introduction enables the analysis of aggregate demand equilibria in terms of the standard IS and LM curves. It is then expanded to the flexible price IS-LM model to analyze the behaviors of real and nominal interest rates. Finally, the short-run IS-LM model is expanded to the endogenous money IS-LM model with the introduction of budget equations of macroeconomic sectors. For this model building, accounting system dynamics (ASD) method is applied. This model is shown successfully to describe the economic behaviors of the Great Depression.

9.1 Macroeconomic System Overview

System dynamics approach requires to capture a system as a wholistic system consisting of many parts that are interacting with one another. Specifically, macroeconomic system has been viewed as consisting of six sectors such as the central bank, commercial banks, consumers (households), producers (firms), government and foreign sector, as illustrated in Figure 4.1 in Chapter 4. It shows how these macroeconomic sectors interact with one another and exchange goods and services for money.

In the previous analysis of money and its creation, these six sectors are regrouped into three sectors: the central bank, commercial banks and non-

[1]This chapter is based on the paper: Aggregate Demand Equilibria and Price Flexibility – SD Macroeconomic Modeling (2) – in "Proceedings of the 23rd International Conference of the System Dynamics Society", Boston, USA, July 17 - 21, 2005. ISBN 0-9745329-3-2, and the joint paper with Yokei Yamaguchi: The Endogenous Money IS-LM Model of the Debt Money System (Part I) - A Paradigm Shift in Macroeconomics, JFRC Working Paper No. 01-2022, Japan Futures Research Center, April 2022, Japan.

financial sector consisting of consumers, produces and government. And government is separated in a later analysis. For the analysis of aggregate demand and supply in this chapter, we need at least four sectors such as producers, consumers, banks and government. When money stock is assumed to be endogenously determined in this chapter, central bank is brought to the analysis. Our analysis here is limited to a closed macroeconomic system and foreign sector is not brought to the discussion here. Figure 9.1 illustrates the overview of the standard macroeconomic framework in this chapter.

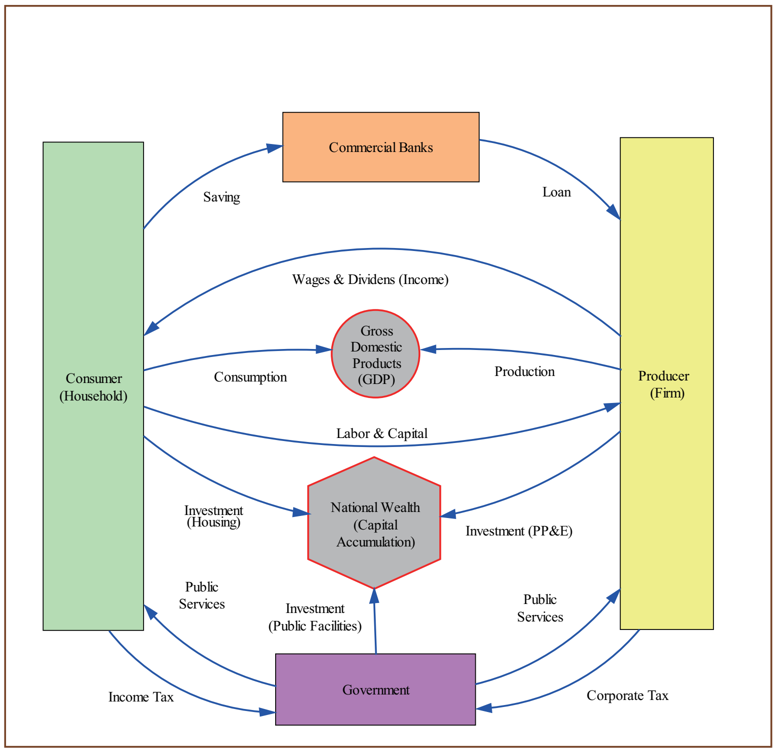

Figure 9.1: Macroeconomic System Overview

How can we describe transactions among these macroeconomic sectors, then? The method we employ here is the same as the one used in the previous chapters; that is, the use of financial balance sheet. Balance sheet is an accounting method of keeping records of all transactions in both credit and debit sides so that they are kept in balance all the time.

9.2 A Keynesian Aggregate Demand Model

Since macroeconomics is one of the major subjects in economics, many standard textbooks are in circulation. As references, textbooks such as Diulio (1998), Mankiw (2016), McConnell and Bruce (2008), and Mishkin (2006) are occasionally used to examine a standard approach to macroeconomics.

A Simple Long-run Macroeconomic Model

Let us start with a typical macroeconomic model that is simple enough but has features of short-run production and long-run capital accumulation. It is described as follows>

$$
\begin{aligned}
Y &= AD && \text{(Determination of GDP)} && (9.1)\\
AD &= C + I + G && \text{(Aggregate Demand)} && (9.2)\\
C &= C_0 + cY_d && \text{(Consumption Decisions)} && (9.3)\\
Y_d &= Y - T - \delta K && \text{(Disposable Income)} && (9.4)\\
T &= \bar{T} && \text{(Tax Revenues)} && (9.5)\\
I &= \bar{I} && \text{(Investment Decisions)} && (9.6)\\
G &= \bar{G} && \text{(Government Expenditures)} && (9.7)\\
\frac{dK}{dt} &= I - \delta K && \text{(Net Capital Accumulation)} && (9.8)\\
Y_{full} &= F(K, L) && \text{(Production Function)} && (9.9)\\
PY_{full} &= AD && \text{(Full Capacity Equilibrium)} && (9.10)
\end{aligned}
$$

This macroeconomic model consists of 10 equations with 10 unknowns; that is, $Y_{full}, Y, K, AD, C, I, G, Y_d, T, P$, with 7 exogenously determined parameters $(L, C_0, c, \bar{T}, \bar{I}, \delta, \bar{G})$.[2] Except Y_{full} which has a *real unit*, 9 unknown variables have all *nominal units*. Equations (9.1) through (9.7) determine short-run income, etc., while equations (9.8) through (9.10) determine long-run full capacity output, price and long-run equilibrium.

Neoclassical View

According to the neoclassical view, long-run equilibrium is attained by the following price adjustment mechanism:

$$\frac{dP}{dt} = \Psi(AD/P - Y_{full}) \quad \text{(Flexible Price)} \tag{9.11}$$

At the equilibrium we have

$$\frac{dP}{dt} = 0 \Longrightarrow AD/P = Y_{full} \Longrightarrow PY_{full} = AD \tag{9.12}$$

[2] L stand for labor. In this model, demand for and supply of labor, L, is not analyzed. To do so we need to add another equation of population (labor) growth such as

$$\frac{dL}{dt} = nL \qquad \text{(Labor Supply)}$$

which will be done in the chapters to follow.

This is a well-known doctrine called *Say's Law*, which states that supply creates its own demand. Therefore, in order to complete this neoclassical logic, we need an equation of price adjustment mechanism (9.11) which adjusts discrepancies between Y_{full} and AD. The introduction of this price adjustment mechanism makes the equation (9.10) redundant. Accordingly, neoclassical macroeconomic system consists of equations (9.1) through (9.9) and (9.11). Left-hand diagram of causal loops in Figure 9.2 illustrates how full capacity output and aggregate demand are adjusted to attain an equilibrium through flexible price. The equilibrium attained this way is called neoclassical long-run equilibrium.

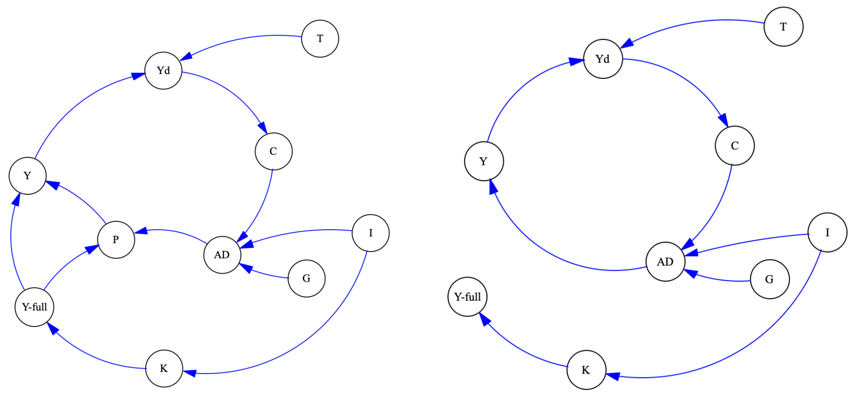

Figure 9.2: Causal loops of Neoclassical and Keynesian Models

Keynesian View

On the other hand, according to a Keynesian view prices are regarded as sticky in the short-run due to imperfect market structures, and cannot play a role to adjust a discrepancy between full capacity output and aggregate demand. Accordingly GDP is determined by the aggregate demand in the short-run by the equation (9.1). In this sense, price adjustment equations such as (9.10) and (9.11) become redundant. Hene, Keysian model consists of 9 equations (9.1) $\sim$ (9.9) and 9 unknown variables such as $(Y_{full}, Y, K, AD, C, I, G, Y_d, T)$, with 7 exogenously determined parameters $(C_0, c, \bar{T}, \bar{I}, \delta, \bar{G}, L)$.

The equilibrium attained this way is called Keynesian aggregate demand equilibrium. Right-hand diagram of Figure 9.2 shows that GDP is determined by the aggregate demand. In this case, the level of GDP is nothing but equal to the level of aggregate demand, and needs not be the same as the amount of output produced by the economy's production function (9.9). Contrary to the neoclassical view, the economy has no autonomous mechanism to attain an equilibrium in which output produced by the equation (9.9) is equal to the aggregate demand; that is, a neoclassical long-run equilibrium. Hence, Keynesian economists argue that such a neoclassical long-run equilibrium could only be attained in the short run through the changes in aggregate demand which are made possible by monetary and fiscal policies.

Can we create a synthesis model to deal with these controversies between neoclassical and Keynesian schools[3]? From a system dynamics point of view, macroeconomy is nothing but a system and different views on the behaviors of the system can be uniformly explained as structural differences of the same system. This is what we like to pursue in this book so that an effectiveness of system dynamics modeling can be demonstrated.

Keynesian Aggregate Demand Adjustment

Let us now consider how the Keynesian aggregate demand equilibrium is attained. A level of GDP that holds $Y = AD$ is obtained in terms of the parameters as follows:

$$Y^* = \frac{C_0 - c\bar{T} + \bar{I} + \bar{G}}{1 - c} \tag{9.13}$$

Let us assign some numerical values to these parameters $(C_0, c, \bar{I}, \bar{G}, \bar{T}) = (24, 0.6, 120, 80, 40)$, then we have $Y^* = 500$.

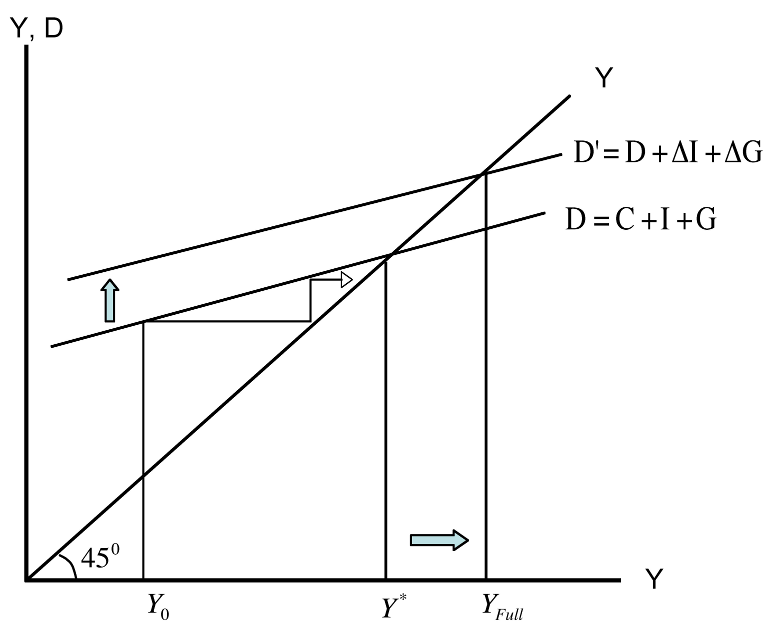

Figure 9.3: Keynesian Comparative Static Determination of GDP

How can such a Keynesian equilibrium GDP be attained if aggregate supply and aggregate demand are not equal initially? The Keynesian model assumes

[3] I once posed this question in the book Yamaguchi (1988). At that time, I was unaware of system dynamics and unable to model my general equilibrium framework for simulation.

that aggregate supply is determined by the size of aggregate demand. Fig 9.3 illustrates how an initial GDP of Y_0 continues to increase until it catches up with the aggregate demand, and eventually attains a Keynesian equilibrium Y^*. In this way the equilibrium can be always gained at a point where aggregate demand curve meets aggregate supply curve. Comparative statics is a well-known analytical method in standard textbooks to compare with two points of equilibria for two different levels of aggregate demand.

To construct a dynamic SD model of these static comparative analyses, the determination equation of GDP or aggregate demand (9.1) has to be replaced with the following differential equation:

$$\frac{d\,Y}{dt} = (AD - Y)/AT \tag{9.14}$$

where AT implies an adjustment time.

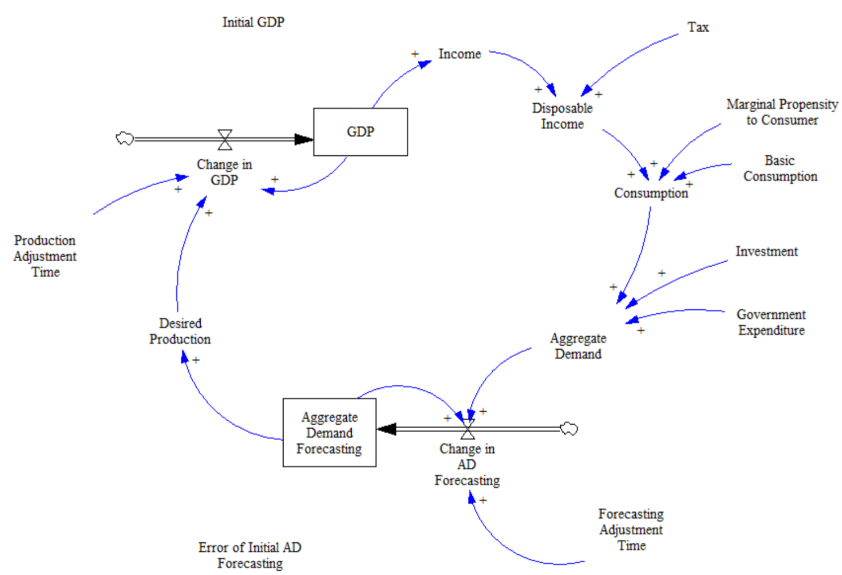

Figure 9.4: Keynesian SD Model of GDP

In system dynamics this process is known as balancing feedback or goal-seeking dynamics in which aggregate demand plays a role of goal and GDP tries to catch up with it. Figure 9.4 illustrates a SD model of such Keynesian process, in which an aggregate demand forecasting mechanism is additionally introduced without changing an essential mechanism of Keynesian adjustment process [Companion model:1 Keynesian.vpmx].

Left-hand diagram of Figure 9.5 illustrates how an initial GDP is smoothly increased to attain the Keynesian equilibrium GDP at $Y^* = 500$. In the right-hand diagram investment and government expenditures are respectively

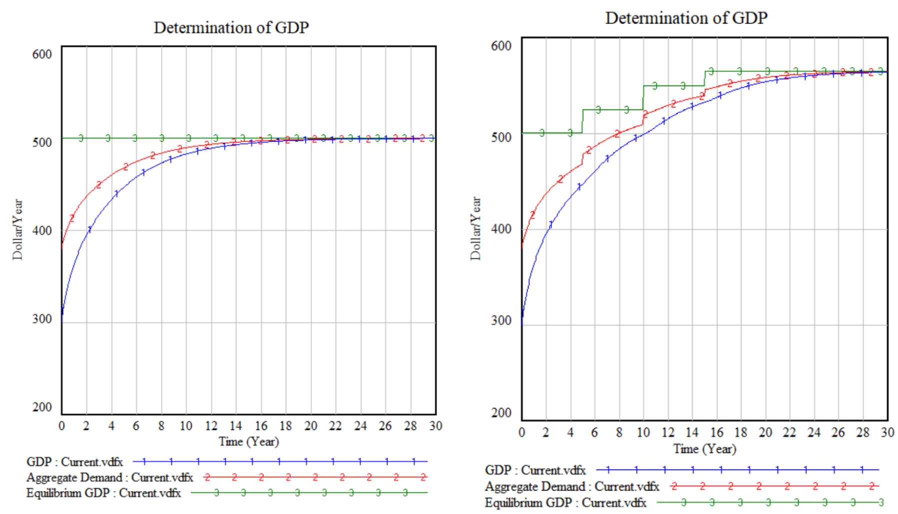

Figure 9.5: Keynesian SD Determination of GDP

increased by 10 at the periods 5 and 10, while tax is reduced by 10 at the period 15. Again, GDP is shown to increase smoothly for attaining new equilibrium levels of aggregate demand.

From the production function (9.9) the maximum amount of output is produced by fully utilizing the existing capital stock K and labor force L.

$$Y_{full} = Y(K, L) \tag{9.15}$$

Obviously, there is no guarantee that the Keynesian equilibrium GDP of Y^* is equal to Y_{full}, and the equilibrium equation (9.10) is met. When it is less than the maximum output level, capital stock is under-utilized and some workers are unemployed; that is, the economy is in a recession. In other words, the Keynesian aggregate demand equilibrium is no longer an equilibrium in the sense that capital and labor are fully utilized.

According to the Keynesian theory, the underutilization is caused by deficiencies of effective demand, and to gain full capacity and full employment equilibrium, additional effective demand has to be created by increasing investment and government expenditures, or decreasing taxes.

How much increase in the effective demand is needed, then? The answer lies in the Keynesian multiplier process. From the equilibrium equation (9.13), we have

$$\Delta Y = \frac{-c\Delta T + \Delta I + \Delta G}{1 - c} \tag{9.16}$$

Thus, multipliers for I, G and T are calculated as follows:

$$\frac{\Delta Y}{\Delta I} = \frac{\Delta Y}{\Delta G} = \frac{1}{1-c} = 2.5 \; ; \; \frac{\Delta Y}{\Delta T} = \frac{-c}{1-c} = -1.5 \tag{9.17}$$

Suppose that $Y_{full} = 560$. Then, to attain a full capacity level of GDP, we need to increase $\Delta Y = Y_{full} - Y^* = 60$. This could be done by increasing the investment or government expenditure by 24 (that is, $\Delta Y = 2.5 \cdot 24$), or decreasing tax by 40 (that is, $\Delta Y = (-1.5) \cdot (-40)$). Figure 9.3 illustrates how Y_{full} is attained by increasing aggregate demand such as investment and government expenditures.

Keynesian Adjustment SD Model with Inventory

The above Keynesian adjustment process is very mechanistic and does not reflect how actual production decisions are made by producers. More realistic decision-making process of production is to introduce an inventory adjustment management as explained in Chapter 2 or in Chapter 18 of Sterman (2000). In reality a discrepancy between production and shipment (or aggregate demand) is adjusted first of all as a change in inventory stock. Hence, the introduction of inventory as a stock is essential for SD modeling of macroeconomic system. The reason why inventory is not well focused in a standard macroeconomic framework may be because inventory is always treated as a part of (undesired) investment and output becomes in this sense identically equal to the aggregate demand.

Keynesian adjustment process (9.14) now needs to be revised as follows:

$$\frac{d\ I_{nv}}{dt} = (Y - AD) \tag{9.18}$$

with the introduction of inventory stock, I_{nv}. This adds another new unknown variable to the macroeconomic system. Accordingly, we need an additional equation to solve the amount of inventory. To do so, let us first define the amount of desired production as a sum of the amount of inventory replacement and aggregate demand forecasting:

$$Y^D = \frac{\text{Desired Inventory} - \text{Inventory}}{\text{Inventory Adjustment Time}} + \text{AD Forecasting} \tag{9.19}$$

where desired inventory is an exogenous parameter and set to be 30 dollars in our model. Then, redefine the aggregate supply as

$$Y = Y^D \quad \text{(Desired Production)} \tag{9.20}$$

Figure 9.6 illustrates our revised SD model of the Keynesian model [Companion model: 2 Keynesian(SD).vpmx]. When this model is run, we observe that aggregate demand and production overshoot an equilibrium as illustrated by the left-hand diagram of Figure 9.7. This overshooting behavior vividly contrasts with a smooth adjustment process of the Keynesian model. Only when desired inventory is zero, behaviors of both model become identical.

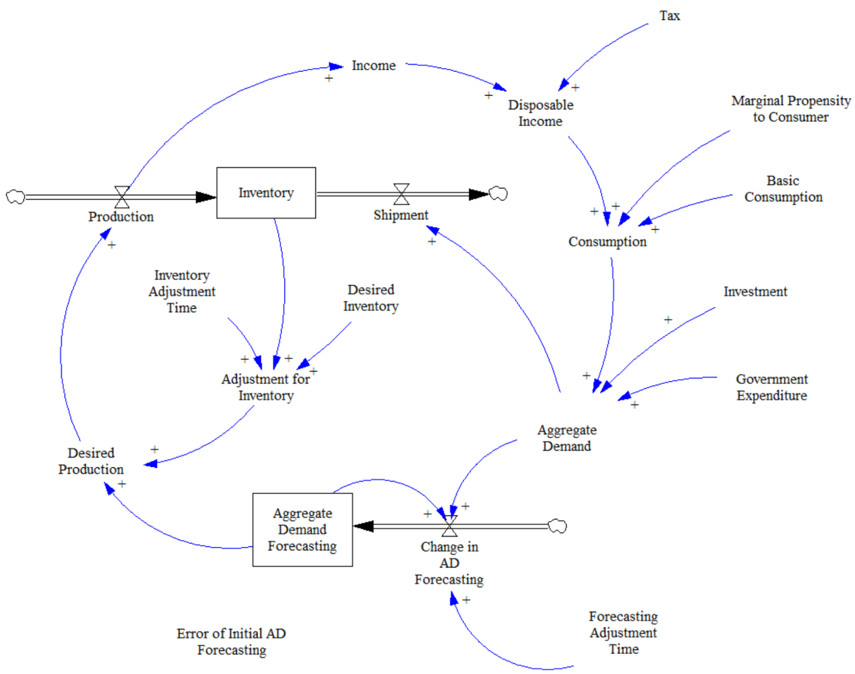

Figure 9.6: Revised Keynesian SD Model of GDP

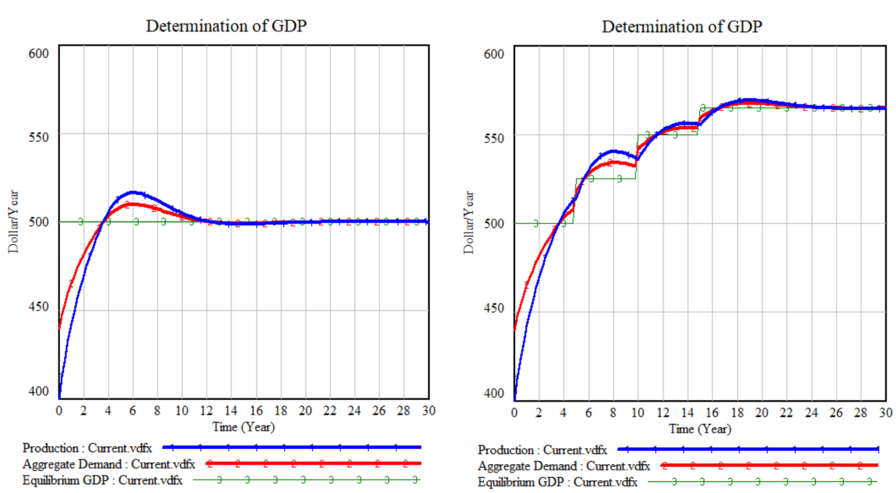

Figure 9.7: SD Determination of GDP

In the right-hand diagram investment and government expenditures are respectively increased by 10 at the periods 5 and 10, while tax is reduced by 10 at the period 15 in the exactly same fashion as the right-hand diagram of Figure 9.5. However, output and aggregate demand do not catch up with new equilibrium levels smoothly here, instead they are shown to overshoot the equilibrium levels. This suggests that Keynesian adjustment process is intrinsically cyclical or fluctuating off equilibrium, rather than smoothly adjusting as illustrated by many standard textbooks. This behavior may be the first finding in our SD macroeconomic modeling against standard Keynesian smooth adjustment process.

9.3 Keynesian Short-Run IS-LM Model

Immediately following the publication of Keynes's General Theory, Hicks (1937) expanded the Keynesian model to include money market. This model is now well known as IS-LM model, and has been widely used as a standard Keynesian model in many macroeconomic textbooks. Let us now formally present Keynesian IS-LM model. According to the Keynesian theory real income Y or GDP is determined by the aggregate demand in the short-run. That is, a Keynesian short-run IS-LM model is described as follows.

$$Y = AD \quad \text{(Aggregate Demand Equilibrium)} \tag{9.21}$$
$$AD = C + I + G \quad \text{(Aggregate Demand)} \tag{9.22}$$
$$C = C_0 + cY_d \quad \text{(Consumption Decisions)} \tag{9.23}$$
$$Y_d = Y - T \quad \text{(Disposable Income)} \tag{9.24}$$
$$T = T_0 + tY - T_r \quad \text{(Tax Revenues)} \tag{9.25}$$
$$I = \frac{I_0}{i} - \alpha i \quad \text{(Investment Decisions)} \tag{9.26}$$
$$G = \bar{G} \quad \text{(Government Expenditures)} \tag{9.27}$$
$$\frac{M^s}{P}V = L^d \quad \text{(Equilibrium of Money)} \tag{9.28}$$
$$L^d = aY - bi \quad \text{(Demand for Money)} \tag{9.29}$$

This Keynesian short-run IS-LM model consists of 9 equations with 9 unknowns:

$$Y, AD, C, I, G, Y_d, T, i, L^d \ (L^d \text{ stands for liquidity preferences}),$$

with 13 exogenously determined parameters:

$$C_0, c, T_0, t, T_r, I_0, \bar{G}, M^s, P, V, \alpha, a, b.$$

Equations (10.1), (10.2), (10.3) and (10.7) are the same as the ones in the previous Keynesian model. However, most variables in the previous Keynesian model are expressed with *nominal* units. In this IS-LM model, all variables are expressed with *real* units except money stock M^s which has nominal unit. Capital accumulation ($\frac{dK}{dt}$), equation (9.8), is excluded from this short-run IS-LM model so that capital depreciation (δK) is also deleted from the equation (10.4).

In the previous Keynesian model taxes and investment are endogenously determined. Here government taxes are assumed to be consisting of three parts in equation (10.5): lump-sum taxes such as property taxes (T_0), income taxes that are proportionately determined by an income level (tY) in which$t$ is an income tax rate, and government transfers such as subsidies (T_r). Hence we have tax revenue equation(10.5). Next, investment is here assumed to be determined by interest rate i in equation (10.6) in which α is an interest sensitivity of investment. Thus, interest rate i becomes unknown variable in the model. These complete the IS side of the short-run IS-LM model: equations (10.1) $\sim$ (10.7)

We have here added a new unknown variable of the interest rate to the model, and hence an additional equation is needed to make it complete. This leads to the construction of LM side of the short-run IS-LM model. According to the standard textbook, it should be an equilibrium condition in money market such that real money stock used in a year is equal to the demand for money L in equation (10.8) where V is velocity of money having a unit 1/year, and P is a price level and it is treated as a sticky exogenous parameter. Demand for money defined in equation (10.9) consists of two parts: transactional demand for money aY in which a is a fraction of income, and speculative demand for money bi in which b is an interest sensitivity of demand for money.

Simple IS-LM Equilirbium

For the purpose of manual analysis of the short-run IS-LM model, the investment decisions of the equation (10.6) is simplified in textbooks as follows:

$$I = I_0 - \alpha i \qquad \text{(Simple Investment Decisions)} \tag{9.30}$$

Then, from the equilibrium condition in the goods market, a relation between income and interest rate, which is called IS curve, is derived as follows:

$$Y = \frac{C_0 + I_0 + G + c(T_r - T_0)}{1 - c(1-t)} - \frac{\alpha}{1 - c(1-t)} i \tag{9.31}$$

On the other hand from the equilibrium condition in the money market, a relation between GDP and interest rate, called LM curve, is derived as

$$Y = \frac{1}{a}\frac{M^s}{P}V + \frac{b}{a}i \tag{9.32}$$

Equilibrium income and interest rate (Y^*, i^*) are now completely determined by the IS and LM curves. For instance, the aggregate demand equilibrium of income is obtained as

$$Y^* = \frac{C_0 + I_0 + G + c(T_r - T_0)}{1 - c(1-t) + \alpha(a/b)} + \frac{\alpha/b}{1 - c(1-t) + \alpha(a/b)}\frac{M^s}{P}V \tag{9.33}$$

This is a standard Keynesian process of determining an aggregate demand equilibrium of income in the short run in which price is assumed to be sticky. Figure 9.8 illustrates how IS and LM curves determine the equilibrium income and interest rate (Y^*, i^*). When C_0, I_0, G_0 increase or decrease, IS curve shifts

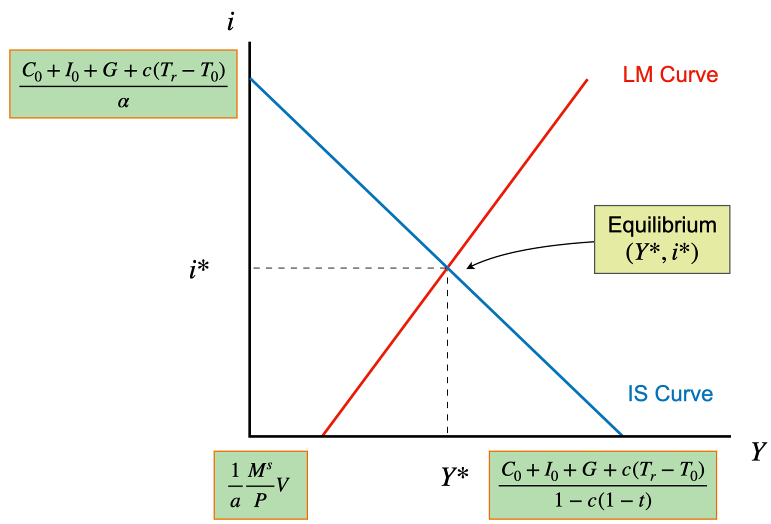

Figure 9.8: IS-LM Determination of GDP and Interest Rate

to the right or left, while LM curve move to the right or left when money supply M^s or real money supply $\frac{M^s}{P}$ increases or decreases. As a result, we can easily predict a movement of new equilibrium income and interest rate (Y^*, i^*). This analytical method has been dominant in introductory and intermediate macroeconomic textbooks.

As discussed in the previous section, income or GDP thus determined needs not be equal to the full capacity output level, Y_{full}. The Keynesian model only specifies GDP as determined by the level of aggregate demand. This is why it is called aggregate demand equilibrium of GDP. To realize a full capacity equilibrium $Y^* = Y_{full}$, price needs to be flexibly changed in the long run. On the contrary the Keynesian model we presented so far lacks this price flexibility.

Endogenous Government Expenditures

In the short-run model, variables such as T and I are made to be endogenously determined. The only remaining exogenous variable is government expenditures, G. It is usually determined by a democratic political process, and in this sense could be left outside the system as an exogenously determined parameter.

We could also make it an endogenous variable. First approach is to assume that the government expenditures are dependent on the economic growth rate, $g(t) = \Delta Y(t)/Y(t)$, such that

$$\frac{d\ G}{dt} = g(t)G. \tag{9.34}$$

This approach seems to be reasonable because many governments try to increase government expenditures proportionally to their economic growth rates so that a run-away accumulation of government deficit will be avoided.

Second approach is to assume that government expenditures are dependent on its tax revenues, since the main source of government expenditures is tax revenues which are endogenously determined by the size of output or income level. Then government expenditures become a function of tax revenues:

$$G = \beta T \tag{9.35}$$

where β is a ratio between government expenditures and tax revenues, called primary balance ratio here. When $\beta = 1$, we have a so-called balanced budget, while if $\beta > 1$, we have budget deficit.

With the introduction of the government expenditures in either one of these two ways, all exogenously determined variables such as T, I, and G are now endogenously determined within the short-run macroeconomic system.

Let us analyze the second case furthermore. In this case IS curve becomes

$$Y = \frac{C_0 + I_0 + (\beta - c)(T_0 - T_r)}{1 - c - (\beta - c)t} - \frac{\alpha}{1 - c - (\beta - c)t} i \tag{9.36}$$

By rearranging, the aggregate demand equilibrium of GDP is calculated as

$$Y^* = \frac{C_0 + I_0 + (\beta - c)(T_0 - T_r)}{1 - c - (\beta - c)t + \alpha(a/b)} + \frac{\alpha/b}{1 - c - (\beta - c)t + \alpha(a/b)} \frac{M^s}{P} V \tag{9.37}$$

How does the introduction of tax-dependent expenditures affect behaviors of the equilibrium? Let us consider, as one special case, how a tax reduction in lump-sum taxes, T_0, affect the equilibrium GDP under a balanced budget; that is, $\beta = 1$. In this case, we have from the equation (9.37)

$$\frac{dY}{dT_0} = \frac{1 - c}{(1 - c)(1 - t) + \alpha(a/b)} > 0 \tag{9.38}$$

On the other hand, in the case of the exogenously determined expenditures, we have from the equation (9.33)

$$\frac{dY}{dT_0} = \frac{-c}{1 - c(1 - t) + \alpha(a/b)} < 0 \tag{9.39}$$

This implies that under a balanced budget a reduction in lump-sum taxes will discourage GDP, contrary to a general belief that it stimulates the economy. This counter-intuitive feature seems to be deemphasized in standard textbooks in which tax cut is usually treated as stimulating the economy.

9.4 SD Model of the Short-Run IS-LM

Whenever the investment decisions in equation (10.6) is restored again, we can no longer apply the above simple determination process of GDP by comparative static analysis. To fully analyze the short-run IS-LM model, therefore, we need to construct a dynamic model of aggregate demand equilibria based on IS-LM curves.

9.4.1 Dynamic IS Sub-Model

The above Keynesian adjustment process is very mechanistic and does not reflect how actual production decisions are made. More realistic decision-making process of production is to introduce an inventory adjustment management. In reality a discrepancy between production and shipment (or aggregate demand) is adjusted first of all as a change in inventory stock. Thus the introduction of inventory as a stock is essential. Accordingly our System Dynamics (SD) modeling of Keynesian macroeconomic system begins with introducing an inventory stock. *IS* sub-model of the SD IS-LM model is already constructed as

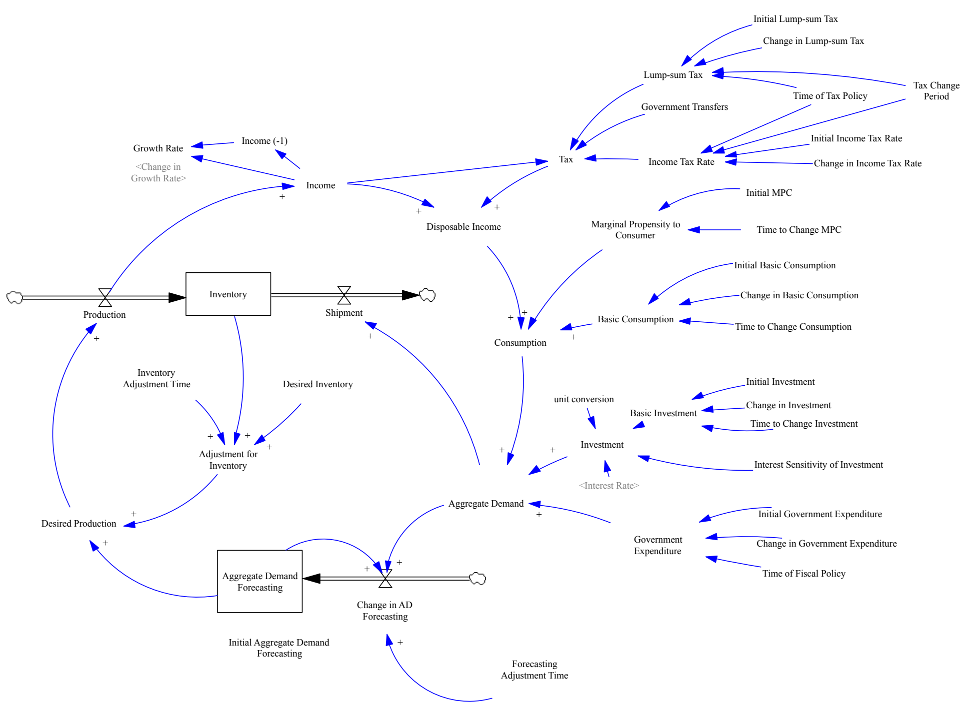

Figure 9.9: Aggregate Demand Adjustment with Inventory – IS Sub-Model

"Keynesian Adjustment SD Model with Inventory [Companion model: 2 Keynesian(SD).vpmx]. Figure 9.9 illustrates the *IS* sub-model of SD version of the

IS-LM model, with new investment and production decisions described above.

Our dynamic *IS* sub-model incorporates such Keynesian process, in which an aggregate demand forecasting mechanism is additionally introduced without changing the essential mechanism of Keynesian adjustment process. A box in the figure indicates a stock variable in SD whereas double-line arrows pointing into and from the stock indicate in- and out-flows. A single line arrow indicates instantaneous relationship between variables and parameters.

9.4.2 Dynamic LM Sub-Model

Interest Adjustment Process

Next, we need to build the LM sub-model of the SD version of the short-run IS-LM model. For this purpose, the equilibrium condition in the money market (equation (10.8)) needs to be replaced with a dynamic adjustment process of interest rate as a function of excess demand for money such that:

$$\frac{d\ i}{dt} = \Phi\left((aY - bi) - \frac{M^s}{P}V\right) \tag{9.40}$$

Applying the formulation of adjustment processes discussed in Section 4 of Chapter 2, the adjustment process of interest rate is further specified as

$$\frac{d\ i}{dt} = \frac{i^* - i}{\text{Delay Time}} \tag{9.41}$$

where i^* denotes desired interest rate. Desired interest rate i^* is obtained as

$$i^* = \frac{i}{\left(\frac{M^s}{P}V/(aY - bi)\right)^e} \tag{9.42}$$

where e denotes a money ratio elasticity of desired interest rate. Figure 9.10 illustrates the LM sub-model of the adjustment process of interest rate. Since price is assumed to be fixed, there should be no price adjustment process incorporated into our model. Yet Figure 9.10 additionally illustrates a price adjustment process for the uses in later sections.

9.4.3 The Standard IS-LM Analysis of Recessions

By utilizing the dynamic model thus developed, let us next see how the short-run IS-LM model can demonstrate the macroeconomic behaviors and effects of monetary and fiscal policies as described in textbooks. Economic recessions can be described as the decrease in income or GDP. One of the benefits of using the IS-LM framework in macroeconomic analysis is that we can visualize recessions as shifts in *IS* or *LM* curve. In other words, causes of recessions can be explained by the shifts in the *IS* curve and *LM* curve. If we can identify the causes of recessions in this way, we can then apply policies at our hands in a reverse way for the recoveries from recessions.

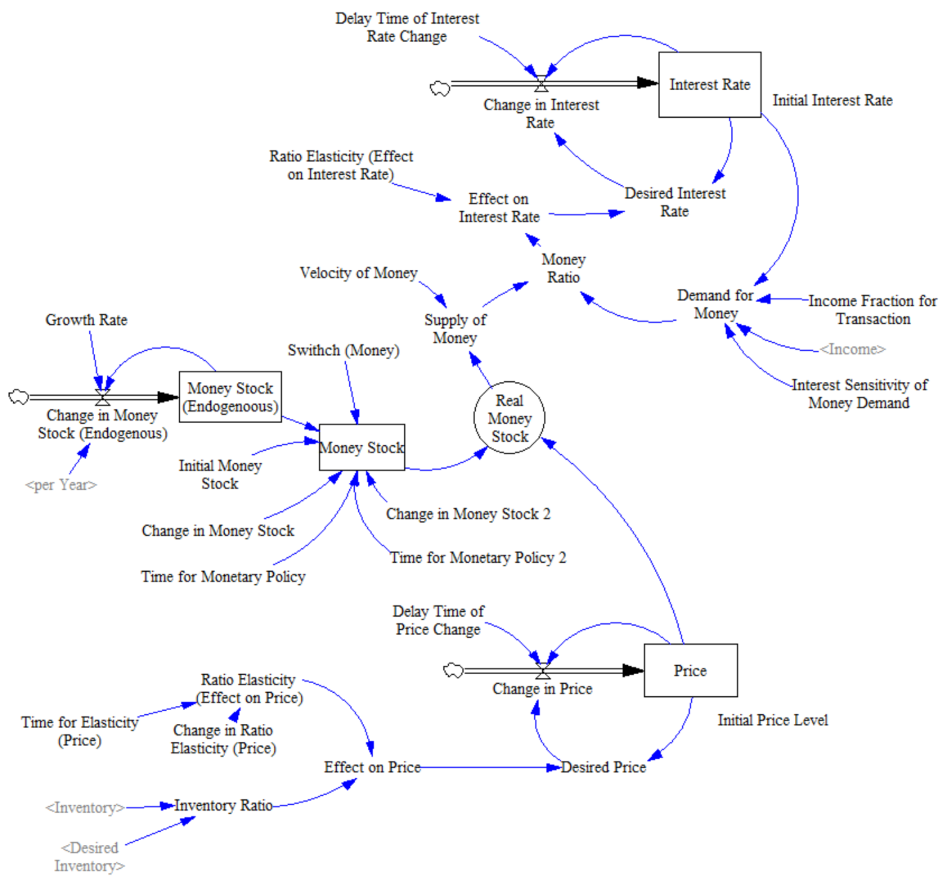

Figure 9.10: Interest Rate and Price Adjustment Processes – LM Sub-Model

Recessions Caused by the Shifts in *IS* Curve

Both diagrams in Figure 9.11 are phase diagrams consisting of interest rate taken on the vertical axis and income on the horizontal axis. First of all, the model is in the equilibrium as shown by the point A in the left diagram. Then recessions caused by decreases in aggregate demand such as investment and consumption can be illustrated by the leftward shift in the *IS* curve. In the left diagram of Figure 9.11, *IS* curve illustrated by a dotted black line is shown to shift leftwards as the original equilibrium point A moves to a new point at B, which is caused by the decrease in investment by $\Delta I = -20$ at t = 8. In our dynamic IS-LM model, this is implemented by decreasing the basic investment (I_0) using a STEP function. That is, the level of investment decline by 20 from t = 8 until the end of the simulation. As Figure 9.11 compares different simulations on the phase diagram, this shift in the *IS* curve is captured as a trajectory shown by a red line (point A $\to$ B).

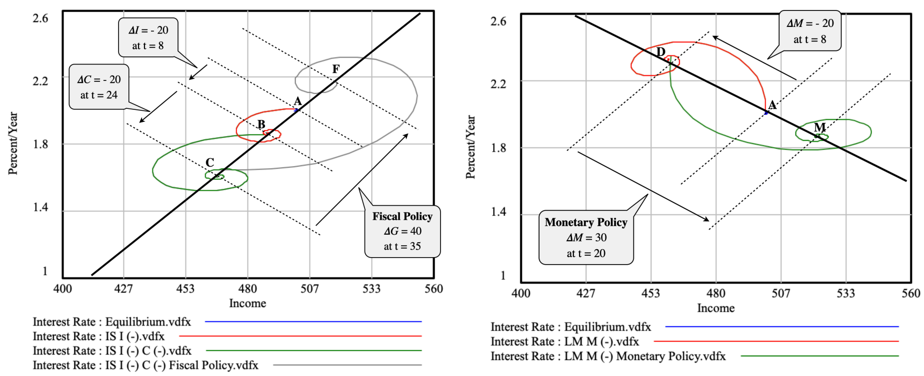

Figure 9.11: IS-LM Analyses of Fiscal (left) and Monetary (right) Policies

Now let us further assume that consumption has declined by $\Delta C = -20$ at t $= 24$ by similarly decreasing the basic consumption (C_0). Then the *IS* curve is moved further towards the left. As a result, the second equilibrium point B moves to point C as captured by the green trajectory line (point B $\to$ C) . We can observe that the equilibrium level of income as well as interest rate decline. If the economy experiences these types of recessions caused by compound decreases in the aggregate demand of the real sectors, IS-LM model tells us that we can not only restore the equilibrium easily, but also grow the economy further to the point F by increasing the government expenditure by $\Delta G = 40$ at t $= 35$. The effects of such government spendings are shown by the gray trajectory line from the previous point C to point F (point C $\to$ F). Notice how these shifts occur along the linear *LM* curve (a thick black line) since changes in aggregate demand do not affect the *LM* curve. This policy is generally known as the fiscal policy through government expenditure in macroeconomic textbooks.

Recessions Caused by the Shifts in *LM* Curve

Recessions caused by the decrease in money stock can be illustrated by leftward shifts of *LM* curve. For our purposes, we do not question how such reductions in money stock are brought about at this stage. In the right diagram of Figure 9.11, *LM* curve illustrated by a dotted black line is shown to move towards the left as the original equilibrium point A move to a new point at D. In our dynamic model of the IS-LM analysis, this shift in the *LM* curve caused by the decrease in money stock by $\Delta M = -20$ at t $= 8$ is captured by the red trajectory line. It can be observed that equilibrium level of income declines and interest rate rise as a result. If recessions are caused by reductions of money stock, the IS-LM model teaches us we can not only restore the equilibrium easily, but also grow the economy further to the new point M by increasing money stock by $\Delta M = 30$ at t $= 20$ as shown by the green trajectory line (point D $\to$ M). Notice how these shifts occur along the gentle hyperbolic *IS* curve (a thick black curve), which is produced by investment decisions in equation (10.6). This is the monetary policy.

With the introduction of the IS-LM model, recessions are analyzed as the shifts of *IS* and *LM* curves toward left while recoveries are analyzed as the rightward shifts of *IS* and *LM* curves. Figure 9.11 illustrates these standard textbook explanations of IS-LM analysis as a phase diagram of income and interest rate in a system dynamics model. By combining the shocks to aggregate demand and money stock, we can describe many possible combinations of recessions. Furthermore the model indicates that we can attain recoveries from wherever recessions end by mixing fiscal and monetary policies (policy mix). Macroeconomics textbooks are full of these exercises and we have been taught in classes, for over 80 years since Hicks first introduced the framework in 1937, that economies are now under the control of policy makers. Indeed our short-run IS-LM model seems to confirm the effectiveness of such macroeconomic 'fine-tunings'.

9.5 IS-LM Case Analysis of the Great Depression

Convinced by the analytical capabilities of IS-LM model, Professor Nicholas Gregory Mankiw at Harvard University (the title will be omitted hereafter) attempted to explain the causes of the Great Depression in his popular macroeconomics textbook used worldwide. Specifically Mankiw (2016, p.351) expresses that "[t]he Great Depression provides an extended case study to show how economists use the IS-LM model to analyze economic fluctuations". Let us next examine how the standard IS-LM analysis is applied to study the case of the Great Depression.

9.5.1 Spending Hypothesis vs Money Hypothesis

As discussed above, there are only two causes that trigger recessions in the IS-LM model; decreases in the aggregate demand (causing leftwards shift of *IS* curve) and decreases in the money stock (causing leftwards shift of *LM* curve). Mankiw (2016, Chapter 12) called the former *spending hypothesis* and the latter *money hypothesis*. The original proponent of the spending hypothesis was John M. Keynes. In essence Keynes (1936) analyzed that under-capacity (investment) and under-consumption in real sectors are the main causes of the Great Depression, and suggested the adjustment of aggregate demand through fiscal and monetary policies as a way out of the recession. In the context of the IS-LM framework, the policies should be aimed at economic stimulus through government expenditures and restoring investments by lowering the costs of borrowing, i.e. interest rates.

On the other hand, Mankiw (2016) argues that *money hypothesis* "places primary blame for the Depression on the Fed for allowing the money supply to fall by such a large amount (p.353)". He then continues to explain as follows:

> The best-known advocates of this interpretation are Milton Friedman and Anna Schwartz, who defended it in their treatise on U.S. monetary history. Friedman and Schwartz argue that contractions in the money supply have caused most economic downturns and that the Great Depression is a dramatic example (p.353).

In order to examine which of the two seemingly contrasting hypotheses is the plausible causes of the Depression using the IS-LM model, Mankiw arranged time-series data beginning from 1929 until 1940. Figure 9.12 below reproduces all data presented in the original Table 12-1 in Mankiw (2016, pp.352-353). We

TABLE 12-1 What Happened During the Great Depression?

Year	Unemployment Rate (1)	Real GNP (2)	Consumption (2)	Investment (2)	Government Purchases (2)	Nominal Interest Rate (3)	Money Supply (4)	Price Level (5)	Inflation (6)	Real Money Balances (7)
1929	3.2	203.6	139.6	40.4	22.0	5.9	26.6	50.6	—	52.6
1930	8.9	183.5	130.4	27.4	24.3	3.6	25.8	49.3	−2.6	52.3
1931	16.3	169.5	126.1	16.8	25.4	2.6	24.1	44.8	−10.1	54.5
1932	24.1	144.2	114.8	4.7	24.2	2.7	21.1	40.2	−9.3	52.5
1933	25.2	141.5	112.8	5.3	23.3	1.7	19.9	39.3	−2.2	50.7
1934	22.0	154.3	118.1	9.4	26.6	1.0	21.9	42.2	7.4	51.8
1935	20.3	169.5	125.5	18.0	27.0	0.8	25.9	42.6	0.9	60.8
1936	17.0	193.2	138.4	24.0	31.8	0.8	29.6	42.7	0.2	62.9
1937	14.3	203.2	143.1	29.9	30.8	0.9	30.9	44.5	4.2	69.5
1938	19.1	192.9	140.2	17.0	33.9	0.8	30.5	43.9	−1.3	69.5
1939	17.2	209.4	148.2	24.7	35.2	0.6	34.2	43.2	−1.6	79.1
1940	14.6	227.2	155.7	33.0	36.4	0.6	39.7	43.9	1.6	90.3

Data from: Historical Statistics of the United States, Colonial Times to 1970, Parts I and II (Washington, DC: U.S. Department of Commerce, Bureau of Census, 1975).

Figure 9.12: Key Macroeconomic Data during the Great Depression (1929–1940)

can easily observe that the IS-related variables such as real GNP, consumption and investment all fell during the initial period between 1929-1933, while the LM-related variables such as (nominal) interest rate, money supply and price level also fell during the same period except real money balances, which rose slightly and then fluctuated. Figure 9.13 plots the time-series data in graphs. As explained in Section 9.5.2 below, the real interest rate (red line) is obtained from the nominal interest rate and inflation data based on the Fisher equation. Accordingly the real interest rate shown in Figure 9.13 corresponds to *ex post* rather than *ex ante* real interest rate.

Mankiw examined both spending and money hypotheses by shifting IS and LM curves to the left, and then rejects the money hypothesis as the cause of the Depression as follows:

> Using the IS-LM model, we might interpret the money hypothesis as explaining the Depression by a contractionary shift in the LM

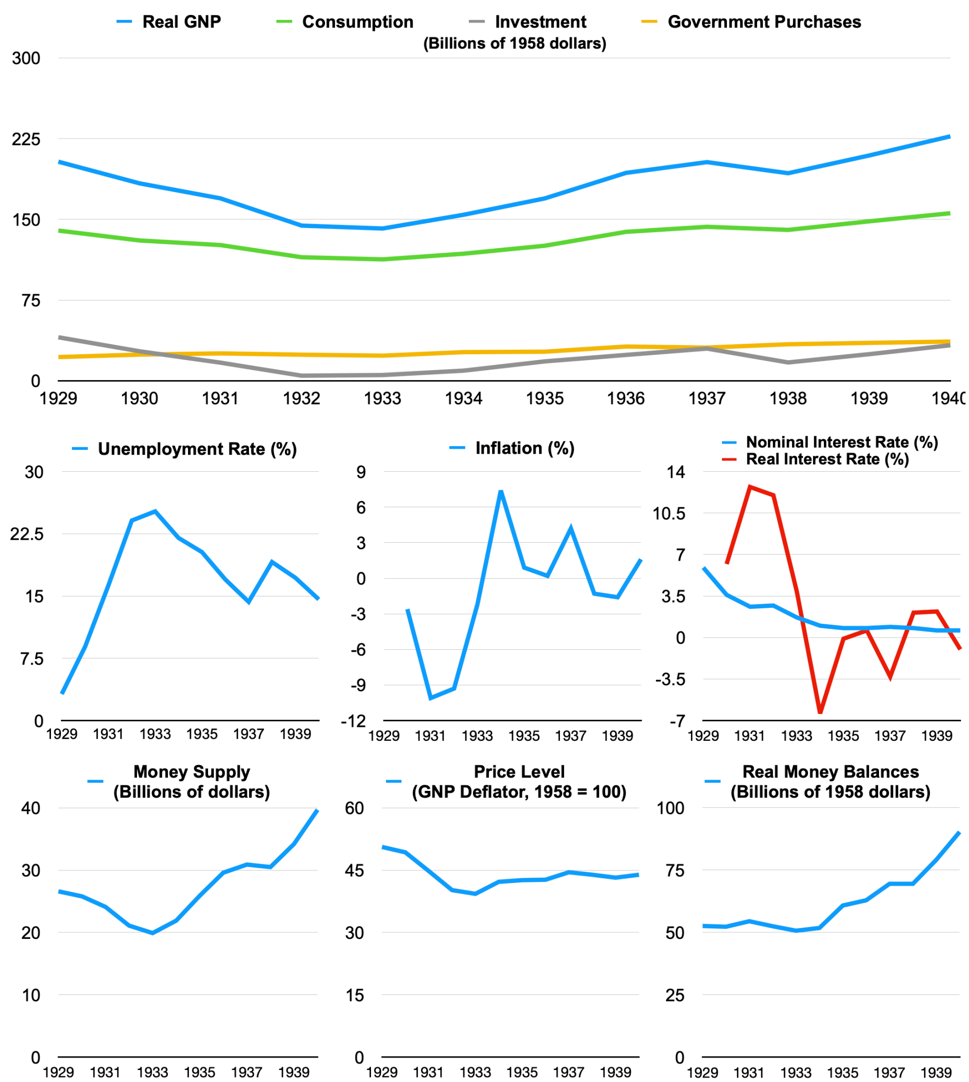

Figure 9.13: Illustrated Key Macroeconomic Data during the Great Depression

curve. Seen in this way, however, the money hypothesis runs into two problems.

The first problem is the behavior of *real* money balances. Monetary policy leads to a contractionary shift in the *LM* curve only if real money balances fall. Yet from 1929 to 1931 **real money balances rose slightly** because the fall in the money supply was accompanied by an even greater fall in the price level. Although the monetary contraction may have been responsible for the rise in unemployment from 1931 to 1933, when real money balances did fall, it cannot easily explain the initial downturn from 1929 to 1931.

The second problem for the money hypothesis is the behavior of interest rates. If a contractionary shift in the *LM* curve triggered the Depression, we should have observed higher interest rates. Yet **nominal interest rates fell continuously** from 1929 to 1933.

These two reasons appear sufficient to reject the view that the Depression was instigated by a contractionary shift in the *LM* curve. (Mankiw, 2016, p.354; Italics original. Bold emphases added by the authors of this paper.)

9.5.2 Which Hypothesis Explains the Great Depression?

Let us now turn to our short-run IS-LM model and examine if the Mankiw's assertions are justified. In the phase diagrams of Figure 9.11 above, shocks to the *IS* curve (spending hypothesis) is represented as a movement from point A to points B and C on the left diagram, and shocks to *LM* curve (money hypothesis) is illustrated as point D on the right digram. In order to study the spending and money hypotheses more in line with that of the Great Depression, let us run simulations by decreasing investment and consumption at the same time. For spending hypothesis, let us suppose that consumption decreases by $\Delta C = -20$ at t = 1930 once, and then investment decreases by $\Delta I = -20$ at t = 1930 and 1931 (for two consecutive periods) and then at t = 1935, respectively. For money hypothesis, let us assume that money stock M is now decreased by $\Delta M = -10$ at t = 1930. In our dynamic model, these scenarios are implemented through PULSE function.[4] These scenarios are more realistic than simply decreasing the level of C and I separately in time using STEP function as was done in the case of Figure 9.11.

Figure 9.14 shows the behaviors of income and interest rate under the two hypotheses as time-series. Note the date (1928-1940) displayed on the horizontal axis is a supplemental label. [5] Note also that the right graph shows the behavior for nominal interest rate instead of real interest rate. Under the fixed price assumption, however, there is no difference between nominal and interest rates and behaviors of the two exactly match in our simulation. Specifically line 1 (blue) in both diagrams show behaviors under the spending hypothesis whereas line 2 (red) shows that of the money hypothesis. On both diagrams the spending hypothesis indicates falls in both income and interest rate, while income falls but interest rate rises under the money hypothesis. Indeed the rise in interest rate under the money hypothesis fails to explain the fall in nominal interest rate

[4]Case analysis of the Great Depression using PULSE function is conducted by Yokei Yamaguchi.

[5]The simulation software (Vensim) has a functionality that allows users to control the appearance of time label of graphs arbitrarily. Overlaying the time range allows us to focus on specific periods of simulation. Simulation is ran for 50 years (1920-1970) but we are only showing the period between 1928-1940 when pulse function is implemented using this graph displaying functionality. It does not mean, however, that model parameters and initial values have been optimized using the actual reference data. Unit of time is set to year.

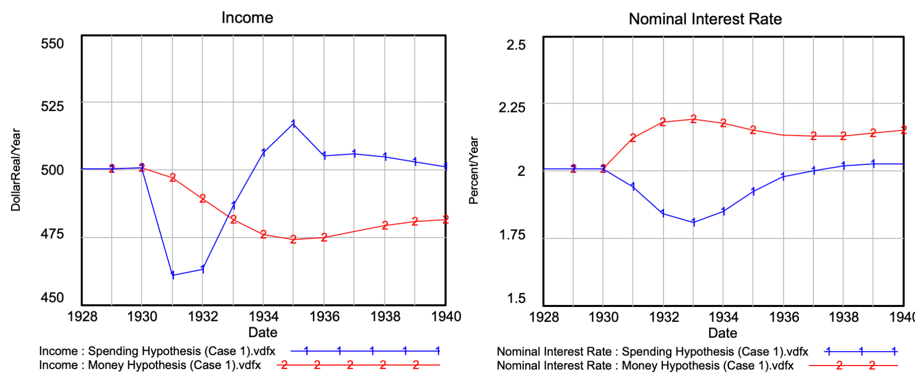

Figure 9.14: Income and Interest Rate under Spending and Money Hypotheses (Case 1)

observed from the data in Figure 9.12. Mankiw pointed out this contradictory behavior in the nominal interest rate as "the second problem for the money hypothesis". Our simulation also shows that each hypothesis has different effects on income.

Note that "Case 1" in the caption of Figure 9.14 means the simulations are run under the fixprice and exogenous money assumptions. To give an overview in advance, these assumptions will be relaxed step-by-step as we proceed in the following sections in this paper. The case 2 model, which will be studied in section 9.6.3, relaxes the fixprice assumption but exogenous money is left untouched as summarized in Table 9.1. From the combination of two assumptions, we will examine four cases in total. The model is developed so that all of the four cases can be examined in a single model through parameters called "ratio elasticity of price" and "endogenous money switch", which will be explained in later sections.

	$M_{exogenous}$	$M_{endogenous}$
P_{fixed}	Case 1	Case 3
$P_{flexible}$	Case 2	Case 4

Table 9.1: Assumptions and Model Cases

How about the the behavior of *real* money balances, then? Figure 9.15 below shows both money stock and real money balance fell under the money hypothesis. Recall that price is fixed under both hypothesis in case 1, which reflects the assumption of the standard short-run IS-LM model in macroeconomic textbooks. Therefore, as Figure 9.15 indicates, both spending and money hypotheses fail to explain that prices fell while real money balances rose during the Depression. In fact, this problem, which Mankiw called "the first problem" of money hypothesis, occurs under both hypotheses. Accordingly both hypotheses should have been rejected as the causes of the Great Depression. In other words the IS-LM model itself should have been rejected at this point of analysis as it cannot explain the behaviors of key macroeconomic variables. However, Mankiw fallaciously rejected the money hypothesis only without examining the

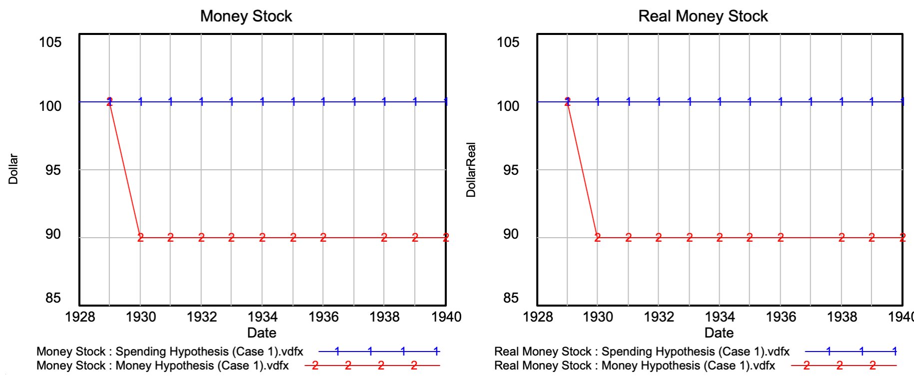

Figure 9.15: Money Stock and Real Money Stock under the Two Hypotheses (Case 1)

applicability of the short-run IS-LM model itself grounded on exogenous money and fixprice assumptions.

Money Hypothesis Explains Money Contraction and Rise in Real Interest Rate

Rejecting the money hypothesis, however, runs into three problems. The first problem is the behavior of real interest rate. Figure 9.13 in Appendix shows the behavior of real interest rate (red line), which is obtained from the nominal interest rate and inflation data in Figure 9.12 using the Fisher equation.[6] To be precise the real interest rate shown in Figure 9.13 corresponds to *ex post* real interest rate since the actual inflation data was used instead of the expected inflation. As we can observe from the graph shown in Figure 9.13, the *ex post* real interest rate initially jumped during the Great Depression. Accordingly one may counter-argue that money hypothesis performs better than spending hypothesis when it comes to explaining the contraction of money supply and initial rise in the (ex post) real interest rate.[7]

The second problem is the contraction of money stock M^s. Money hypothesis accounts for the contraction in M^s, which caused the banking crisis of the U.S. in the 30s. On the other hand, spending hypothesis does not take into account this critical aspect of the Great Depression nor the rise in real money stock or balance $\frac{M^s}{P}$. Furthermore M^s is treated as an exogenous variable as shown

[6]From the Fisher equation, the *ex ante* real interest rate (r_{ante}) can be approximated by subtracting expected inflation (π^e) from nominal interest rate (i) such that $r_{ante} = i - \pi^e$.

[7]The fundamental issue here is that price (P) is assumed to be fixed in the short-run IS-LM model; that is, expected inflation is zero ($\pi^e = 0$) as well as actual inflation ($\pi = 0$). Thus there is no theoretical distinction between real (r) and nominal interest rate (i) in the IS-LM model. It can be both nominal and real interest rates under the fixprice assumption. Accordingly one cannot take the interest rate in IS-LM model as showing either nominal or real interest rate and then evaluate it as contrasting with the data. In this case Mankiw interpreted the interest rate in the model as showing nominal rate (i) and compared it with that of the real world.

in the model equations. This reflects a key assumption of the standard IS-LM model that the amount of money in circulation can be controlled presumably by the central bank. Therefore it becomes logically unpleasant to assume that "M has contracted endogenously" in the first place. In other words, economists should have verified whether the assumption that "M^s is given exogenously" is wrong or the hypothesis that "M^s has contracted" is wrong at this point. Looking at the data, we can clearly see that money stock has shrunk significantly. We then come to understand the assumption that "M^s is an exogenous variable" is strange, and that, if M^s is an endogenous variable, it would then be unreasonable to pursue the Federal Reserve with full responsibility for the Depression, knowing that it cannot control money stock directly but only influences it. This point will be discussed in detail in the next Section 9.7.

The third problem is the behavior of price changes, i.e. the deflation, which was one of the two main causes that precipitated the Great Depression according to Irving Fisher, who was one of the original proponents of money hypothesis as we also discuss in the next section.[8] Therefore rejecting the money hypothesis in favor of the spending hypothesis runs into its own problems. Rational economists should have questioned the validity of the IS-LM model itself, rather than applying each hypothesis separately and rejecting only one of them in favor of the other.

9.6 Flexible Price IS-LM Analysis

9.6.1 Mankiw's Extended Model

In an attempt to explain the effects of deflation on income under the spending hypothesis, Mankiw (2016, p.355) then presents an extended version of the IS-LM analysis in a section titled "The Money Hypothesis Again: The Effects of Falling Prices". Referring to the debt-deflation theory proposed by Irving Fisher in 1933, Mankiw introduces a new variable: expected future inflation ($E\pi$). His extended IS-LM analysis is then presented as follows:

$$Y = C(Y-T) + I(i - E\pi) + G \qquad IS \qquad (9.43)$$

$$\frac{M}{P} = L(i, Y) \qquad LM \qquad (9.44)$$

where *ex ante* real interest rate (r) is the difference between nominal interest rate (i) and expected future inflation ($E\pi$) from the Fisher equation.[9] With the introduction of expected future inflation, nominal and real interest rates are now distinguished. Mankiw then goes on to explain that the spending hypothesis

[8] Mankiw himself acknowledges this, though he does not specify the name, as in the following sentence: "From 1929 to 1933 the price level fell 22 percent. Many economists blame this deflation for the severity of the Great Depression. They argue that the deflation may have turned what in 1931 was a typical economic downturn into an unprecedented period of high unemployment and depressed income."(Mankiw, 2016, p.354)

[9] Notice the different symbols used for expected inflation in Mankiw's textbook ($E\pi$) and in our model (π^e).

in his extended version of the IS-LM analysis shown above can explain how the destabilizing effects of deflation affect income without a need to rely on the money hypothesis as follows:

> Now suppose that everyone suddenly expects that the price level will fall in the future, so that $E\pi$ becomes negative. The real interest rate is now higher at any given nominal interest rate. This increase in the real interest rate depresses planned investment spending, shifting the *IS* curve from IS_1 to IS_2. (The vertical distance of the downward shift exactly equals the expected deflation.) Thus, an expected deflation leas to a reduction in national income from Y_1 to Y_2. The nominal interest rate falls from i_1 to i_2, while the real interest rate rises from r_1 to r_2.
>
> Here is the story behind this figure. When firms come to expect deflation, they become reluctant to borrow to buy investment goods because they believe they will have to repay these loans later in more valuable dollars. The fall in investment depresses planned expenditure, which in turn depresses income. The fall in income reduces the demand for money, and this reduces the nominal interest rate that equilibrates the money market. The nominal interest rate falls by less than the expected deflation, so the real interest rate rises.
>
> Note that there is a common thread in these two stories of destabilizing deflation. In both, falling prices depress national income by causing a contractionary shift in the *IS* curve. Because a deflation of the size observed from 1929 to 1933 is unlikely except in the presence of a major contraction in the money supply, these two explanations assign some of the responsibility for the Depression—especially its severity—to the Fed. In other words, if falling prices are destabilizing, then a contraction in the money supply can lead to a fall in income, even without a decrease in real money balances or a rise in nominal interest rates. (pp.355-356)

The first one of the "two stories of destabilizing deflation" refers to the debt-deflation theory proposed by Irving Fisher, which, according to Mankiw, analyzed that the wealth redistribution effects of deflation between debtors and creditors reduce the spending of debtors more than the creditors raise their spendings, thus giving rise to a net reduction in spending and causing contractionary shift in the *IS* curve. The second story is the role that expected inflation plays in the rise of real interest rate as explained in the quotation above.

There are two problems in this formulation when applying his extended analysis to the case of the Great Depression. The first issue is unit inconsistency in the *LM* equation (9.44). From system dynamics modeler's perspective, the supply of money $\frac{M}{P}$ on the left side of equation (9.44) has a stock unit expressed in real term (e.g. DollarReal) whereas the right side (demand for money) has a flow unit (e.g. DollarReal/Year). In system dynamics modeling convention, the Mankiw's extended version of the IS-LM model does not pass the unit consistency test.[10]

The second issue is the treatment of price P. The extended model introduced the expected inflation, which is a human psychological variable. However, P remains to be fixed in the short-run IS-LM model. Therefore it remains unclear how the Mankiw's extended model describe an expected deflation without flexible price in the first place. This leads us to a methodological issue, which is that he presents no dynamic model with which readers can run simulations and verify his claims. Model-less arguments can mislead policy makers and the public at large, which we will discuss in Section **??** in the context of the Japanese experience since 1990s.

9.6.2 Flexible Price Short-Run IS-LM Model

Let us incorporate the Mankiw's idea of extending the short-run model towards flexible price. The introduction of expected inflation allows us to distinguish nominal and real interest rates within our IS-LM model presented in Section **??**. Based on the Fisher equation, an *ex ante* real interest rate r can be approximated as the difference between nominal interest rate i and expected inflation rate π^e such that $r = i - \pi^e$. With the introduction of expected inflation and real interest rate, our extended version of the IS-LM model is now described as follows:

$$
\begin{aligned}
Y &= AD && \text{(Aggregate Demand Equilibrium)} && (9.45)\\
AD &= C + I + G && \text{(Aggregate Demand)} && (9.46)\\
C &= C_0 + cY_d && \text{(Consumption Decisions)} && (9.47)\\
Y_d &= Y - T && \text{(Disposable Income)} && (9.48)\\
T &= T_0 + tY - T_r && \text{(Tax Revenues)} && (9.49)\\
I &= \frac{I_0}{r} - \alpha r && \text{(Investment Decisions)} && (9.50)\\
G &= \bar{G} && \text{(Government Expenditures)} && (9.51)\\
\frac{M^s}{P} V &= L^d && \text{(Equilibrium of Money)} && (9.52)\\
L^d &= aY - bi && \text{(Demand for Money)} && (9.53)\\
r &= i - \pi^e && \text{(Fisher Equation)} && (9.54)
\end{aligned}
$$

With the addition of a new equation (10.10) into the previous model in Section 9.3, our extended IS-LM model now consists of 10 equations with 10 unknowns;

$$Y, AD, C, I, G, Y_d, T, i, r, L^d$$

with 14 exogenously determined parameters

[10] Refer to the equation (10.8) in our model where Real Money Balance (DollarReal) is multiplied by Velocity (1/Year). Our model clears the unit as well as model check tests built into the SD simulation software.

$$C_0, c, T_0, t, T_r, I_0, \bar{G}, M^s, P, V, \alpha, a, b, \pi^e$$

Equations (9.45) through (9.49) are the same formulation as in equation (10.1) through (10.5) of the previous model under fixprice. The extended model described above distinguishes nominal (i) and (*ex ante*) real interest rate (r) as in equation (10.10). Furthermore we can similarly define the *ex post* real interest rate (r_{post}) based on the Fisher equation. Note also that the investment decisions in equation (9.50) is now a function of *ex ante* real interest rate r whereas the liquidity demand is a function of *nominal* interest rate i.

9.6.3 SD Model of the Flexible Price IS-LM

To examine whether the Mankiw's assertions on the validity of spending hypothesis under the flexible price assumption are justified, let us introduce the expected inflation into our system dynamics model. To do so, we first need to incorporate price dynamics into our model.

Price Adjustment Process

Price level in the short-run IS-LM model is assumed to be exogenously determined, by reflecting the Keynesian view that price tends to be rigid in the short run.[11] Hence price has been assumed to be fixed in our model so far. Introducing the inventory stock, which we discussed already in Section 9.4.1, allows us to model price dynamics even in the short run, because fluctuations of inventory are always reflected as a change in price in the real economy such that

$$\frac{dP}{dt} = \Psi \left(I_{nv}^{*} - I_{nv} \right) \tag{9.55}$$

where I_{nv}^{*} denotes desired inventory, which represents the amount of inventory stock that the economy as a whole desires to hold at any moment in time. The difference between desired and current inventories may be called "inventory gap". This price adjustment process can be further specified as follows

$$\frac{dP}{dt} = \frac{P^{*} - P}{\text{Adjustment Time}} \tag{9.56}$$

where the desired price P^{*} is obtained as

$$P^{*} = \frac{P}{\left(I_{nv} / I_{nv}^{*} \right)^{e}} \tag{9.57}$$

where e is an inventory ratio elasticity of desired price. This elasticity can be changed as a parameter in our SD model so that users can try out different

[11] Chapter 2 explains the different views on the role of price adjustment in the Neoclassical and Keynesian models and presents causal loop diagrams respectively.

assumptions on the degree of price rigidity or stickiness.[12] The default value is set to 0 which assumes the fixprice. We have set the price adjustment time to 4 (years) in the subsequent simulations. The stock-flow diagram in Figure 9.10 illustrates this price adjustment process in advance.

Expected Inflation Formation Process

With the introduction of price adjustment process above, the model can now be extended further to incorporate the formation of expected inflation as a psychological variable. Specifically the expected inflation rate can be modeled as

$$\frac{d\pi^e}{dt} = \frac{\pi - \pi^e}{\text{Adjustment Time}} \tag{9.58}$$

where the inflation rate is obtained as follows:

$$\pi = \frac{d(lnP(t))}{dt} \tag{9.59}$$

where $lnP(t)$ is a natural logarithm of price $P(t)$. The adjustment process of expected inflation above reflects the *adaptive expectation*. With the inclusion of the price adjustment and expected inflation rate, our extended IS-LM model with flexible price assumption is now completed.

9.6.4 Spending and Money Hypotheses under Flexible Price

We have completed the extension of our model to incorporate price flexibility. Let us now run simulations and test the spending and money hypothesis in this extended model. Specifically we allow the price to move flexibly by setting its elasticity to 0.2 at t = 0 from its default value of 0 (fixprice). The inflation expectation adjustment time is set to 10 (years).

Figure 9.16 below shows the behavior of income (left) and price level (right). "Case 2" in the caption means that the simulation is run under flexible price assumption. Reductions in consumption, investment (spending hypothesis) and money stock (money hypothesis) are implemented in the same way as previously done in case 1. Both hypotheses cause income to fall similar to case 1 simulations.

A left diagram in Figure 9.17 below shows nominal interest rate (line 1 in blue), *ex ante* real interest rate (line 2 in red) and the *ex post* real interest (line 3 in green) rates under the spending hypotheses. The right diagram shows those of the money hypothesis. Spending hypothesis in our flexible price model (case 2) captures what Mankiw called the *destabilizing effects of deflation* on income, the fall in nominal interest rate as well as rise in real interest rate. Though the rise in *ex ante* real interest rate (line 2) under the spending hypothesis is

[12] Many textbooks adopt the view that price level P is fixed in the short run, but not in the long run. Yet, flexible prices caused by the inventory gap take place in the short run, furthermore, price flexibility can be adjusted according to the ratio elasticity of the inventory gap. This is one of examples of the flexibility of SD-based approaches.

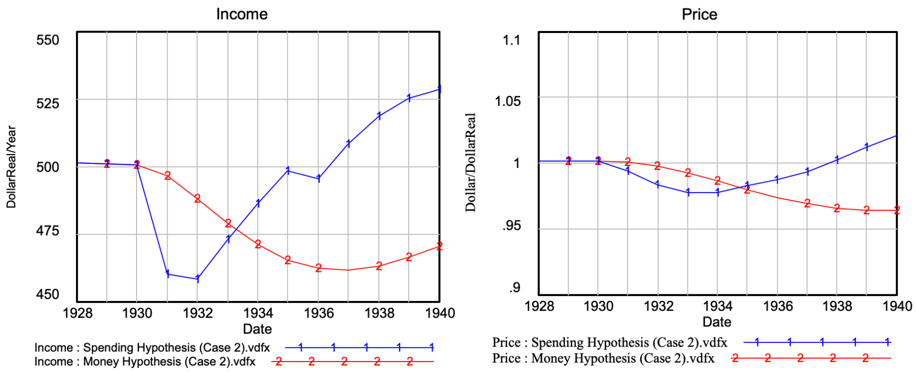

Figure 9.16: Income and Flexible Price by the Two Hypotheses (Case 2)

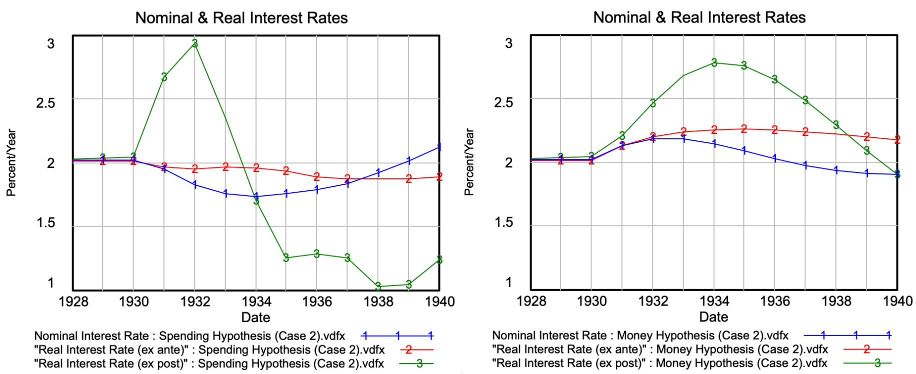

Figure 9.17: Nominal and Real Interest Rates by the Two Hypotheses (Case 2)

not significant in our simulation, the decline in nominal interest rate causes the *ex ante* real interest rate to appear relatively higher. Moreover the spending hypothesis captures the sudden rise in *ex post* real interest rate (line 3), which is consistent with what had been observed during the Great Depression (see Figure 9.13 also).

Case 2 analysis is what Mankiw's extended model of the IS-LM has attempted to implement, but he did not present a dynamic model. Our simulation results indeed confirms the validity of Mankiw's claim, and this is one of the contributions of this paper. However, the problem of spending hypothesis in case 2 model is that it still treats money stock M as exogenously given, thus failing to explain the contraction of money as was discussed in case 1 also. To see this visually, Figure 9.18 compares the behaviors of money stock (left) and real money balance (right) under the two hypotheses. From the graph on the right, we can observe that real money stock under the spending hypothesis (line 1 in blue) increases whereas that of money hypothesis (line 2 in red) decreases

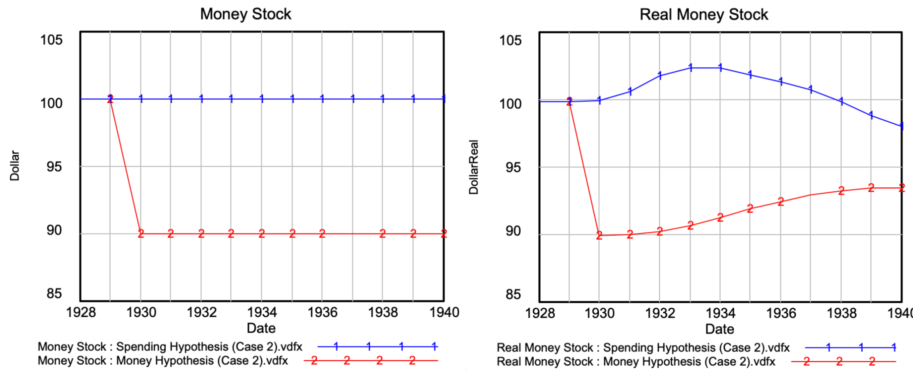

Figure 9.18: Money Stock and Real Money Balance by the Two Hypotheses (Case 2)

initially and then rise. This seems to suggest that spending hypothesis explains the behavior of real money balance during the Depression better than the money hypothesis. Looking at the graph on the left, however, the spending hypothesis does not take into account the contraction of money in the first place. The rise in real money balance without contractions in money stock shows that the spending hypothesis in case 2 model does not explain the real money balance for the right reason. As far as our simulation results suggest, therefore, we did not find a theoretical evidence which supports Mankiw's claim under the spending hypothesis in his extended IS-LM analysis.[13]

Money hypothesis in case 2, on the other hand, captures the money contraction, deflation, and rise in real money balance for the right reason. Also the rise in *ex post* real interest rate is consistent with the data. However, the nominal interest rate also rises under the money hypothesis, which is inconsistent with what was observed during the Great Depression.

Problems of Spending Hypothesis under the Flexible Price Model

In summary, spending hypothesis in the extended model still fails to explain the contraction of money, and thus the behavior of real money balances for the right reason. It does not take into account the fact that money stock contracted significantly during the Depression. This anomaly alone should have prompted economists to question the validity of IS-LM model itself, rather than rejecting only the money hypothesis in favor of the other twice, that is, first in the standard short run model and, again, in the extended model. Our simulations imply that the conventional IS-LM model, which is built upon the fixprice and

[13] Recall from the quotation above that Mankiw (2016) maintained that "if falling prices are destabilizing, then a contraction in the money supply can lead to a fall in income, even without a decrease in real money balances or a rise in nominal interest rates. (p.356)". One can see here that he presupposes the money contraction under the spending hypothesis in his extended analysis. This assumption, however, contradicts with his definition of spending hypothesis or with the exogenous money still assumed in his extended model.

exogenous money assumptions, fails to explain the causes of the Great Depression under both hypotheses. Should we abandon the IS-LM model, then? If so, the cause of the Great Depression becomes unexplained again and that would be an undesirable situation for the macroeconomics.

9.7 Endogenous Money Spending Hypothesis

What is wrong with the IS-LM model, then? As discussed so far, the problem lies in the assumption that money stock M is exogenously given and price is fixed in the short-run. Since the introduction of IS-LM model by Hicks in 1937, it has been a norm among economists to assume that money is exogenously determined by the monetary authority; that is, money stock has been assumed to be put into circulation and can be controlled by the central bank or government. Empirical studies, on the contrary, show that the majority of money is created endogenously as interest-bearing debts of non-banking sectors under the current fractional reserve banking systems (Werner, 2016; Yamaguchi, 2021b; Yamaguchi and Yamaguchi, 2021a).[14]

9.7.1 Fisher's Debt-Deflation and 100% Money Theories

Have the economists been ignorant for such a long time so as to disregard the role of money and debts? No, they have not. Indeed, just as the same time when Keynes published the General Theory in 1936, Irving Fisher, who was the leading American economists and just became the first president of newly-founded Econometric Society in 1931, proposed that the main cause of the Great Depression is the structure of the fractional reserve banking system where money is created and destructed endogenously. His main interest at the time was to elucidate the causes of business cycles. And, just like Keynes, he has been struggling in search for the remedies.[15]

The Debt-Deflation Theory

Fisher's solution was the paper published in the first volume of Econometrica entitled "The Debt-Deflation Theory of Great Depressions" (Fisher, 1933), which was essentially a summary of his book "Booms and Depressions" (Fisher, 1932) published a year before. Fisher analyzed that the crux of the Depression was the *over-indebtedness* ("debt disease"), which triggered the financial crisis initially, and the *deflation* ("price-level disease") that worsened the burden of debtors. In other words, he had a conviction that the central factors that precipitated the

[14]In the original article, Hicks (1937) simply assumed "Let M be the given quantity of money (p.148)". We do not know whether Hicks himself, and others who later followed the IS-LM framework, made such an assumption for the sake of mathematical simplicity or by the unfamiliarity with the fractional reserve banking. This was, however, and still is an over-simplification of the money and banking systems of the real world.

[15]Section 9.7.1 owes to Chapter 8 of Yamaguchi (2015) titled "What is the Chicago Plan (Monetary Reform)?".

Depression were debt disease (bank loans) and dollar disease (increasing value of the dollar) rather than real economic factors such as over- or under-production, consumption, saving or investment. Let us first briefly revisit the debt-deflation theory based on his article.

Fisher focused on nine macroeconomic variables and described them as the "chain of consequences" that he considered characterized the dynamics of the Great Depression as follows:

> (1) *Debt liquidation* leads to *distress selling* and to (2) *Contraction of deposit currency*, as bank loans are paid off, and to a slowing down of velocity of circulation. This contraction of deposits and of their velocity, precipitated by distress selling, causes (3) *A fall in the level of prices*, in other words, a swelling of the value of the dollar. Assuming, as above stated, that this fall of prices is not interfered with by reflation or otherwise, there must be (4) *A still greater fall in the net worths of business*, precipitating bankruptcies and (5) *A like fall in profits*, which, in a "capitalistic," that is, a private-profit society, leads the concerns which are running at a loss to make (6) *A reduction in output, in trade, and in employment* of labor. These losses, bankruptcies, and unemployment, lead to (7) *Pessimism and loss of confidence*, which in turn lead to (8) *Hoarding and slowing down still more the velocity of circulation*. The above eight changes cause (9) *Complicated disturbances in the rate of interest*, in particular, a fall in the nominal, or money, rates and a rise in the real, or commodity, rates of interest. (Fisher, 1933, p.342; emphasis original).

Evidently Fisher pointed out the contraction of money stock and a fall in nominal or a rise in real interest rates in his debt-deflation theory. Furthermore system dynamics practitioners can easily notice that his line of thought is inherently a causal analysis.[16]

Figure 9.19 below illustrates a causal loop diagram of the debt-deflation theory.[17] As we have just seen, the starting point of his analysis is the occurrence of over-indebtedness and insolvency upon the burst of the bubble (numbers in parenthesis show the sequence in the original exposition by Fisher). Companies and individuals repay bank loans in order to reduce their debts (1). Demand deposits will decrease as a result (2). Distress selling on margin calls causes the stock market to crash, and sales in both real and financial markets become sluggish in the process of debt repayments. The velocity of money slows down.

[16] Fisher uses the term "logical order" as opposed to "chronological order". The former is generally called the 'causal (loop) analysis' and the latter 'behavior analysis (over time)' in system dynamics. Fisher is known to have also explained systematically the importance of stock-flow distinction and a need for the strict adherence to it in economic theory and analysis (Fisher, 1906), not to mention his contribution to fundamental concepts underlying the macroeconomics including the Fisher equation (Fisher, 1930).

[17] Adopted from Yamaguchi (2015, Figure 8.1, p.177) with minor modifications and translation from Japanese. Blue arrows indicate the causal relationship changes in the same direction whereas red indicate the opposite.

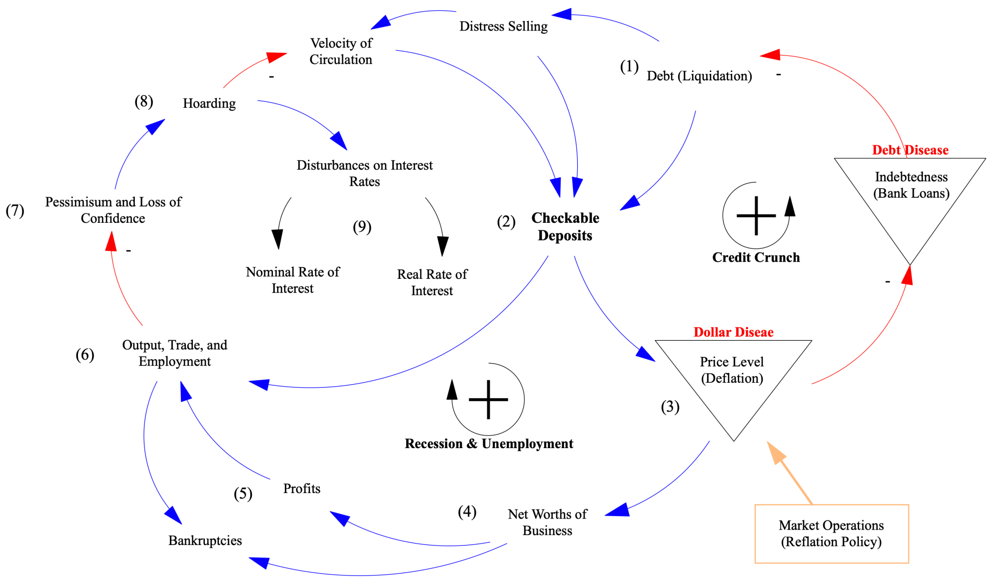

Figure 9.19: The Debt-Deflation Theory in A Causal Loop Diagram

As a result of the declines in investment and consumption, price levels will fall (3). Then, net assets of business corporations begin to decrease further (4), and bankruptcies increase. At the same time profits will decrease (5) and corporate losses increase. Levels of production will decrease in this way (6), which in turn decrease employment. In addition, the recession makes corporate managers pessimistic and reduce confidence in their businesses as losses and bankruptcies become more evident (7). They then decrease expenditures and stop spending money. Money begins to be hoarded and its velocity of circulation slows down further (8). As a result, recession will accelerate decline in prices (3). All of the above turmoils affect interest rates, lowering nominal interest rates as demand for money and loans plunge, while raising real interest rates (9). This causal loop is referred to as "recession and unemployment loop" in the causal digram.

Fisher called this effects of excess debts and insolvency "debt disease", and effects of deflation on the economy "dollar disease". He then analyzed that debt disease results in the contraction of money stock, lower prices, and bring about the dollar disease. Compounding effects of debt and dollar diseases bring about the fallacy of composition: "*the very effort of individuals to lessen their burden of debts increases it, because of the mass effect of the stampede to liquidate in swelling each dollar owed* (. . .) *the more the debtors pay, the more they owe.* (Fisher, 1933, p.344; emphasis original)". This feedback loop is referred to as "credit crunch loop". When we focus on the dynamics around the falling prices, this is a deflationary spiral. As we have just seen, the debt and money always occupy the central positions in Fisher's analysis.

Note that Fisher's causal analysis stops at the interest rates (9) as is illustrated in Figure 9.19. However, under our integrated hypothesis applied in the flexible price IS-LM model, which we will discuss in the next Section 9.7.2, the *ex ante* real interest rate affects the level of investment I such as describe in the equation (9.50). Accordingly the feedback loop will be closed in our case 4 model with flexible price and endogenous money assumptions.

Reflation Policy – Fisher's Initial Prescription

How do we get out of the Depression, then? The Fisher's answer was straightforward. He came to a conclusion that price levels should be stabilized and the economy will be reflated. More specifically he considered that prices P would naturally rise if the Federal Reserve conducts open market operations and increases the amount of money M. Using the causal diagram in Figure 9.19, this policy can be thought of as breaking the credit crunch loop. On the other hand, Keynes's analysis put more emphasis on the real economic variables such as aggregate demand. Thus, the Keynesian policies can be thought of as breaking the 'recession and unemployment loop'. Behind this logic, Fisher had the quantity theory of money (Fisher, pany) in mind:

$$MV = PT \tag{9.60}$$

where T denotes "Trade" or Transaction volumes (not to be confused with Tax Revenues in equation (10.5). Notice how this quantity theory is embedded in the causal analysis in Figure 9.19 above. Based on this equation of exchange, Fisher argued that the increase in money M will eventually lead to an increase in prices P or transaction volume T (or income Y), if the money velocity V remains constant (or increases). Specifically he contended that, as long as the velocity V keeps its pace with T, which had already been observed statistically by Dr. Carl Snyder (a statistician at the Federal Reserve Bank of New York) according to Fisher, the price level P can be kept steady along with the steady progress of T in the long-run. Let us call such a policy *reflation policy*. Fisher (1932, Chapter X) conveyed that the reflation policy causes prices to rise moderately, and the economy would eventually recover from the dollar disease as illustrated at the bottom right corner of Figure 9.19. For this reflation policy to be effective, Fisher (1932) stated that "[w]e need only to assume that an increase in the quantity of the circulating medium has *some* tendency to raise the price level, and *vice versa* (p.124; emphasis original)".

Fisher himself seemed very pleased at the time that his theory was highly regarded by experts as "both new and important (Fisher, 1933, p.337)". As a matter of fact, he was convinced that the reflation policy, though it was not a panacea, could have escaped the Depression as follows:

> In fact, in my opinion, this [prevention of the Depression] would have been done had governor Strong of the Federal Reserve Bank of New York lived, or had his policies been embraced by other banks and the federal reserve board and pursued consistently after his death. (Fisher, 1933, p.347)

The reflation policy continued to have influences on economists even today and it became the rationale of large scale asset purchase programs known as Quantitative Easing (QE) policy.

From "Debt-Deflation" to "100% Money" – Fisher's Conversion

In march of 1933, the same year as he published the debt-deflation paper, Fisher received a proposal called "The Chicago Plan for Banking Reform" proposed by the eight economists at the University of Chicago.[18] With his debt-deflation theory published in October, Fisher appears to have had full hopes for the reflation policy by the Federal Reserve as stated above. In fact, as if to support his expectations and confidence in his theory, Fisher (1945) confessed that he "had not at the time of stating them [conclusions of the Booms and Depressions] given attention to the 100% system (p.119)". However, from around 1934, Fisher began to devote himself with the monetary reform envisioned by the Chicago Plan to the extent he abandoned his own reflation theory. Undoubtedly Fisher must have been in a hurry to publish 100% Money at the time. Due to the demanding publication schedule, he simply reproduced the original section titled "THE ROLES OF DEBT AND DEFLATION" from the Econometrica article into Chapter 7 of his new book with the section titled "BOOMS and DEPRESSIONS". In doing so, he took the insight he gained after the publication of the debt-deflation theory and slipped the following sentence into his new book published two years later in March of 1935:

> It should be noted that *all the events listed occur through a contraction of check-book money.* (Fisher, 1945, p.123; emphasis original)

All the events listed imply the nine economic events he listed in the original paper, and *check-book money* implies demand deposits. So, what was the insight he gained after the publication of the debt-deflation theory? Fisher realized, upon receiving the Chicago plan, that money stock was not exogenous. Instead he realized bank loans create new deposits under the fractional reserve banking system or "the 10% system" *à la* Fisher (1945).

Specifically he observed this endogenous expansion and contraction of bank deposits as shown in Table 9.2.[19] First, from 1926 to 1929, the money stock

[18]They were: G. V. Cox, Aaron Director, Paul H. Douglas, A. G. Hart, Frank H. Knight, Lloyd W. Mints, Henry Schultz, and Henry C. Simons. Phillips (1995) provides a detail account of the background, thesis and outcomes of monetary and banking reform proposals in the 1930s. The proposals, in principle, consisted of 1) requiring 100% reserve ratio on checkable deposits, and 2) establishing and authorizing the "Currency Commission" a la Fisher (1945, p.119) to provide money banks need for the 100% reserve ratio, and to manage total money stock towards price stability objective. The former arrangement structurally increases resiliency, safety and stability of the domestic financial system by making all M1 backed by legal tender, thus achieving M0 = M1. Note that deposits are merely promises by banks to refurnish currency, i.e. legal money, on demand under the current fractional reserve banking system. As a by-product of the reform, national debts will also be liquidated. See Yamaguchi (2010, 2011, 2021a) for Accounting System Dynamics (ASD) model-based studies, and Benes and Kumhof (2012) for DSGE model-based study on the topic further.

[19]Prepared by the authors based on descriptions by Fisher (1945, pp.5-6). Numbers were

	1926	1929	1933
Money Stock (M^s)	26	27	20
Cash	4	4	5
Deposits	22	23	15
Cash-Deposit Ratio	4/22	4/23	5/15
($= \frac{\text{Cash}}{\text{Deposits}}$)	(= 18.2%)	(= 17.4%)	(= 33.3%)

Table 9.2: Deposits Contraction during the Great Depression and Changes in Money Stock during 1926-1933 (in billions)

increased by 1 billion dollars from 26 to 27 billion dollars. This reflects the economic booms of the time (the Roaring 20s). Then, from 1929 to 1933, cash holdings increased by 1 billion dollars from 4 billion to 5 billion dollars. This is the result of depositors flooding banks and withdrawing cash. In other words, depositors raised the cash ratio from 17.4% in 1929 to 33.3%, reducing bank reserves by 1 billion dollars. As a result, demand deposits have fallen by as much as 8 billion dollars from 23 billion in 1929 to 15 billion dollars in 1933. In summary cash increased by 1 billion over the period of four years, while demand deposits decreased by 8 billion, resulting in the disappearance of 7 billion dollars in the money stock. This contraction in money stock can also be confirmed in Figure 9.12 above. At that time, instability caused by bank runs in the U.S. developed into a systemic scale, forcing at least more than 10,000 banks to close operations. Observing this, Fisher likened the money stock to a highway for business activities, describing that the 23 billion miles (dollars) of highways needed for daily business operations were suddenly destroyed by 8 billion miles (dollars).[20]

As a result, the supply of money or money stock M is endogenously determined, and the quantity equation (9.60) is not an equation but merely an identity that always holds. In other words, the quantity theory as an identity must be accurately expressed, considering that money stock is a function of transactions, as follows:

$$M(T)V \equiv PT \tag{9.61}$$

Expressed in this way, the causal inference that money stock M affects prices P and the real economy is no longer convincing and discernible.[21] On the contrary, the relationship between money and economic activities becomes clear. Changes

rounded. Hence the cash-deposit ratios do not precisely correspond to the values calculated using numbers in the table.

[20]Yamaguchi and Yamaguchi (2021b, Chapter 1) observed that almost the same ratio of money stock M_1 was potentially destroyed during the burst of the Japanese bubble in the 90s. It was 'potentially' because during the post-bubble period, the Japanese government, following the Keynesian fiscal policy, increased deficit spendings through bond issuance, which increased the money stock. Recall that fiscal expenditures financed by bonds underwritten by banks will result in increase in money stock (Yamaguchi and Yamaguchi, 2021a).

[21]Fisher proposed the quantity theory as an identity. However it was somehow transformed later into an equation that determines price P and income-related variables by the monetarists. This is also noticeable from the Mankiw's interpretation and explanation of the money hypothesis originally put forward by Fisher.

in money stock occur endogenously and M should not be treated as an exogenous policy variable. Thus the reflation policy initially envisioned by Fisher himself is only effective up to the stage where base money (M_0) can be increased through rediscounting and open market operations by central banks. The asset purchase programs, however, do not increase money stock M^s (such as $M_{1,2,3}$) per se, which consists of currency and private bank deposits. This means that another assumption of the reflation policy, as described below, will not be guaranteed under the fractional reserve system:

$$M_1 = mM_0 \Longrightarrow (\text{if } m \text{ is stable}) \Longrightarrow \Delta M_1 = \Delta M_0 \tag{9.62}$$

where m is the money multiplier.[22] In other words Fisher realized further that the money multiplier m cannot be assumed to be stable. This means that the two major assumptions of reflation policy, i.e., the stable velocity V and money multiplier m, do not hold under the fractional reserve banking system simply because m cannot be controlled by the central bank nor by the government. This was the reason why Fisher emphasized in italics that the Great Depression, as analyzed in the debt-deflation paper, "*occur through a contraction of deposits*". Upon receiving and studying the Chicago plan carefully, he was convinced that the fundamental causes of the Depression lies in the structure of fractional reserve banking system itself. Under this system, money is created through bank loans, driving speculative investments and financial bubbles. When the bubble bursts, the $8 billion dollars of "check-book money" disappeared during the Great Depression. He then continued his analysis and concluded as follows:

> Booms and depressions can doubtless, to some extent, be cured and prevented without recourse to the 100% system, but, if my analysis is correct, not so surely, quickly, and easily as under 100% system; for an underlying cause (or precondition) of great booms and depressions is the 10% system itself (Fisher, 1945, p.120)

In this way Fisher buried his own reflation theory with his own hands and replaced it with 100% money theory where he contended the effectiveness of stabilization policy and other socio-economic benefits.[23] In the 100% reserve system, demand deposits will not disappear from circulation even if debts are

[22] If the cash-deposit ratio (α_c), legally required reserve ratio (β_r), and excess reserve ratio (β_e) are defined, then the money multiplier (m) is obtained as

$$m = \frac{\alpha_c + 1}{\alpha_c + \beta_r + \beta_e} \tag{9.63}$$

The cash-deposit ratio is a value determined by the liquidity preference of non-banking private sectors such as households and producers, and excess reserve ratio is determined by the lending of deposits (assuming the financial intermediation theory of banking). If the cash-deposit ratio or excess reserve ratio rises due to some external factors, then the money multiplier would fall and money stock M^s will also be out of a control since the central bank can only control the required reserve ratio. See Yamaguchi and Yamguchi (2016) further.

[23] See Fisher (1945, pp.10-14) further. All of them still applies even today as the basic structure of the current debt money system remains the same as was in the 1930s, except the gold standard was abolished in 1971.

repaid due to over-indebtedness or insolvency. Also the velocity will not be affected. That is, the causal arrow pointing from "Debt (Liquidation)" towards "Checkable Deposits" disappears, and the credit crunch loop is eliminated. As a result, there will be no debt disease or dollar disease that causes the depression. Even if they do occur, they will not have a significant impact on real economy. The reflation policy may eliminate the effects of dollar disease, but they could not eliminate the effects of debt disease. Fisher was theoretically convinced that, even if these illnesses occurred, they would not cause economic fluctuations to be as severe as the Great Depression under the *100% system*. After the World War II and until his death in 1947, Fisher continued to advocate the monetary reform, collaborating with other economists, informing members of the American Economic Association (AEA) where he was the past president in 1918, and engaging with members of the Congress and Senators to enact a bill that will establish the *100% system* in the United States and at international levels (Phillips, 1995). For some reasons, however, the Fisher's endogenous money analysis was gradually forgotten, and later disappeared completely from textbooks as if it were a *taboo*.

9.7.2 SD Model of the Endogenous Money IS-LM

Empirical results show that the majority of money supply are created by bank loans. That is, money stock M^s exists as interest-bearing debts of non-banking sectors under the current *debt money system*.[24] Accordingly money stock needs to be reincorporated as an endogenous variable into the IS-LM model. This has prompted us to revise the 'exogenous money' assumption of the conventional IS-LM analysis. How can we revise our IS-LM model, then, into the one in which money is endogenously created and destroyed? More specifically, how can we integrate the spending hypothesis by Keynes and money hypothesis by Fisher?

Endogenous Money Spending Hypothesis

The conventional IS-LM model assumes money is an exogenously given and controlled by the monetary authority. However, as shown in equation (9.61) above, money must be a function of transactions within the framework of the

[24] Yamaguchi (2021b) examined the money-debt relationship, as suggested by the deposit creation theory, in the case of United States Dollar (USD) and found that total debts from banks approximate total money stock $M2$ of the U.S. during 1945-2020, following the previous case observed in Japanese Yen (JPY) during 1980-2019 (Yamaguchi and Yamaguchi, 2021a,b). As a reference, Yamaguchi (2021b, p.16, Fig.9) reports that the correlation coefficient between total debts and $M2$ of the U.S. is 0.998 during the period between 1945-2020 and 0.996 during the period between 1980-2020. The money-debt relationship in the USD case was observed more precisely than it did in JPY case where the correlation coefficient between total debts and $M3$ is 0.987 during 1980-2019. Furthermore the correlation coefficient between total debts and nominal GDP of the U.S. is reported to be 0.987 during a period between 1945-2020 and 0.978 during 1980-2020 respectively.

Fisher's quantity theory such that

$$M = M(T) \tag{9.64}$$

Since the IS-LM model analyzes this transaction volume in a narrower sense as transactions related to the income, money stock must be a function of income, i.e. $M = M\ (Y)$. Income in turn is determined by effective demand such as consumption, investment and government spending under the IS-LM framework. Under the current debt money system, debts by private sector and government debts (borrowing) precede investment and spending, since money stock is only put into circulation when banks make loans by creating deposits on their books. If the private sector increase investments or the government issues debt securities, then the amount of money in the economy will increase endogenously. That is, money stock M^s in the LM curve must be a function of investment (I) and government debt (D_{gov}) such that

$$M = M(I, D_{gov}) \tag{9.65}$$

If effective demand is determined by investment and government spending and *IS* curve is drawn, then the money stock would also change simultaneously. Therefore *LM* curve also have to be drawn again in conjunction with it.

Based on this insight of endogenous debt money, we propose an alternative integrated hypothesis for the causes of the Great Depression; that is, *Endogenous Money Spending Hypothesis*. Specifically, we have assumed that economic recessions under the debt money system are generally caused by a combination of spending and money hypotheses as follows:

(a) Aggregate demand falls (the real sector is assumed to trigger recessions here).

(b) Declines in demand for loans follow, including forced debt repayments (credit crunch).

(c) Money stock contracts as a result, followed by deflation, which increases debt burdens of borrowers and real interest rate, which brings the causality back to (a).

Left diagram of Figure 9.20 illustrates the above three events as a positive feedback loop of our endogenous money spending hypothesis. It can cover the case of recessions as well as economic booms. In the case of economic booms, one can visualize by simply reversing the causal direction in events (a), (b) and (c) in the same feedback loop. This causal loop diagram can compactly demonstrate how economic recessions and booms are triggered and intensified under the debt money system. This is our revised model of endogenous money IS-LM where debts from banks play a central role in the overall dynamics. To incorporate this feedback loop into the SD model, however, we need to bring the analyses of budget equations additionally.

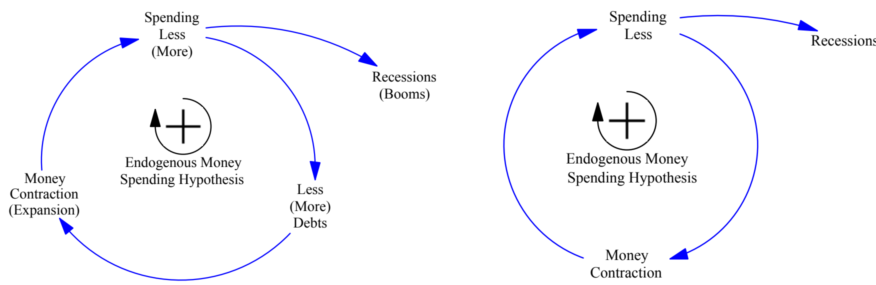

Figure 9.20: Endogenous Money Spending Hypothesis: Positive Feedback Loop

Endogenous Money IS-LM Model

To avoid such complexity in this chapter, the right diagram of Figure 9.20 illustrates a feedback loop of simpler version of our endogenous money IS-LM model where money is increased or decreased endogenously and proportionately with growth rate of income (this causal relationship from income to money is omitted for simplification) such that

$$\Delta M^s = \Delta Y \tag{9.66}$$

This is a straightforward approach to incorporate the endogenous money without modeling balance sheets of macroeconomic sectors and inter-sector transactions among them (which will be done in our next paper Part II). We have employed this simple approach in this paper without losing a generality of the debt money system. This built-in mechanism is already included in the stock-flow diagram in Figure 9.10 as Money Stock (Endogenous). By turning on-off the "Switch (Money)" shown on the upper left of Money Stock, users can turn on and off the endogenous money model within a single model. In our subsequent simulations we assume that money increases or decreases endogenously by 70% of the income growth rate. This ratio can be changed by a variable called Endogenous Money Fraction in the model so that users can try different assumptions on the degree of money endogeneity defined above. The default value is set to 0.7. "Switch (Money)" allows you to switch between the exogenous or endogenous money mode. By setting the endogenous money fraction = 0, the rate of money growth becomes zero and the model will also run in the exogenous money mode.

9.7.3 Endogenous Money Spending Hypothesis under Flexible Price

Now we are in a position to examine how this revised model of IS-LM analysis behave under the endogenous money spending hypothesis. We have run simulation by switching the model to endogenous money mode and applying the same spending hypothesis implemented in the previous case 1 (fixed price, exogenous money) and case 2 model (flexible price, exogenous money). We have set the money stock adjustment time to 4 (the same value for price adjustment time explained in Section 9.6.3).

Figure 9.21 shows behaviors of nominal and real interest rates on the left, and inflation rates on the right diagram. "Case 4" in the caption means that the simulation is ran under the flexible price and endogenous money assumptions.[25] Because the case 4 model assumes endogenous money, the spending hypothesis now becomes the endogenous money spending hypothesis. Note, however, that each legend shown below the graphs only says the spending hypothesis (Case 4).

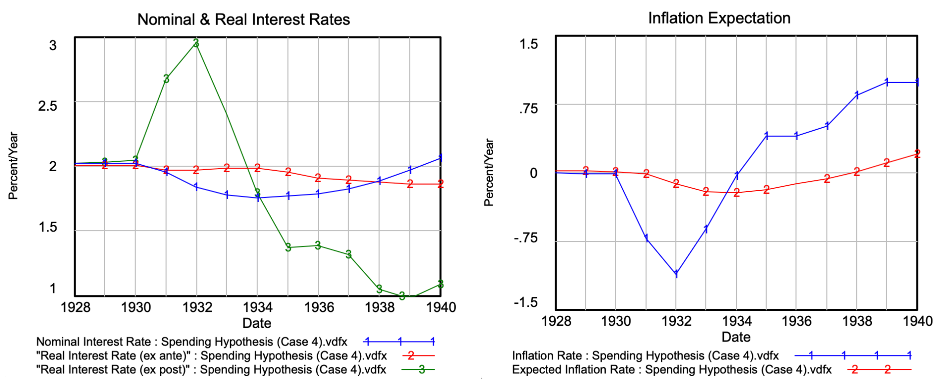

Figure 9.21: Interests and Inflation by the Endogenous Money Spending Hypothesis (Case 4)

Figure 9.22 compares behaviors of money stock (left) and real money balance (right) under the spending hypothesis in case 2 model (line 1 in blue) and the endogenous money spending hypothesis (line 2 in red). Our simulation shows that endogenous money spending hypothesis, which was the original analysis on the causes of the Great Depression proposed by Fisher, captures the behaviors of nominal and real interest rates already explained under the spending hypothesis in case 2 model, but also the contraction of money, which was unexplained in the previous case 2 model. Accordingly the rise in real money balance is now explained for the right reason. As explained already, the current model is not optimized for reference data. Therefore the initial rise in real money balance in the data is not replicated precisely. The direction of change in real money balance is determined by the changes in price level and money stock. It is therefore a matter of optimization, which is not the purpose of this paper.

[25]Simulation results under the spending hypothesis in case 3 model (fixprice, endogenous money) will be discussed in the next Section 9.8 where we summarize all simulation results under all cases.

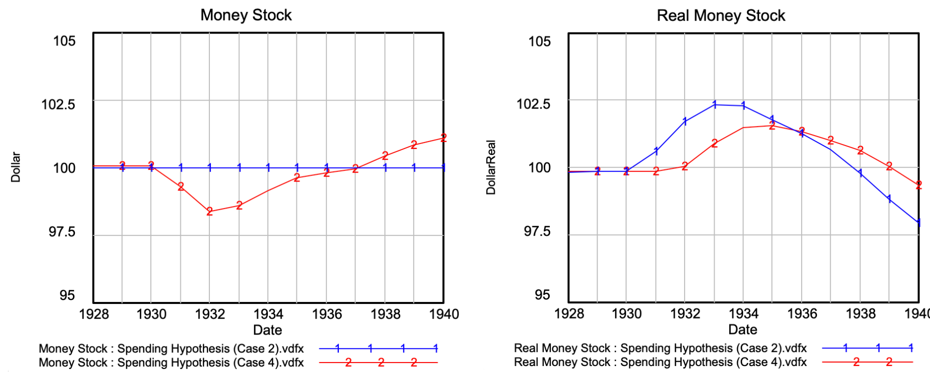

Figure 9.22: Money Stock and Real Money Stock by the Endogenous Money Spending Hypothesis (Case 4)

9.8 Evaluation of Endogenous Money Spending Hypothesis

9.8.1 Simulation Results: Cases 1 through 4

Figure 9.23 and 9.24 show our results of all simulations run in case 1 through case 4. Underlying assumptions in each case is explained in Table 9.1. Simulation under the spending hypothesis in case 1 model is shown by line 1 (blue) and money hypothesis is shown by line 2 (red). Spending hypothesis in case 2 model is shown by line 3 (green) and money hypothesis is shown by line 4 (pink). Spending hypothesis in case 3 model is shown by line 5 (light blue) while spending hypothesis in case 4 is shown by the thick line 6 (orange).

To summarize in the exact order of sections in this chapter, line 1 and 2 (case 1) are the simulation results discussed in Section 9.5.2. Line 3 and 4 (case 2) corresponds to the simulations discussed in Section 9.6.4. Line 6 (case 4) is the simulation under the endogenous money spending hypothesis discussed in Section 9.7.3. Note that behaviors of nominal and real interest rates are identical in each case 1 and 3 since price is fixed in both cases. Also, cases 3 and 4 assume the endogenous money. Therefore, simulations are run under the spending hypothesis only in both cases.

9.8.2 Qualitative Evaluation of the Hypotheses

Evaluation of Hypotheses under the Conventional IS-LM Analysis

A table shown at the top of the Figure 9.25 summarizes the qualitative evaluations of spending and money hypothesis applied on the textbook model of short-run IS-LM analysis as the comparative statics. Arrows indicate the implied direction of changes in each variable. There are simply three types of

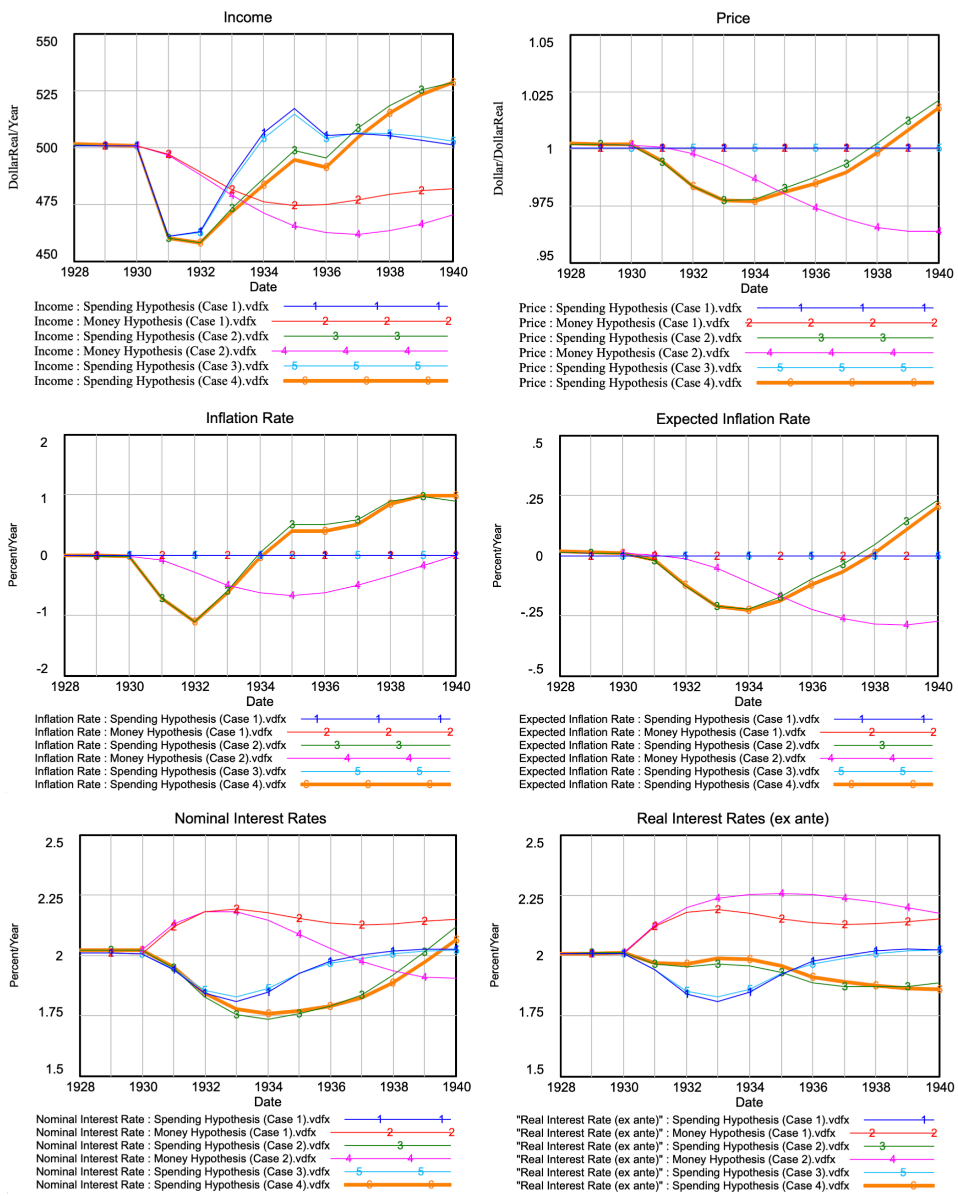

Figure 9.23: Simulation Results of IS-LM Case Analysis on the Great Depression (1 of 2)

arrows in our qualitative evaluation. Arrows pointing upward imply an increase or rise in the specified variable. Similarly, arrows pointing rightward imply no change or 'fixed', and downward arrows imply a decrease or reduction. Furthermore, arrows in blue indicate that the simulation under a certain hypothesis is consistent with the data. Specifically, we have evaluated both hypothesis by

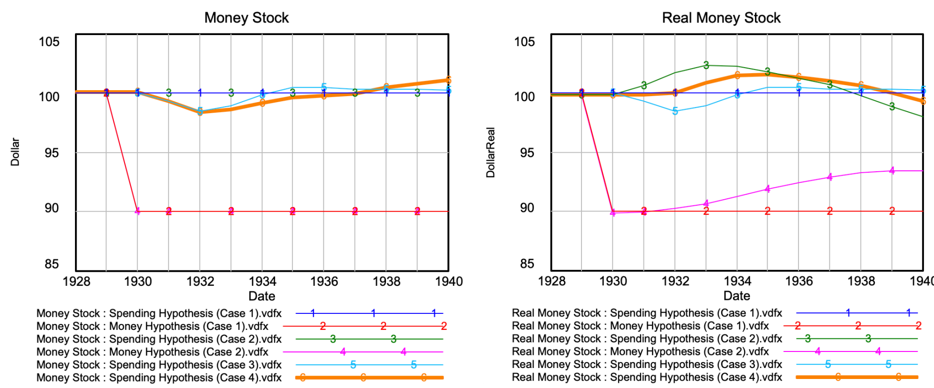

Figure 9.24: Simulation Results of IS-LM Case Analysis on the Great Depression (2 of 2)

comparing the implied direction of changes in each macroeconomic variables shown in columns against the data from the Great Depression, which are shown on the second row of the table. Black arrows, on the other hand, indicates that the simulation result is not consistent with the data. By applying this evaluation criteria, the top table summarizes results of the spending and money hypothesis applied under the standard short-run IS-LM analysis in macroeconomic textbooks. The second row of the table shows the observed direction of changes in the data during the initial period between 1929-1933. The third row shows the spending hypothesis, and the fourth row the money hypothesis.

As discussed in Section 9.5.2, Mankiw pointed out that money hypothesis cannot explain the rise in real money balances ("the first problem") and decline in nominal interest rate ("the second problem"). He then argued that the decline in nominal interest rate i and rise in real money balance $\frac{M^s}{P}$ observed in the data are sufficient to reject the money hypothesis. However, we discussed that spending hypothesis alone does not explain the contraction of money in the first place. It was further pointed out that, when i and P declined during the Great Depression, the real interest rate r must have risen, which is what money hypothesis correctly implies. Accordingly one may similarly counter-argue that money hypothesis explains better than spending hypothesis when it comes to explaining the behavior of (ex post) real interest rate, even though the data is absent in the original table in Mankiw (2016). We then discussed further that the fundamental issue of his analysis is the fixprice assumption. As long as price level P is fixed, there is no theoretical distinction between nominal and real interest rates, or between *ex ante* and *ex post* real interest rates. This means one cannot fully evaluate the behavior of interest rate against the real world data, and cannot reject either one of hypothesis by looking at the implied behavior of interest rate in the short-run IS-LM analysis.

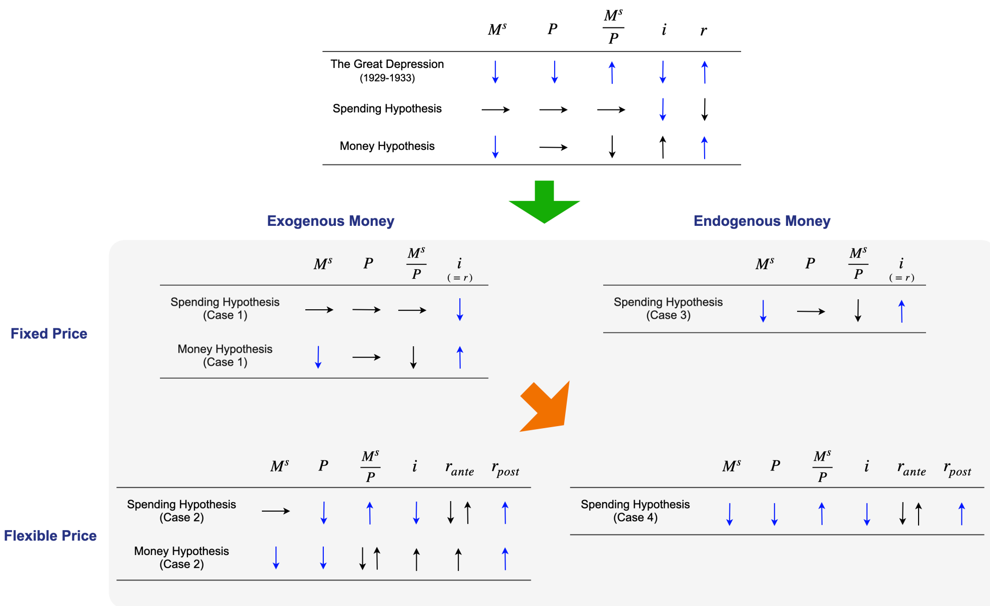

Figure 9.25: Evaluations of Spending and Money Hypothesis

Evaluation of Hypotheses under Cases 1 through 4

Shown at the bottom of the Figure 9.25 is a table summarizing the qualitative evaluations of simulation results in all cases using the same evaluation criteria. The arrangement of cases corresponds to the sequence explained in Table 9.1. For instance, the endogenous money spending hypothesis (case 4 model) is shown at the bottom right corner.

Case 1 model (fixprice & exogenous money) is the model discussed in Section 9.5.2, and corresponds to the conventional short-run IS-LM analysis explained in standard textbooks. Case 1 model can be alternatively interpreted as what Mankiw's extended model actually analyzed because his model only introduced the expected inflation rate, not the flexible price itself. Spending hypothesis in case 1 model (line 1 in blue in Figure 9.23 and 9.24) captures the reduction in nominal interest rate i in the data, but not other variables. Since M and P is assumed to be fixed, real money balance $\frac{M^s}{P}$ is also fixed. Money hypothesis in case 1 (line 2 in red), on the other hand, accounts for the contraction of M, but not for the decline in nominal interest rate i. As discussed above, Mankiw interpreted the interest rate in short-run IS-LM model as showing i and compares it with that of the data to reject the money hypothesis.

Case 2 model (flexible price & exogenous money) is the model used in Section 9.6.4. Spending hypothesis in case 2 model (line 3 in green in Figure 9.23 and 9.24) captures what Mankiw called the destabilizing effects of deflation on income, the fall in nominal interest rate i as well as the sudden rise in *ex post* real interest rate in the data. Case 2 analysis is what the extended analysis in Mankiw (2016) has attempted, but he did not present a working model. Our simulation results corroborate Mankiw' s claim. However, the problem of spending hypothesis in case 2 model is that it still treats M as an exogenous policy variable, thus failing to explain its contraction during the Depression. This meant that behavior of real money balance is not explained under spending hypothesis for the right reason. For the behavior of *ex ante* real interest rate, our simulation suggests that it rises relative to nominal interest rate and then fluctuate, as it is affected by multiple factors including inflation and the nominal interest rate, which in turn is affected by various factors even in our simple model. Money hypothesis in case 2 (line 4 in pink), on the other hand, captures the money contraction, deflation, and rise in real money balance for the right reason. Also the rise in *ex post* real interest rate is consistent with the data. However, the nominal interest rate i rises, which is inconsistent with the data.

Spending hypothesis in case 3 (line 5 in Figure 9.23 and 9.24) captures the endogenous contraction of M under the debt money system. Decrease in real money balance, however, contradicts with the data. This contradicted behavior under the spending hypothesis is not mentioned at all in Mankiw's analysis. Recall that the decrease in real money balance under the money hypothesis was the main reason why Mankiw rejected it in the short-run IS-LM (case 1) model. We cannot fully evaluate the behavior of interest rates for the same reason as in case 1 (no theoretical distinction between nominal and real interest rates in the short-run IS-LM model).

Case 4 model (flexible price & endogenous money) is the model used in Section 9.7.3 where the endogenous money spending hypothesis was examined. It captures the data already explained in case 2 as well as the endogenous contraction of money stock, which was unexplained in case 2. Accordingly the rise in real money balance is explained for the right reason under the endogenous money spending hypothesis. As a result, arrows are all in blue, indicating that the direction of changes in all variables are consistent with the data except the *ex post* real interest rate. The *ex ante* real interest rate is shown in black as we have no data presented in Figure 9.12.

In this paper we began our analysis by first translating the conventional IS-LM framework of the comparative statics into a system dynamics model. Figure 9.25 illustrates how the behaviors of the Great Depression unexplained in the short-run IS-LM analysis are now fully captured by our endogenous money IS-LM model. A wide green arrow represents a *methodological paradigm shift* from comparative statics to system dynamics simulation. A wide orange arrow represents a *theoretical paradigm shift* from exogenous money to endogenous money analysis.

9.9 Endogenous Money IS-LM: A Paradigm Shift

9.9.1 Recessions by the Endogenous Money Spending

We have presented our SD model in Section 9.4.3 that produces the standard IS-LM analysis of recessions dynamically. Using this standard model, Mankiw (2016) tried to explain the causes of the Great Depression with spending and money hypotheses, and rejected the money hypothesis. We have rejected both of them under exogenous money, and proposed an alternative endogenous money spending hypothesis for the analysis of the Great Depression. Successfully it was able to explain the behaviors of the Depression. In this section we continue

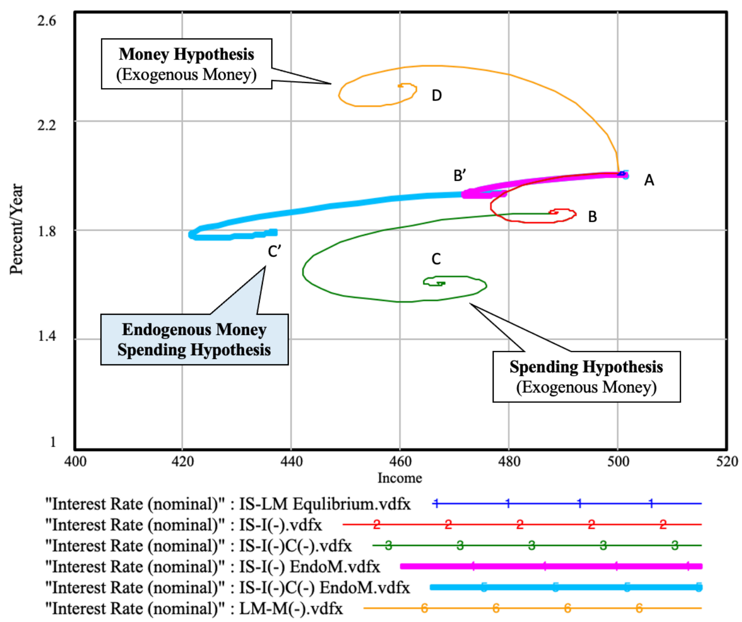

Figure 9.26: Joint Shifts of IS-LM Curves under Endogenous Money Spending Hypothesis

to explore this hypothesis furthermore to see if it can explain other cases of economic recessions.

In Figure 9.26 we have produced behaviors of the above three hypotheses under more general cases of economic recessions by using STEP function.[26] To make the comparative analysis crystal clear between exogenous and endogenous money, fixprice is assumed in the figure. Behaviors of spending hypothesis around points B and C and money hypothesis around point D under the exogenous money are the same as shown in Figure 9.11. On the other hand, behaviors

[26]For the analysis of the Great Depression, we have used PULSE function to reproduce better behaviors of data without running optimization for data fitting.

around points B' and C' under the endogenous money spending hypothesis are newly shown as the movement from points B and C. They share similar behaviors as those under the spending hypothesis. For instance, nominal interest rate taken on the vertical axis continues to fall in a similar fashion as in the spending hypothesis under exogenous money. That is, a rise in nominal interest rate at point D, which Mankiw called the second problem of money hypothesis, does not occur under the endogenous money spending hypothesis. Yet, these points no longer move along the LM curve as was the case under the spending hypothesis in the exogenous money (case 1) discussed in Section 9.4.3. Consequently, the endogenous money spending hypothesis can be said to be a better prospect for the analysis of economic recessions in general. Not only that, it provides the unified view of Fisher and Keynes on the causes of the Great Depression.

9.9.2 Joint Shifts of IS-LM Curves under Endogenous Money

Our endogenous money IS-LM model further provides a new finding such that spending and money hypotheses, which had been applied separately under the exogenous money assumption, occur as if simultaneously or jointly as Figure 9.27 illustrates. Line 6 in the figure shows how point C' under endogenous money spending hypothesis can be attained as a combination of unrelated

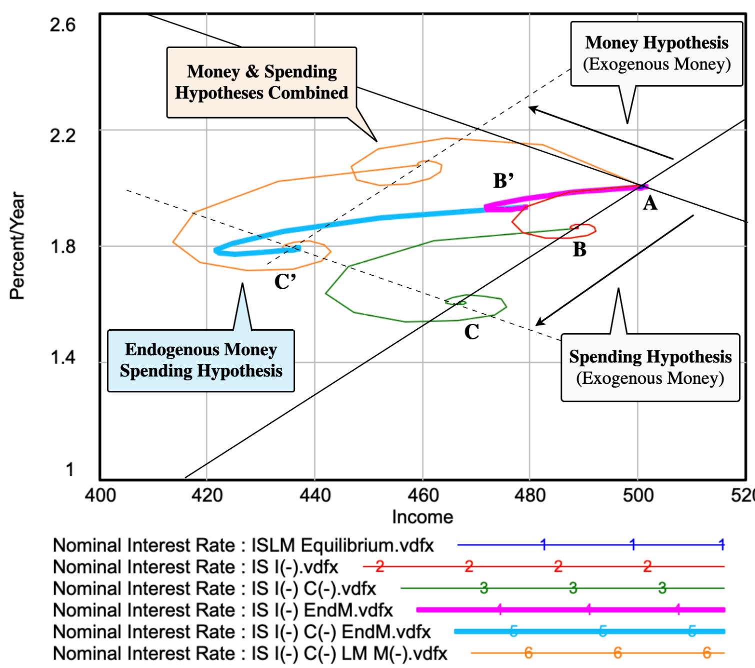

Figure 9.27: Analysis of the Joint Shifts of IS-LM Curves under Endogenous Money

shifts in IS curve caused, firstly, by the spending hypothesis (point A $\rightarrow$ C

: $\Delta I = -20$ at t = 8, and $\Delta C = -20$ at t = 24), and those in LM curve caused, secondly, by the money hypothesis (point C → C' : $\Delta M = -14$ at t = 8). The point C' can be attained irrespective of the combination orders among $\Delta I, \Delta C$ and ΔM. This implies that behaviors under endogenous money spending hypothesis can be produced all the time as joint shifts of IS and LM curves under exogenous money simultaneously. Accordingly, comparative static analysis of shifting either IS or LM curve independently or separately and observing its impact on macroeconomic behaviors, as we have been taught in macroeconomic textbooks, is no longer applicable to the analysis of economic recessions under the current debt money system. For the analysis of recessions, both IS and LM curves must be jointly shifted all the time.

Economists must abandon the traditional comparative static analysis of IS-LM model in the textbooks, which has been dominant for over 80 years since Hicks (1937), and adopt dynamic analysis along the endogenous money IS-LM model presented here. This is a paradigm shift in macroeconomics.

9.9.3 Japan's Lost 30 Years as Joint Shifts of IS-LM Curves

Monetary policy explained in the traditional exogenous IS-LM model, which is to control money stock M^s as discussed in Section 9.4.3, is no longer available in the endogenous money IS-LM model, simply because the central bank cannot control money stock that is endogenously created. Furthermore, it cannot control real interest rate as well, because money stock and price are no longer under its control. Central bank can only change base money M_0, and through its market operations it manages to guide nominal interest rates as its policy target variable. In this sense, we have been falsely taught in textbooks that central banks in the real world somehow exercise a directly control over money stock as its policy instruments. Indeed, monetary policy turned out to be far less effective in the real economy. This is why QE policies that have been intensively implemented during the Japan's post-bubble period turned out to be ineffective. As discussed in section 9.7.1, they were destined to fail at a theoretical level as Irving Fisher, the original advocate of the reflation policy, had already predicted in the 1930s.

How about fiscal policy by the government, then? In Figure 9.28 below we have implemented a fiscal policy of increasing government spending by $\Delta G = 40$ at t = 35 to get out of the recession at point C'. As a result, we have attained the point F' with the higher level of income. This movement from point $C' \to F'$ seems predictable since the government expenditure G is increased in the same fashion as was done in the exogenous money IS-LM model, which moves a new equilibrium point along the LM curve (dotted line) toward the point F (point C → F).

Driven by this expectation on the fiscal policy, the Japanese government has increased its debt and spent 595 trillion yen to stimulate the post-bubble economy during the last 30 years; that is, its increased amount became larger than its nominal GDP. On average it became about 20 trillion yen of deficit spending per yer. Yet, her GDP only increased by 60 trillion yen in total during

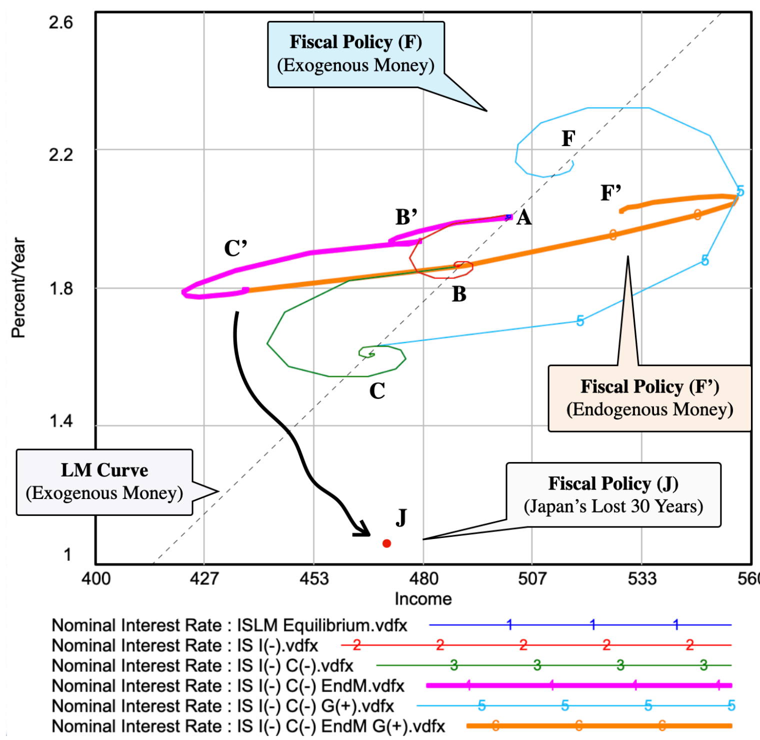

Figure 9.28: Fiscal Policy under the Endogenous Money IS-LM & Japan's Lost 30 Years

the same period, that is, an increase in 2 trillion yen per year on average. This expansionary fiscal expenditure of 20 trillion yen only ended with an increase in GDP by 2 trillion yen per year.

This poor performance vividly contrasts with the textbook explanation of fiscal multiplier by the Keynesian theory. By substituting the parameter values[27] into the simple IS-LM equilibrium in equation (9.33), the fiscal multiplier can be obtained as follows:

$$\frac{\Delta Y}{\Delta G} = \frac{1}{1 - c(1-t) + \alpha(a/b)} = 2.427 \tag{9.67}$$

If we use this multiplier for the calculation purpose only, then Japan's nominal GDP should have increased by 48.5 trillion yen (= 2.427 x 20) every year instead of the 2 trillion yen that is actually realized. The Japanese policy-makers seemed to have been fooled by this illusion of fiscal multiplier effects provided by the standard textbooks.[28] They might have expected that the economy would

[27] Parameter values are as follows: $c = 0.76$, $t = 0.1$, $\alpha = 8$, $a = 0.3$, $b = 25$. These are the same values used in all simulations discussed in the previous sections of this paper.

[28] IS-LM analysis is a popular subject used in the recruitment examinations for government officials of Japan.

move, say, from the point C to the point F in Figure 9.28. This is another example of the flawed interpretation of Keynesian comparative static analysis. The conventional IS-LM analysis gives an impression that one-time government spending brings the economy into a new equilibrium point with higher level of income. However, if we examine the effects of fiscal policy in a dynamic model, we could easily learn that it is not the case.[29] Hence the correct interpretation of fiscal multiplier should be that the government needs to continue spending by either raising taxes or borrowing money, until a new (comparative statics) equilibrium is attained by the application of fiscal multiplier.

Based on the real data in Japan, the effect of its fiscal policy must be shown to have moved its equilibrium point in Figure 9.28 from point C' to, say, a point J, which was manually drawn and its real scales of income and interest rate are neglected here. This was how fiscal policy failed to stimulate the economy contrary to what the standard IS-LM analysis would have predicted. So long as we use the revised IS-LM model, however, we are also led to expect that the economy will move toward north-east direction such as the point F'. In other words, there is no way to end up with the point J as long as government expenditure is increased even in the endogenous money IS-LM model. Accordingly, the point J such as observed in Japan becomes entirely unpredictable even under the endogenous money IS-LM model. In this sense, its inability to explain the point J becomes one of its limitations. Can we further revise the IS-LM model so as to produce the point J by simultaneously holding the endogenous money spending hypothesis as a true premise? This challenge is to be addressed in our next paper (part II).

9.10 Addendum: Irving Fisher and John M. Keynes on Endogenous Money

We discussed in Section 9.7.1 how Irving Fisher, upon his realization of the significance of endogenous money under the current debt money system, incorporated it into his theory of debt-deflation. As the original proponent of reflation theory, Fisher immediately came to the conclusion that the very structure of the debt money system itself ("the 10% system") is what was stopping the economy from not only recovering as quickly as possible, but has been the structural cause of the Great Depression. As the proponent of spending hypothesis, what was the Keynes position on the endogenous money, then? As the final analysis of this chapter, let us briefly examine how the original proponents of the spending and money hypothesis incorporated the endogenous money analysis into their theories of the Depression and policy proposals.[30]

The subject of money and banking seems to have been a confusing topic even for Keynes. Werner (2005, p.189), for instance, observed that Schumpeter

[29] See Chapter 9 of Yamaguchi (2021a) further.

[30] This section owes to Section 8.4.2 of Yamaguchi (2015, p.204-206) titled "Keynes and the Chicago Plan".

(1954) had been curious as to why Keynes, who initially recognized banks as creators of new deposits in his Treatise (Keynes, 1930), failed to incorporate such a significant role of banks in the General Theory as follows:

> The deposit-creating bank loan and its role in the financing of investment *without any previous saving up of the sums thus lent* have practically disappeared in the analytic schema of the General Theory, where it is again the saving public that holds the scene. Orthodox Keynesianism has in fact reverted to the old view according to which the central facts about the money market are analytically rendered by means of the public's propensity to save coupled with its liquidity preference. I cannot do more than advert to this fact. Whether this spells progress or retrogression, every economist must decide for himself. (Schumpeter, 1954, p.1115; Italics in original)

Keynes began his research on monetary theory from the treatise on money. But since he was in the U.K., it might be possible that he was simply not aware of the Chicago plan nor the 100% money proposal by Fisher. Perhaps he was busy writing the General Theory at the time and didn't consider it as deeply as Fisher did. Or, he had to ignore it because he thought the General Theory would not complete unless he assumed that investment comes from savings and that the supply of money was determined exogenously.[31] The answer seems to be the latter. Keynes was, in fact, one of the 40 people that Henry C. Simons and other original proponents of the Chicago plan selected to privately forward the memorandum that laid out the money and banking system reform. Keynes replied to Simons on March 31st of 1933, stating "Much interested by the memorandum which you kindly send me" (Phillips, 1995, p.51).

Eleven years later, in July 1944, delegates from forty-four nations gathered in Bretton Woods, New Hampshire to discuss the post-war international monetary system. Keynes, then adviser to the British Treasury, participated in the Bretton Woods negotiations and proposed a global central bank called the Clearing Union and to create a new supranational currency called Bancor to facilitate clearing of imbalances in international settlements. The U.S. delegate Harry Dexter White, the then chief international economist at the Treasury Department, proposed a Stabilization Fund plan such as the establishment of the

[31] Readers of the General Theory immediately find the following reflection by Keynes in its preface:

> The relation between this book and my *Treatise on Money*, which I published five years ago, is probably clearer to myself than it will be to others; and what in my own mind is a natural evolution in a line of thought which I have been pursuing for several years, may sometimes strike the reader as a confusing change of view. (...) This book, on the other hand, has evolved into what is primarily a study of the forces which determine changes in the scale of output and employment as a whole; and, whilst it is found that money enters into the economic scheme in an essential and peculiar manner, technical monetary detail falls into the background. (...) The difficulty lies, not in the new ideas, but in escaping from the old ones, which ramify, for those brought up as most of us have been, into every corner of our minds. (Keynes, 1936, Emphasis original)

IMF and what became the World Bank Group. Meanwhile Fisher sent a letter to Keynes on July 4th, 1944, asking him to informally take up the 100% reserve system in the Bretton Woods negotiations as follows:

> I think it's quite possible it could, after the war, be put over for Americans and other countries, as the best *national* plan to interlock with the *international* plan you are now trying to put over. We could then avoid great inflation and deflation in future over a wide area. (Allen, 1993, p.715; Emphasis original)

Namely it was a proposal by Fisher to integrate the 100% reserve plan with Keynes's international monetary stabilization scheme. Three days later, on July 7th, Keynes replied to Fisher that he was "one of my earliest teachers on these matters," but expressed his "considerable reservations" about "the 100 per cent money," and declined being "an advocate." (Allen, 1993, p.715). He then continued as follows:

> In my judgment deflation is in the near future a much more dangerous risk than inflation. I am afraid of your formula because I think it would, certainly in England, have a highly deflationary suggestion to a great many people. Apart from that, I am satisfied that in British conditions anyhow . . . we can obtain complete control over the quantity of money by means much less capable of exciting unfavorable comment and opposition. (*ibid.*)

As is now clear from his reply letter to Fisher, Keynes was fully aware that the 100% money excited "unfavorable comment and opposition" in the United States. We can also see Keynes had still believed that money stock could be controlled, and that he was opposed to the analysis of the Great Depression by Fisher and the Chicago economists. Keynes knew the money stock would be expanded and destroyed endogenously by loans of private banks, but did not think they were the causes of the Depression. When Fisher received the Chicago plan, he immediately noticed a theoretical flaw in his debt-deflation theory and pointed out the potential inefficacy of reflation policy under the fractional reserve banking system. As Schumpeter observed, Keynes initially emphasized the role of deposit creation in his treatise. Yet, he later categorically denied the need for incorporating the endogenous money into his theory and policy proposals upon the suggestion by Fisher. These flaws in the treatment of money and banking in the Keynesian theory have led to the government debt crisis such as discussed in Section 9.9.3.

Conclusion

The Keynesian short-run IS-LM model, which is built on the exogenous money and fixprice assumptions, is shown to be no longer applicable to explain the behaviors of economic recessions simply because our economy is operating under the fractional reserve banking system where money is created and destroyed endogenously against private bank loans. It is then demonstrated that the endogenous money IS-LM model of the debt money system is shown to produce behaviors consistent with the data observed during the Great Depression. Specifically, the endogenous money spending hypothesis, which integrates the spending hypothesis as proposed by Keynes and money hypothesis as originally proposed by Fisher is shown to capture the previously unexplained behaviors of the Great Depression. Macroeconomic theories must be rebuilt on this integrated framework that allows the endogenous money analysis. A shift from the old paradigm that has dominated the field for nearly a century is emphasized accordingly.

Questions for Deeper Understanding

1. In the companion model: 2 Keynesian(SD).vpmx, the equilibrium GDP is assumed to be attained at GDP = 500. Suppose the full employment GDP is to be realized at GDP = 550; that is, the net increase in GDP of 50 has to be added to the current level of GDP.
a) Discuss how this can be done by running simulations. List as many policies as theoretically possible.
b) From the list, pick up the most feasible policies to stimulate the economy in your country and discuss why.

2. Figure 9.3 illustrates how GDP is determined by the amount of aggregate demand. This is a method of the so-called Comparative Static Analysis which is heavily used in standard macroeconomic textbooks. According to it, in order to increase GDP, it is not necessary to increase the same amount of aggregate demand, say, government expenditures, due to the multiplier effect such that

$$\Delta GDP = \frac{1}{1-c}\Delta G$$

For instance, when c = 0.6, the multiplier of the government expenditures becomes 2.5 so that to increase GDP by $\Delta GDP = 50$, the government needs to spend only $\Delta G = 20$. This explanation gives us an incorrect impression that one time government expenditure attains a new equilibrium GDP. Using the above Keynesian SD model, discuss how comparative static analysis leads to such misperception of GDP determination.

3. Equilibrium GDP is obtained as Y^* in the equation (9.13). Calculate MPC elasticity of equilibrium GDP ($\equiv \frac{dY^*}{Y^*} / \frac{dc}{c}$). Then, re-build the Keynesian model: 2 Keynesian(SD).vpmx by adding this MPC elasticity to the model, and show how the MPC elasticity is affected by the changes in aggregate demand; specifically, by tax cut. This may suggest the existence of a missing feedback loop from Change in Tax to Change in MPC in our Keynesian SD model such that

$$\text{Change in Tax} \Longrightarrow \text{Change in MPC} \longrightarrow \text{Consumption} \longrightarrow \text{GDP.}$$

In other words, tax cut may have more positive impact on GDP than generally considered by the standard Keynesian models.

4. (Fiscal and Monetary Policies by IS-LM Approach)
Traditional Keynesian IS-LM model is thoroughly reconstructed by the ASD Keynesian macroeconomic model: 3 IS-LM (Short-run).vpmx. This SD model can easily trigger recessions out of the equilibrium state. A typical case of such recessions, called underconsumption recession here, can be triggered by reducing the amount of basic consumption by - 20 at t = 4 under fixprice setting.
Run the model and show how the equilibrium can be restored out of the

underconsumption recession by Keynesian fiscal and monetary policies. Equilibrium state is defined as
Full Production = Production = Aggregate Demand.
Fiscal policies can be more specifically implemented by the changes in

(1) Government Expenditure
(2) Lump-sum Taxes
(3) Excise Tax Rate, and
(4) Income Tax Rate.

Monetary policy can be implemented by the change in

(5) Money Stock.

Neoclassical theory proposes that the equilibrium can be restored by introducing

(6) Flexible Price.

The ASD Keynesian model can handle these 6 macroeconomic policies in a uniform fashion. Show how these 6 policies can attain the equilibrium, one by one, by illustrating simulation results in the graph titled: "Full Production, Production & Aggregate Demand" which is included in the three simulation pages of the model. Then, summarize these 6 policies by integrating all of them as graphs of Interest Rate and Debt (Government), and briefly compare them.

5. (Limitations of the IS-LM model by the Mainstream Theory)
The IS-LM framework has been the dominant approach to Keynesian macroeconomic theory. Yet, two theoretical limitations have been pointed out recently as follows:

(a) As a main cause of the Great Depression in 1929, Milton Friedman and Anna Schwartz presented the decline of money stock by 25% from 1929 to 1933. This is a well-acknowledged "money hypothesis". Yet, Mankiw pointed out as follows:

> "Using the IS-LM model, we might interpret the money hypothesis as explaining the Depression by a contractionary shift in the LM curve. ⋯
> The second problem for the money hypothesis is the behavior of interest rates. If a contractionary shift in the LM curve triggered the Depression, we should have observed higher interest rates.Yet nominal interest rates fell continuously from 1929 to 1933."
> – Macroeconomics, 9th edition, 2016, by Gregory Mankiw, page 354 –

(b) After her bubble burst in mid 1990' s, Japanese economy has been suffering from the prolonged recessions of almost three decades. To get out of the recessions, Japanese government as well as the Bank of Japan have heavily applied the Keynesian monetary policy of increasing money stock which is dubbed as Quantitative Easing policy. As you have run simulations above, this QE policy shifts the LM curve to the right and stimulates GDP. In reality, however, it didn' t work as predicted by the theory.

Consequently, the IS-LM model has failed to explain these two observations of the economic recessions. In other words, there exist some theoretical limitations to the IS-LM model as macroeconomic policy tools. Under the circumstances, answer the following two questions.
(A) Reproduce the Mankiw' s assertion (a) above by running the ASD model, and discuss what' s wrong with the IS-LM approach of macroeconomic monetary policies.
Tip: Reduce money stock by - 10 at t = 4.
(B) Discuss why the shift of LM curve (that is, QE policy) didn' t work as expected by the IS-LM model in the Japanese economy.

Chapter 10

Endogenous Money IS-LM Model

In this chapter[1] we expand the endogenous money IS-LM model presented in the previous chapter to more comprehensive models by adding budget equations of all domestic macroeconomic sectors on the basis of Accounting System Dynamics (ASD) approach. The first expanded model is called *Loanable Funds IS-LM* model in which money stock is exogenously given by the central bank, and banks play a role as intermediaries of existing funds (savings). The second expanded model is called *Endogenous Money IS-LM* model in which a central bank and private banks finance loans by creating deposits when government, households and producers come to borrow money. These two models are easily switched back and forth by selecting a switch value of 0 or 1. The first model is shown to fail supportifng the Keynesian view that aggregate demand creates its supply as confirmed by simulations in the previous chapter. The second model, on the other hand, is shown to support the view that aggregate demand creates its supply (production). The endogenous money IS-LM model also successfully reproduces the dynamics of the Great Depression as was obtained in the previous chapter, as well as those of the Japan's lost 30 years, which were not explained by the model of the previous chapter. As a result of the structural expansion, the second model also captures the money-debt relationship as well as its decomposition such that the government debts approximate M_1, and total debts held by households and producers approximate time deposits, respectively. Our simulation analyses indicate that the endogenous money IS-LM model presented in this chapter could serve as a new standard framework for simulation-based macroeconomics and applied modeling for real-world case studies.

[1]This chapter is based on the joint paper: The Endogenous Money IS-LM Model of the Debt Money System (Part II) – Loanable Funds vs Endogenous Money – JFRC Working Paper No. 02-2022, Japan Futures Research Center, April 2022, Japan.

Introduction

This is the second series chapter. In the previous chapter, we have shown that the standard Keynesian IS-LM model failed to explain the behaviors of the Great Depression due to its assumption that money is exogenously supplied to the economy. As discussed in the previous chapter, this is a fatal flaw as a macroeconomic model. To address this, we have constructed a system dynamics (SD) model of the IS-LM analysis, and found that the extended model, with flexible price and endogenous money newly incorporated, captures the unexplained behaviors of key macroeconomic variables observed during the Great Depression in the United States. Specifically, we proposed the alternative *endogenous money spending hypothesis* where it was assumed that decline in spending (aggregate demand) and money contractions took simultaneously during the Depression. The structural and behavioral assumptions we employed in the revised IS-LM model was that money is endogenously created along with economic activities, or transactions in terms of the quantity theory of money proposed by Irving Fisher. For this purpose, we took a simple mechanistic approach that money is created endogenously according to the growth rate of income. We called this alternative model endogenous money IS-LM model in the previous chapter.

As expected, the model worked well in that it is able to explain the Great Depression and economic recessions in general. Yet, we have also identified its limitations. Specifically the model cannot produce the case of the decades-long stagnation of the Japanese economy since the burst of financial bubble in the mid 1990s. The Japan's prolonged recession, often called *the lost 30 years*, is characterized by the stagnation of aggregate demand and ineffectiveness of monetary and fiscal policies, which, according to the conventional IS-LM analysis, would have brought the economy back into a new equilibrium point with a higher level of income and interest rate either by fiscal or monetary policy alone, or through the combination of the two as the policy mix. The series of aggressive deficit spendings and the unconventional monetary policy known as Quantitative Easing (QE), however, have been largely ineffective contrary to what the standard IS-LM model would have predicted. As a result of this policy failures, the money stock continues to grow while the economic growth remains stagnant. The government debts are increasing at an exponential rate and the economy is now facing public debt crisis. The revised IS-LM model developed in the previous chapter failed to capture this peculiar case of policy failures observed in Japan, which we described as "the point J" in Figure 9.28 of the previous chapter.

This observation suggests that our endogenous money IS-LM model has to be further revised so that it can capture borrowings and lendings of money among macroeconomic sectors; that is, through incorporating budget equations instead of the simple mechanistic approach we took in the model of the previous chapter. This is the purpose of this chapter.

10.1 The Flexible Price IS-LM Model Revisited

To make our description of modeling self-complete within this chapter, let us start by briefly summarizing the flexible price IS-LM model presented in the previous chapter; subsection 9.6.2. The Keynesian short-run IS-LM model under flexible price assumptions is described as follows.

$$
\begin{aligned}
Y &= AD && \text{(Aggregate Demand Equilibrium)} && (10.1)\\
AD &= C + I + G && \text{(Aggregate Demand)} && (10.2)\\
C &= C_0 + cY_d && \text{(Consumption Decisions)} && (10.3)\\
Y_d &= Y - T && \text{(Disposable Income)} && (10.4)\\
T &= T_0 + tY - T_r && \text{(Tax Revenues)} && (10.5)\\
I &= \frac{I_0}{r} - \alpha r && \text{(Investment Decisions)} && (10.6)\\
G &= \bar{G} && \text{(Government Expenditures)} && (10.7)\\
\frac{M^s}{P}V &= L^d && \text{(Equilibrium of Money)} && (10.8)\\
L^d &= aY - bi && \text{(Demand for Money)} && (10.9)\\
r &= i - \pi^e && \text{(Fisher Equation)} && (10.10)
\end{aligned}
$$

The model consists of 10 equations with 10 unknowns;

$$Y, AD, C, I, G, Y_d, T, r, i, L^d$$

with 14 exogenously determined parameters

$$C_0, c, T_0, t, T_r, I_0, \bar{G}, M^s, P, V, \alpha, a, b, \pi^e.$$

Here L^d stands for liquidity demand or preferences, and π^e, expected inflation rate. In this IS-LM model, all variables are expressed with real units except money stock M^s which has nominal unit. Investment is here assumed to be determined by real interest rate r in equation (10.6), while demand for money is determined by nominal interest rate i in equation (10.9). Real interest rate r is determined by the expected inflation rate π^e in the Fisher equation (10.10). Capital accumulation ($\frac{dK}{dt}$) is excluded from this IS-LM model so that capital depreciation (δK) is also deleted from the equation (10.4).[2]

[2]When capital accumulation is considered in the next chapter of this series, this Keynesian model needs to be revised as follows:

$$
\begin{aligned}
Y_d &= Y - T - \delta K\\
\frac{dK}{dt} &= I - \delta K
\end{aligned}
$$

10.2 Loanable Funds IS-LM Model

The Keynesian flexible price IS-LM model presented above is not complete in the sense that it lacks the analysis of budget equations, the borrowing and lending of money, and debts. As a result, in our extended IS-LM model in the previous chapter, endogenous money is incorporated in a mechanistic way along with the growth rate of income. Consequently, the model is shown to have a limitation as pointed out above. For instance, it failed to present endogenous money creation by the government spending and accumulation of debts as its consequence.

With these analytical limitations in mind, we now start with the construction of a complete IS-LM model with budget equations. Yet, at this stage of the current chapter, we hold the mainstream Keynesian assumption again that money is exogenously given, and that banks only play a role as intermediaries of funds between savers and borrowers who make investments. That is to say, savings (time deposits) are considered as the source of loanable funds for banks to make loans. Let us call this model *Loanable Funds IS-LM model*, and examine its workings analytically in this section first. Then, we will construct the *Endogenous Money IS-LM model* by applying the Accounting System Dynamics (ASD) method in the next section.[3]

Budget Equation of Households

Let us begin with the budget equation of households. Their income consists of distributed incomes of wages and profits (dividends) $(W+\Pi)$ paid by producers, in nominal unit, and borrowings from banks (ΔD_H) for housing investments. With these income revenues, households spend on consumption, pay taxes to the government, and purchase houses (I_H). The remaining income after these expenditures are saved with banks (S). Hence, their budget equation becomes as follows.

$$PC + PT + PI_H + S = W + \Pi + \Delta D_H \quad \text{(Households Budgets)} \tag{10.11}$$

$$W + \Pi = PY \quad \text{(Distributed Income)} \tag{10.12}$$

$$PI_H = \Delta D_H \quad \text{(Housing Budgets)} \tag{10.13}$$

$$I_H = \bar{I}_H \quad \text{(Housing Investment)} \tag{10.14}$$

where housing investment is assumed to be made by the given amount of $\bar{I}_H$ for simplicity, and paid with the borrowings from banks.

[3]In this sense this chapter is following the same analytical steps as employed in the previous chapter; that is, building exogenous and endogenous money IS-LM models (with budget equations in this chapter) and compare the workings of the two models. Previous chapter examined four cases in total: fixprice & exogenous money (case 1), flexible price & exogenous money (case 2), fixprice & endogenous money (case 3), and flexible price & endogenous money (case 4).

Budget Equation of Producers

Producers' income comes from the sales of outputs (Y), which is assumed to be fully distributed among workers as wages (W) and their owners (shareholders) as profits (dividends) (Π). Accordingly, producers are obliged to raise funds to make new investment (I_P). For simplicity we assume that they borrow all of the funds for their investment from banks (ΔD_P). Hence, their budget equation becomes as follows:

$$W + \Pi + PI_P = PY + \Delta D_P \quad \text{(Producers Budgets)} \quad (10.15)$$
$$I_H + I_P = I \quad \text{(Total Private Investment)} \quad (10.16)$$

where total investment in the economy consists of housing investment and corporate investment by producers.

Budget Equation of the Government

Government's revenues consist of taxes (T) and borrowings by issuing bonds (ΔD_G) in case government expenditures (G) exceeds tax revenues. For simplicity, we assume that government borrows directly from banks, instead of issuing and selling bonds to the banks. Hence, the budget equation of the government becomes as follows:

$$PG = PT + \Delta D_G \quad \text{(Government Budget)} \quad (10.17)$$

Budget Equation of Banks

Banks receive savings deposits from households, and make loans (called loanable funds ΔLF) out of the savings deposits accepted from households. In this sense, banks here are assumed to merely play a role of financial intermediaries as the mainstream economics assumes. Hence, their budget equation becomes as follows:

$$\Delta LF = S \quad \text{(Banks Budget)} \quad (10.18)$$

A Complete Loanable Funds IS-LM Model

Now the construction of loanable funds IS-LM model with budget equations is complete. In addition to the flexible price IS-LM model consisting of 10 equations (10.1) through (10.10), 8 equations (10.11) through (10.18) have now been added. Accordingly, 8 additional unknown variables that correspond to these 8 equations are identified as follows:

$$S, I_H, W + \Pi, I_P, \Delta D_H, \Delta D_P, \Delta D_G, \Delta LF \text{ [4]}$$

[4] Distributed income of wages and profits ($W + \Pi$) is to be determined by producers' output (PY) and treated as an unknown variable.

with one additional parameter: $\bar{I}_H$

More comprehensively, Keynesian loanable funds IS-LM model presented here consists of 18 equations in total; that is, (10.1) through 10.10 and (10.11) through (10.18), with 18 unknown variables and 15 parameters (consisting of the previous 14 parameters and the additional parameter $\bar{I}_H$). Money stock M^s is here assumed to be exogenously determined and price level is fixed in this model by default. Hence, the loanable funds IS-LM model does not change the analytical framework of the flexible price IS-LM model in the previous chapter itself.

Loanable Funds Equilibrium

To examine the workings of this IS-LM mode, let us now obtain the so-called Walras Law, which is calculated from the budget equations (10.11) through (10.18) as follows:

$$P(C+I+G-Y)+\Delta LF-(\Delta D_H+\Delta D_P+\Delta D_G)\equiv 0 \quad \text{(Walras Law)} \quad (10.19)$$

This Walras law holds true under any situations, that is why it is presented as identity (≡). Since the Keynesian aggregate demand equilibrium of real economic sector is assumed as the equation (10.1), the equilibrium of the following *loanable funds* is simultanously attained:

$$\Delta D_H+\Delta D_P+\Delta D_G=\Delta LF \qquad \text{(Loanable Funds Equilibrium)} \qquad (10.20)$$

This indicates that banks must make loans to households, producers and government out of their loanable funds deposited (or 'saved') by the households. Since total amount of money M^s is exogenously provided by the central bank as parameter value under the loanable funds IS-LM model, bank lending behaviors are always constrained by the available amount of the loanable funds. In other words, banks are simply financial intermediaries to transfer excess funds from depositors (households) to borrowers. There is no extra room for credit creation under this loanable funds model. This has been the mainstream doctrine of exogenous money that has dominated in macroeconomics for over 80 years, as discussed in the previous chapter in detail.

From the Walras law, if the equilibrium of the loanable funds (10.20) is assumed first, the aggregate demand equilibrium (10.1) is also simultaneously attained. As the appropriate loanable funds IS-M model, which assumption of the equilibrium should be made, then? Aggregate demand equilibrium or loanable funds equilibrium?

Since households, producers and government cannot start their economic transactions without enough funds at hand, apparently their borrowings have to come first. This means that the equation of the loanable funds by banks (10.20) must be met first. Then, the aggregate demand equilibrium is simultaneously attained to be equal to GDP. In this way, from the macroeconomic point of view, it would be more appropriate to assume the loanable funds equilibrium in the IS-LM model first such that

$$(\Delta D_H + \Delta D_P + \Delta D_G = \Delta LF) \Longrightarrow (C + I + G = Y) \tag{10.21}$$

Hence, the loanable funds IS-LM model must be formally presented by replacing the aggregate demand equilibrium (10.1) in the Keynesian short-run IS-LM model with the loanable funds equilibrium (10.20). That is, the loanable funds IS-LM model now consists of 18 equations, from (10.2) through (10.10), (10.11) through (10.18) and (10.20), with the same 18 unknowns, and the same 15 parameters.

Savings in the loanable funds IS-LM model are fully utilized as follows:

$$S \Rightarrow \Delta LF \Rightarrow PI_H + PI_P + \Delta D_G = PI + \Delta D_G \tag{10.22}$$

That is, savings become the sources for investment by households and producers, and government debts.

Model Anatomy with *Ex Ante* and *Ex Post* Incomes

The loanable funds IS-LM model developed here is in its framework the same as the Keynesian IS-LM model presented in the previous chapter. We have already shown in the previous chapter that the conventional IS-LM model (even under the flexible price assumption which we called the extended analysis in the previous chapter) failed to explain economic behaviors such as the Great Depression and Japan's lost 30 years, and discussed the reason why: the standard IS-LM analyses incorrectly assumed the exogenous money under the current debt money system. Can we then similarly argue that the loanable funds IS-LM model is flawed?

Let us examine the validity of the model by introducing the concepts of *ex ante* and *ex post* discussed by Keen (2014). *Ex ante* is used here as a period of time in which income is distributed as wages and profits such as last month, last quarter or last year, while *ex post* as its next period such as this month, this quarter or this year.[5] Keynesian theory asserts that *ex post* aggregate demand determines *ex post* income. Yet, the loanable funds IS-LM model leads us to the opposite result; that is, *ex ante* income determines *ex post* aggregate demand.

To examine this reasoning against the Keynesian theory, let us now interpret aggregate demand $AD = I + C + G$ as *ex post* demand, and income Y as *ex ante* income $\underline{\mathrm{Y}}$ in the model. This makes sense because *ex ante* income by producers is assumed to be distributed as wages and profits. For the economy to grow, then, we need to assume that

$$C + I + G > \underline{\mathrm{Y}} \qquad (\textit{Ex post } AD \ > \ \textit{Ex ante } \underline{\mathrm{Y}}) \tag{10.23}$$

From the Walras law (10.19), we have

$$C + I + G > \underline{\mathrm{Y}} \iff \Delta\underline{\mathrm{LF}} < \Delta D_H + \Delta D_P + \Delta D_G \tag{10.24}$$

[5] To avoid confusion, it should be noted here that the terms *ex ante* and *ex post* are used in different way as we did in the previous chapter to distinguish the *ex ante* and *ex post* real interest rates.

where $\Delta\underline{\text{LF}}$ implies *ex ante* loanable funds saved by households as deposits with banks. This is because loanable funds by banks are constrained by the *ex ante* savings from the budget constraints of banks (10.18). Hence, *ex ante* loanable funds equilibrium (10.20) must be applied all the time under the exogenous debt money. Accordingly, from the Walras law we must have

$$C + I + G = \underline{\text{Y}} \qquad (Ex\ post\ AD\ =\ Ex\ ante\ \underline{\text{Y}}). \tag{10.25}$$

In this way, loanable funds IS-LM model is destined such that *ex post* income (or aggregate demand) is always determined or constrained by the *ex ante* income.

In order for the *ex post* aggregate demand to determine the *ex post* income Y, as the Keynesian theory asserts under the exogenous debt money, the additional amount of money ΔM^E must be put into circulation exogenously such that

$$\Delta M^E = \Delta D_H + \Delta D_P + \Delta D_G - \Delta\underline{\text{LF}} \tag{10.26}$$

Then, in order for the Walras law to hold we must have

$$C + I + G = \underline{\text{Y}} + \Delta M^E \iff \Delta\underline{\text{LF}} + \Delta M^E = \Delta D_H + \Delta D_P + \Delta D_G \tag{10.27}$$

Keen (2014, p.284) attained a similar assertion such that "*ex post* expenditure equal *ex ante* income, plus the velocity of money multiplied by the *ex post* change in debt", which is equal to ΔM^E defined in equation (10.26).

In order to claim that the aggregate demand determines the *ex post* income, the loanable funds IS-LM model must have a built-in mechanism to put ΔM^E into circulation automatically. Only under such situation, we have

$$C + I + G\ (= ex\ post\ \text{AD}) \Longrightarrow\ \underline{\text{Y}} + \Delta M^E = Y\ (= ex\ post\ \text{Income}) \tag{10.28}$$

The loanable funds IS-LM model lacks this mechanism. That is why the model failed to explain the Great Depression as discussed in the previous chapter. That is, the flawed assumption of exogenous money discussed in the previous chapter is the same as that of the loanable funds discussed here. This failure can only be fixed when the flawed loanable funds IS-LM model is replaced with the endogenous debt money IS-LM model, as discussed similarly in the previous chapter, which we will address in the next section.

Remarks: It should be noted that the loanable funds IS-LM model itself is not flawed under certain conditions. For instance, the 100% reserve system proposed by the Chicago Plan economists and Irving Fisher, which we discussed in the previous chapter, and the public money system proposed by (**?**, Part V), are the examples of macroeconomic systems where money stock is exogenously provided and adjusted by the monetary authority. Under such systems, the balance between *ex post* and *ex ante* incomes are constantly adjusted through public money policy by the government to sustain a sustainable economic growth and price stability.[6] Hence, aggregate demand can be said to determine *ex post* income even by the loanable funds IS-LM model under the public money system. Loanable funds IS-LM model is claimed to be flawed only under the present *debt money* system, not under the exogenous *public money* system.

[6] For separation of powers, Yamaguchi (2012, 2014, 2015) proposes that public money

10.3 Endogenous Money IS-LM Model

The loanable funds IS-LM model presented above is destined to fail, in a similar way as the conventional IS-LM model did, to explain the Great Depression and Japan's lost 30 years, as well as to depict the effects of Keynesian fiscal and monetary policies due to the assumption that money stock is exogenously given in the model. Now we are in a position to formally present a paradigm shift of IS-LM model with endogenous debt money. Our target is to change the exogenous money stock (M^s) into the endogenously-created money stock.

Endogenous Budget of Banks

So far, banks are assumed to play a role as intermediaries by accepting savings deposits from households, and making loans (called loanable funds ΔLF) out of these savings. In the world of banking business, loanable funds of banks are not constrained by savings, because banks can create new deposits out of nothing to finance loans under the current fractional reserve banking system. Deposits thus created can be interpreted as the increment of money stock (ΔM^s), because deposits thus created are used for payments as functional money.[7] Let us continue to use the same terminology of the loanable funds (ΔLF), without confusions, to describe the sources of making loans by banks. Then, budget equation of the banks (10.18) is now replaced with the following:

$$\Delta LF \quad = \quad \Delta M^s \qquad \text{(Engogenous Deposits Creation)} \qquad (10.29)$$

Money stock M^s is now endogenously obtained by integrating ΔM^s as follows:

$$M^s = \int \Delta M^s dt \qquad \text{(Endogenous Money Stock)} \qquad (10.30)$$

We have now added two more unknowns to the loanable funds IS-LM model: ΔM^s and M^s for one additional equation (10.30). Hence, we need one more equation to complete the model. For this purpose, we have brought back the aggregate demand equilibrium (10.1), which was deleted in the loanable funds IS-LM model as a redundant equation from the Walras law. Under the endogenous debt money system, it is no longer redundant because the revised Walras law now becomes

$$P(C+I+G-Y)+\Delta LF-(\Delta D_H+\Delta D_P+\Delta D_G)+S-\Delta M^s \equiv 0 \text{ (WalrasLaw)} \qquad (10.31)$$

policy should be implemented by the Public Money Administration (PMA), an independent committee established under the direct supervision of the legislature such as the Congress and the Parliaments. This governance mechanism ensures the PMA is isolated from daily political pressures by other branches of government in fulfilling the price stability objective and other functions as the sole issuers of public money. See further Yamaguchi (2010, 2011) for ASD-based simulation studies on the topic.

[7] See Chapters 5, 6 and 7 further.

Due to the additional equation of savings and increment of money stock ($S - \Delta M^s$), the aggregate demand equilibrium (10.1) and loanable funds equilibrium (10.20) can now coexist. Under the loanable funds IS-LM model, this additional equation of savings and money stock was missing. As a result, either the aggregate demand equilibrium or loanable funds equilibrium must be made redundant.

Endogenous Money IS-LM Model

The furthermore revised IS-LM model is now complete, in which money stock M^s is made to be endogenously created. Let us call this revised model *Endogenous Debt Money IS-LM model with Budgets*, which is hereafter simply called *endogenous money IS-LM* model in comparison with the *loanable funds IS-LM* model. The endogenous money IS-LM model consists of the following 20 equations; (10.1) through (10.10), (10.11) through (10.17), (10.20), (10.29) and (10.30) with 20 unknowns:

$$Y, AD, C, I, G, Y_d, T, r, i, L^d, S, I_H, W+\Pi, I_P, \Delta D_H, \Delta D_P, \Delta D_G, \Delta LF, \Delta M^s, M^s$$

and 14 exogenously determined parameters:

$$C_0,\ c,\ T_0,\ t,\ T_r,\ I_0,\ \bar{G},\ P,\ V,\ \alpha,\ a,\ b,\ \pi^e,\ \bar{I}_H.$$

Model Feature 1: Money Stock = Total Debts

We know, both theoretically and empirically, that total money stock is approximated by the total debts from banks held by non-banking private sectors including households and producers (business corporations) and the government.[8] Let us denote these debts by D_H, D_P, D_G, respectively. Then, these debts (stocks) can be obtained by integrating their flow amounts of $\Delta D_H, \Delta D_P, \Delta D_G$ such that

$$D_H = \int \Delta D_H dt \qquad \text{(Debts of Households)} \tag{10.32}$$

$$D_P = \int \Delta D_P dt \qquad \text{(Debts of Producers)} \tag{10.33}$$

$$D_G = \int \Delta D_G dt \qquad \text{(Debts of Government)} \tag{10.34}$$

[8] More specifically, total money stock in the case of Japanese Yen (JPY) is M_3. In the case of United States Dollar (USD), it is M_2. Yamaguchi (2021b) examined the money-debt relationship in the case of USD and found that total debts from banks approximate M_2 during a period between 1945-2020, following the previous JPY case observed during a period between 1980-2019 (Yamaguchi and Yamaguchi, 2021a,b). As a reference, Yamaguchi (2021b, p.16, Fig.9) reports that the correlation coefficient between total debts and M_2 of the U.S. is 0.998 during 1945-2020 and 0.996 during 1980-2020. The money-debt relationship in the USD case was more precisely observed than it did in the JPY case where the correlation coefficient between total debts and M_3 is 0.987 during 1980-2019. Furthermore, the correlation coefficient between total debts and nominal GDP of the U.S. was reported to be 0.987 during 1945-2020 and 0.978 during 1980-2020 respectively.

Thus, from the equations (10.20), (10.29) and (10.30), we obtain the following:

$$M^s = \int \Delta LF = \int (\Delta D_H + \Delta D_P + \Delta D_G) dt = D_H + D_P + D_G \tag{10.35}$$

Accordingly, we have shown that money stock M^s is to be endogenously determined, and equals to the total debts held by households, producers and government under the endogenous money IS-LM model.[9]. In the case of discrete formula, equations (10.32) $\sim$ (10.34) can be replaced with

$$D_{H_t} = D_{H_{t-1}} + \Delta D_{H_t} \tag{10.36}$$
$$D_{P_t} = D_{P_{t-1}} + \Delta D_{P_t} \tag{10.37}$$
$$D_{G_t} = D_{G_{t-1}} + \Delta D_{G_t} \tag{10.38}$$

where initial stock amounts are given as
$D_{H_{t-1}} = \bar{D}_H,\ D_{P_{t-1}} = \bar{D}_P,\ D_{G_{t-1}} = \bar{D}_G.$

This is the paradigm shift we have discussed in the previous chapter. LM curve is no longer independent of IS curve. Both *IS* and *LM* curves are closely linked one another and must move jointly. Flow amounts of money stock such as $\Delta D_H, \Delta D_P, \Delta D_G$ by households, producers (firms) and government, respectively, have to be borrowed from banks. Hence, such borrowing behaviors must be precisely analyzed here as the budget equations.

Model Feature 2: Increased Money Stock Ends up with Savings

Let us continue to examine the endogenous money IS-LM model in more detail. At the equilibrium, we have, from the revised Walras law (10.31),

$$S = \Delta M^s \qquad \text{(Savings as Monetary Increase)} \tag{10.39}$$

That is, savings are equal to the increased amount of money stock. How should we interpret this relation? When the aggregate demand determines (*ex post*) GDP as the Keynesian theory claims, loanable funds by banks must be first made available to meet the demand for the total flow amounts of debts, which in turn creates the increased amount of money stock ΔM^s. In this way loanable funds are indeed created endogenously by banks.

$$\Delta D_H + \Delta D_P + \Delta D_G \Rightarrow \Delta LF \Rightarrow \Delta M^s \tag{10.40}$$

On the other hand, at the equilibrium, aggregate demand determines (*ex post*) GDP such that

$$C + I_H + I_P + G \Rightarrow Y \tag{10.41}$$

[9] Public money such as coins issued by the government only constitutes 0.3% of total money stock M_3 in Japan, and neglected in this endogenous money IS-LM model.

Accordingly, from the Walras law (10.31) we must have

$$\Delta M^s \Rightarrow S \tag{10.42}$$

What does this mean? In the IS-LM models, whether loanable funds or endogenous model, we have assumed that households receive all distributed income of wages and profits $(W + \Pi)$. Hence, savings S are defined in equation (10.11) as the balance between income and expenditure by households, and include all kind of savings made by the macroeconomic sectors. Specifically, savings thus made by the households are first deposited as demand deposits, which are transferred further into time deposits as a leakage from circulation or withdrawn back to demand deposits as an injection back into the monetary circulation, as illustrated in Figure 10.1. However, the endogenous money IS-LM model we are discussing here does not display this two-tier structure of the savings.

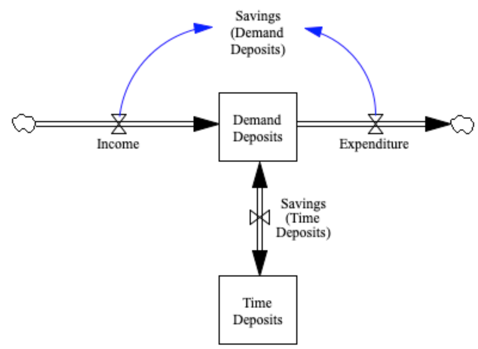

Figure 10.1: Two Tiers of Macroeconomic Savings

Yamaguchi and Yamaguchi (2021b) and Yamaguchi (2021b) found that time deposits are approximated by total debts held by non-banking private sectors (such as households and producers), while M_1 is approximately equal to the government debts in Japan and in the U.S., respectively (the case in Japan is shown in Figure 10.19 below). From the equations (10.40) and (10.42), we could say that debts by households and producers $\Delta D_H + \Delta D_P$ end up with time deposits, and debts by the government ΔD_G end up with demand deposits (86.5% of Japan's M_1 as of the end of 2018).

$$\Delta M^s \Rightarrow S \Rightarrow \begin{cases} \Delta D_H + \Delta D_P \Rightarrow \text{Time Deposits} \\ \Delta D_G \qquad\qquad\;\; \Rightarrow \text{Demand Deposits} \end{cases} \tag{10.43}$$

This implies that money newly created under the debt money system ends up with savings, which are further broken down into demand deposits and time deposits. In the loanable funds model, savings become the source of loans (and investment). In the endogenous money model, savings become the final leakages of newly created money, accumulating into demand and time deposits. This provides a theoretical foundation of our findings as a case in Japan. Against the mainstream theory, which claims that savings determines investment, we have observed completely opposite behaviors in our macroeconomy; that is, debts determines investment, ending up with savings.

Summary: To summarize our discussions here, when aggregate demand (AD) exceeds *ex ante* income $\underline{\text{Y}}$, two different macroeconomic behaviors take place under two different assumptions of loanable funds (exogenous money) and endogenous *debt money* systems as follows:

$$AD > \underline{\text{Y}} \;\Rightarrow\; \Delta LF = \underline{\text{S}} \;\Rightarrow AD = \underline{\text{Y}} \quad \text{(Loanable Funds)} \quad (10.44)$$

$$\Rightarrow\; \Delta LF = \Delta M^s \Rightarrow AD = Y \Rightarrow S \quad \text{(Endogenous Money)} \quad (10.45)$$

where $\underline{\text{S}}$ implies *ex ante* savings, and Y and S imply *ex post* income and savings, respectively.

As discussed in equation (10.25), in the loanable funds (exogenous money) IS-LM model, aggregate demand always ends up with *ex ante* income. In other words, it ends with the Say's law which says "supply creates its own demand". Ironically, the loanable funds IS-LM model has played a role of supporting the Say's law, even though the Keynes's General Theory originally intended to departure from or oppose to the Say's law. In the endogenous money IS-LM model, on the other hand, aggregate demand always determines *ex post* income as claimed by the Keynesian theory, that is, "demand creates its own supply".

In Conclusion, we have shown here that the true presentation of Keynesian theory must be made under the endogenous money IS-LM model that reveals the following two features:

- Debt money is endogenously created out of nothing so that central bank has no direct control over the money or stock (negation of "exogenous money").
- Investment is not constrained by the loanable funds, but followed by the *ex post* savings (negation of "banks as intermediaries").

Our paradigm shift of the endogenous money discussed in the previous chapter is now completed in our mathematical model with budget equations.

10.4 ASD Modeling of the IS-LM

To confirm this paradigm shift in macroeconomic theory, we will now attempt to construct the integrated model of the above loanable funds and endogenous money models for comparative analysis. For the analysis of budget equation, the Accounting System Dynamics (ASD) method turns out to be very effective for describing various inter-sector transactions that includes lending and borrowing of money and debts. For this integrated macroeconomic modeling, we apply the stock approach modeling of bank lending transaction based on the deposit creation theory (Yamaguchi and Yamguchi, 2016; Yamaguchi and Yamaguchi, 2021a), and attempt to embody savings (time deposits) as the source of loanable funds for banks. Once model is built, we can easily run either loanable funds or endogenous money model within a single model by turning on and off the switch. In this way, Keynesian controversies such as described above are, can be comparatively analyzed to find out which of the model assumption, i.e. loanable funds or endogenous money, is better suited for the macroeconomic analysis.

Producers

Let us begin with transactions of producers. In the macroeconomic system, they face two important decisions: production for this year and investment for the futures. We have already assumed that production decision is made by the desired production in the IS sub-model described in the previous chapter, while investment decision is assumed to be made by the standard macroeconomic investment function (10.6).

Based on these main decisions, major transactions of producers are illustrated in Figure 10.2 and summarized as follows.

- Producers are constantly in a state of cash flow deficits as analyzed by **?**, Chapter 4. To make new investment, therefore, they have to raise funds. In the case of loanable funds, they can utilize time deposits saved by their shareholders, while in the case of endogenous money, they borrow from banks (interest payment to banks are not considered for simplicity).
- Out of the production revenues, producers deduct the amount of depreciation, and pay wages to workers and dividends to their shareholders (wage distribution ratio among workers and shareholders is assumed constant).

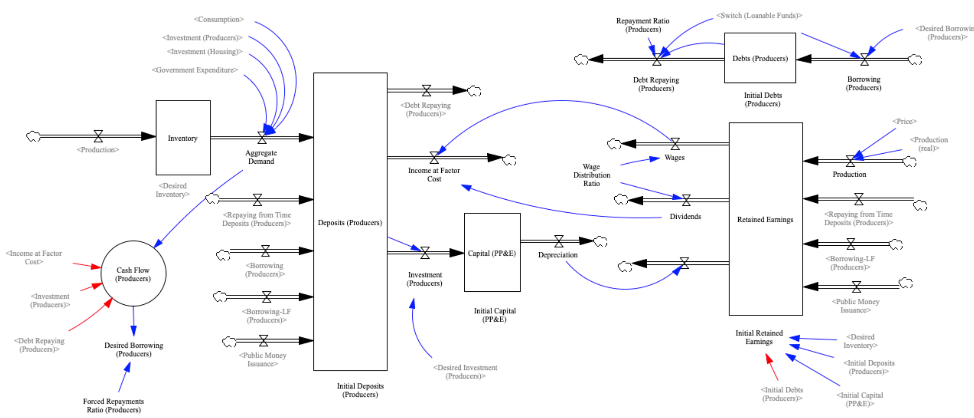

Figure 10.2: Transactions of Producers

Households

Households as consumers have to make two decisions: firstly, how much to consume and how much to save, and secondly, how much to borrow for housing investment. Consumption decision is assumed to be made according to the standard consumption function (10.3).

Transactions are illustrated in Figure 10.3, some of which are summarized as follows.

- Households receive income as wages and dividends.
- Out of the income as a whole, they pay income taxes, and the remaining amount becomes their disposable income.
- Out of their disposable income, they spend on consumption. The remaining is thus saved.
- Households purchase houses by utilizing their time deposits in the case of loanable funds, or by borrowing from banks in the case of endogenous money.

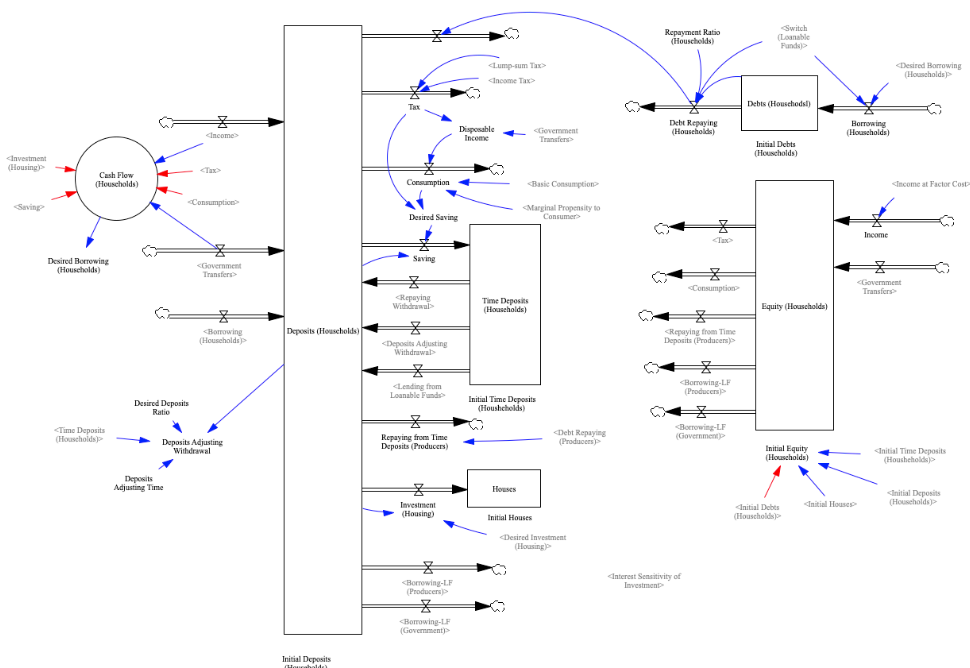

Figure 10.3: Transactions of Households

Government

Government faces decisions such as how much taxes to levy as its revenues and how much to spend as expenditures. Tax revenues are assumed to be collected according to the standard formula in equation (10.5), while expenditures are determined by the revenue-dependent tax and primary balance ratio. Primary balance ratio is assumed to be larger than one by default so that the government has to borrow to cover the incurring fiscal deficits.

Transactions are illustrated in Figure 10.4, some of which are summarized below.

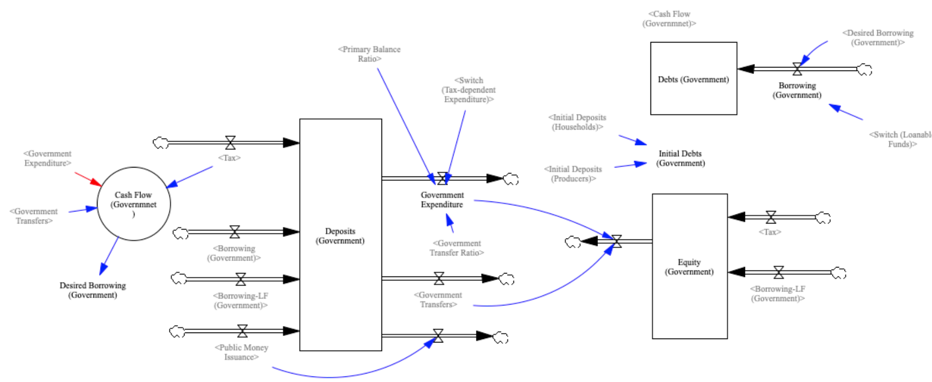

Figure 10.4: Transactions of Government

- Government receives income taxes from households as tax revenues.
- Government spending consists of government expenditures and transfer.
- Government expenditures are assumed to be endogenously determined by tax revenue-dependent expenditures.
- If spending exceeds tax revenues as assumed here by default, government has to utilize time deposits through banks as intermediaries in the case of loanable funds, or assumed to borrow directly from the central bank for simplicity in the case of endogenous money. Payments involving government are done through banks for simplicity.

Banks

In the case of loanable funds, banks are assumed to play a role as intermediaries of time deposits from depositors to investors. In the case of endogenous money, banks are assumed to play a passive role; that is, they only make loans to by the amount asked by producers and households. In other words, they do not purchase government securities and need to make no portfolio decisions among loans and other financial products. Transactions of banks are illustrated in Figure 10.5, some of which are summarized below.

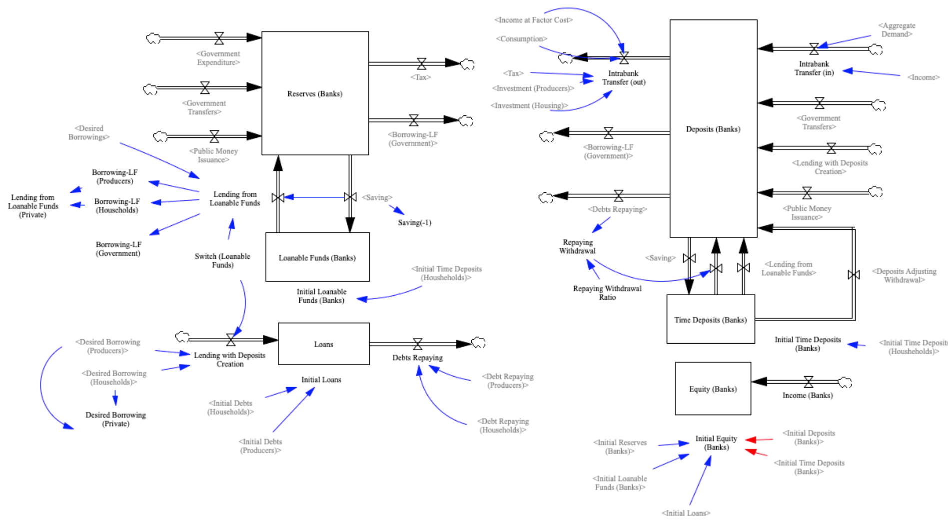

Figure 10.5: Transactions of Banks

- Banks receive demand deposits from households and producers, and time deposits from households (interests payments are neglected for a simplicity here).

- In the case of loanable funds, banks make loans out of the savings of time deposits, while in the case of endogenous money, they make loans by creating deposits as much as the desired amount of borrowings by producers and households. Interests on these loans are not considered likewise for a simplicity.

Central Bank

The central bank opens deposits accounts for banks and the government. It is assumed to transfer money on behalf of the government, as well as make loans directly to the government in the case of endogenous money. Transactions are made simple and summarized as follows.

- In the case of loanable funds, it is assumed that the central bank transfers funds to the government through reserves of the banks, while in the case of endogenous money, the central bank make loans directly to the government for simplicity.

- As explained at the end of Section 10.2, the workings of loanable funds model are fundamentally the same and, thus, applicable to that of the public money system. Therefore it is assumed to be able to issue public money as an exceptional case.

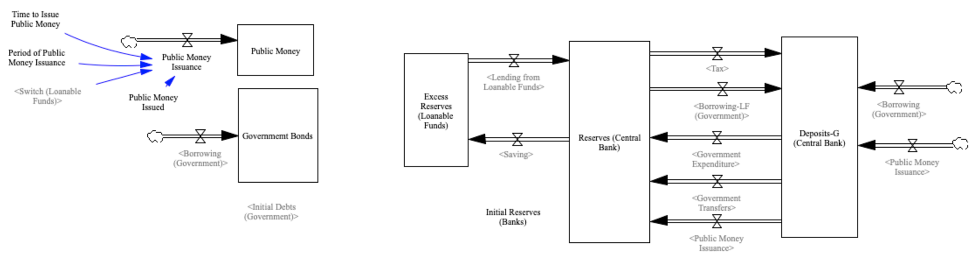

Figure 10.6: Transactions of Central Bank

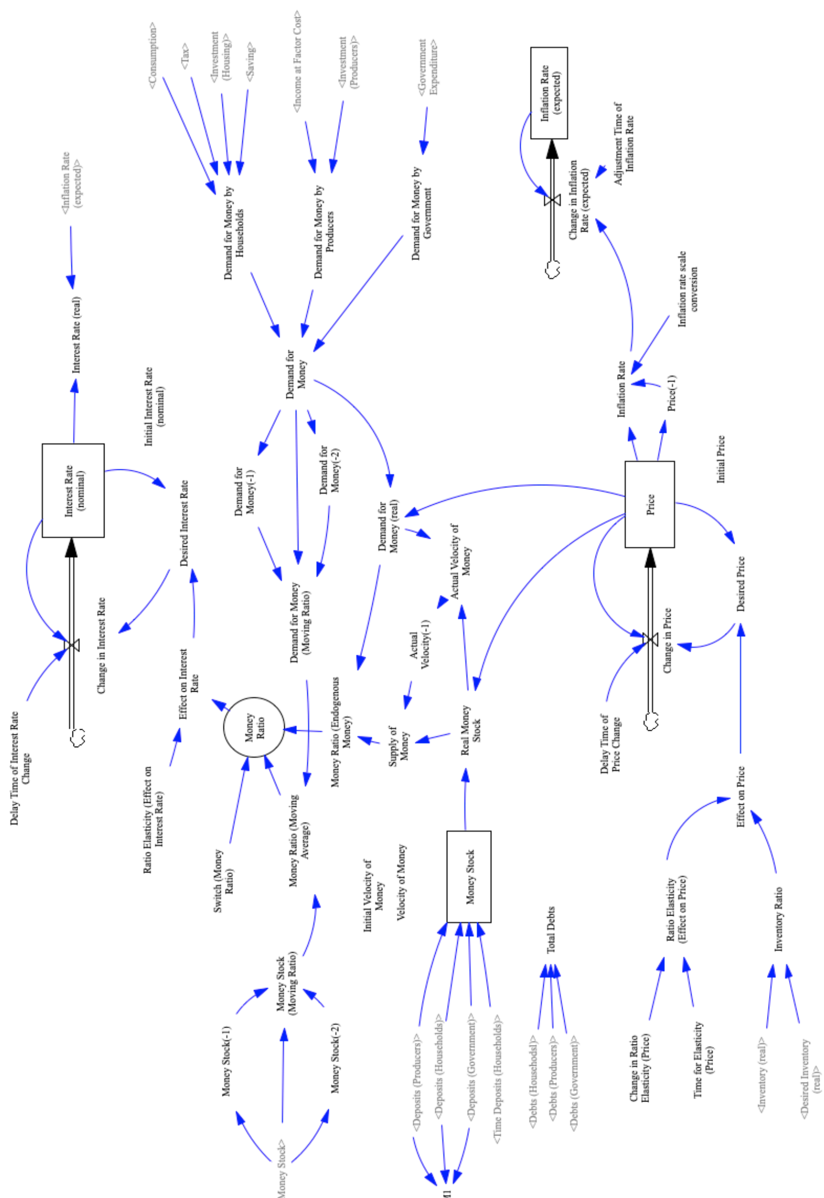

Figure 10.7: Integrated LM Sub-Model

The LM Sub-Model

With the introduction of budget equations, money stock can now be obtained within the model as follows:

$$\text{Money Stock} = M_1 + M_T(\text{Time Deposits}) \tag{10.46}$$

where M_1 is the sum of deposits by producers, households and government as illustrated in left end of Figure 10.7. Demand for money are obtained as the sum of outflows from deposits (stocks). Money Ratio is modified as a moving average ratio of real money stock and demand for money.

Validations of the ASD Model of the IS-LM

(1) Validation of SD Model: Model and Units Check

Built-in model tests performed by the SD simulation software (Vensim) such as "Check Model" and "Units Check" must be all cleared as a legitimate model. Our model have passed both tests. We have pointed out in the previous chapter that the extended IS-LM model with expected inflation presented by Mankiw (2016, Chapter 12) failed this unit check.

(2) Validation of ASD Model: BS and FF Checks

Accounting system requires that balance sheets of all sectors must be in balance. This test is called balance-sheets (BS) check. Furthermore, the flow-of-funds framework requires that all assets and liabilities (equity) of all transaction items in the model must be in balance across all macroeconomic sectors involved. This test is called the flow of funds (FF) check. A left diagram of Figure 11.3

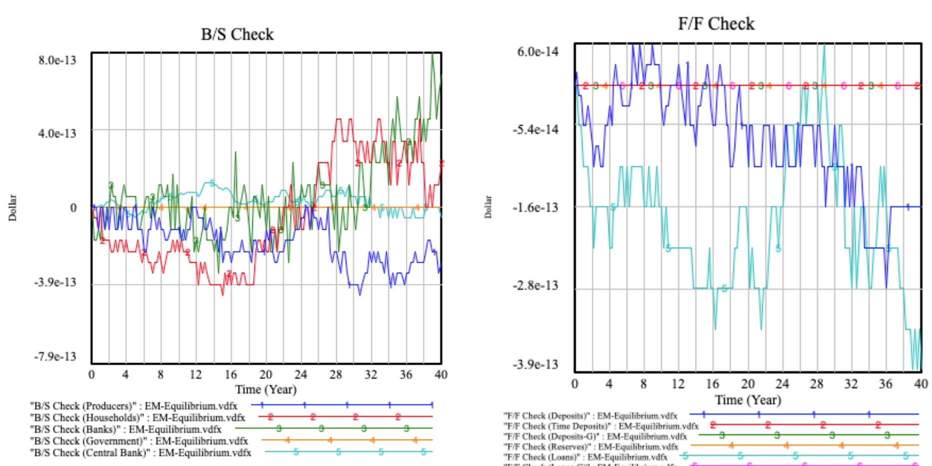

Figure 10.8: Validation (2) - Balance Sheets (BS) and Flow of Funds (FF) Checks

illustrates that, for the Endogenous Money (EM) model, the balance of each sector's balance sheets are almost zero, indicating that the model passes the B/S check for all macroeconomic sectors. The right diagram illustrates that the Flow of Funds are all in balance (almost zero) among transaction items such as deposits, time deposits, reserves, and loans. F/F check on Loanable Fund (LF) model is also confirmed.

(3) Validation of Macroeconomic Model: Debt Money Check

We have mathematically presented in the equation (10.35) that money stock is equal to the total debts under the debt money system. Yamaguchi and Yamaguchi (2021b) reported that, under the current debt money system, the following three relations hold in the Japanese economy between 1980 and 2019 (details are discussed below).

1. Money Stock (M_3) $\simeq$ Total Debts (line 1 $\simeq$ line 2)
2. Time Deposits (M_T) $\simeq$ Private Debts (by Producers and Households) (line 3 $\simeq$ line 4)
3. M_1 (= Currency + Demand Deposits) $\simeq$ Government Debts (line 5 $\simeq$ line 6)

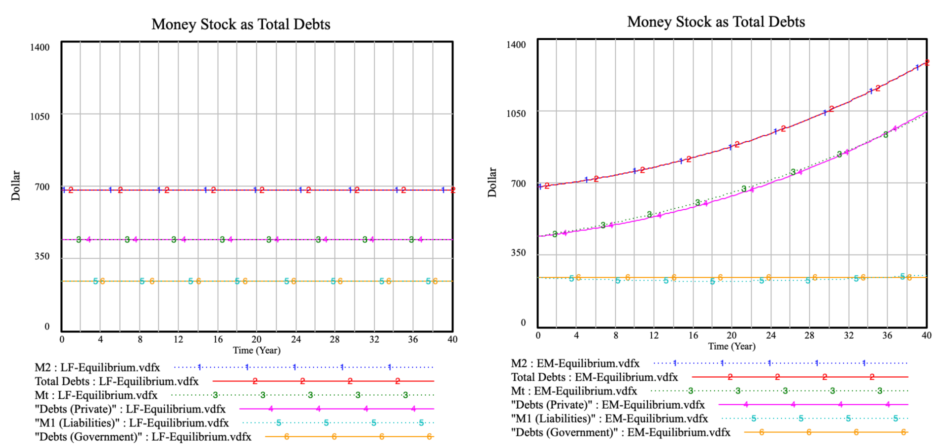

Figure 10.9: Validation (3) - Debt Money Check: Money Stock $\simeq$ Total Debts

As explained above, Yamaguchi (2021b) found further that the similar relations were observed in the U.S. following the Japanese case. Empirical results show that the first relation must hold in any economy operating under the current debt money system world-wide. Hence, this additional validation test for macroeconomic models is called Debt Money check. Figure 11.4 shows that all three relations of Debt Money Check hold at the equilibrium in our integrated ASD model of the IS-LM.

10.5 ASD Model of Loanable Funds and Endogenous Money

Our integrated IS-LM ASD model of loanable funds and endogenous money is now completed. Let us call the loanable funds portion of the IS-LM model simply the LF model, and the endogenous money portion of the IS-LM model the EM model, hereafter. To run the LF model, we simply set a "Money (switch)" value of the integrated IS-LM model to be 1. Its default value is set to be 0 for the EM model as was also the case in the model of previous chapter.

Figures 10.10 and 10.11 present comparative behaviors of LF and EM models under fixprice. Lines 1 and 2 are behaviors of the EM model at the equilibrium and for the case of investment increase by \$30 at t=10, while lines 3 and 4 are those of the LF model for the same environment. These simulation files are listed in Table 10.5.

Endogenous Money IS-LM	Loanable Funds IS-LM
Line 1: EM-Equilibrium	Line 3: LF-Equilibrium
Line 2: EM-Investment(+30)-Fixprice	Line 4: LF-Investment(+30)-Fixprice

Table 10.1: Simulations of LF vs EM models under Fixprice Case

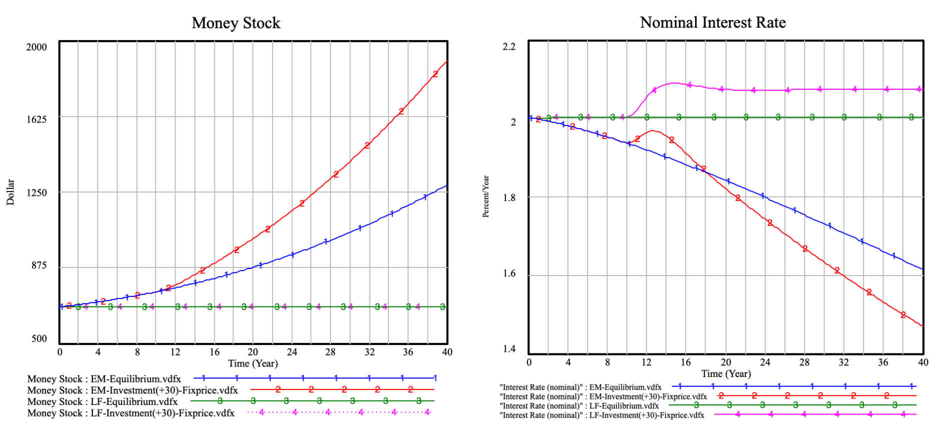

Figure 10.10: Loanable Funds vs Endogenous Money: Money Stock and Interest Rate

Figure 10.10 presents comparative behaviors of money stock and nominal interest rate. Under fixprice assumption, these nominal values also become real values. Lines 1 (blue) and lines 2 (red) indicate steady growth of money stock and gradual declines in interest rate by the EM model. Meanwhile, in the LF model money stocks (lines 3 and 4) do not increase, and interest rate (line 3) stays constant. After the investment increase at t=10, interest rate in the LF model jumps but eventually converges to a constant level (line 4).

These different behaviors of interest rate affect investment and, then, income as illustrated in Figure 10.11. That is, incomes (lines 1 and 2) continue to grow under the EM model due to the endogenous creation of money, while they get stagnated at constant level under the LF model (lines 3 and 4) due to the exogenously fixed amount of money. Right figure shows the IS-LM phase diagram of both EM model and LF model. The EM model indicates a move toward south-east (line1 for equilibrium and line 2 for investment increase), while the move of LF model is confined in a small region (line 3 as dot and line 4).

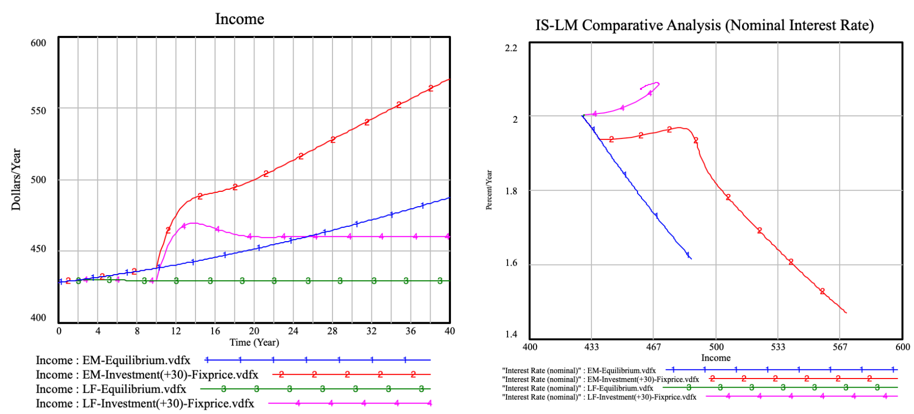

Figure 10.11: Loanable Funds vs Endogenous Money: Income and IS-LM Phase Diagram

Where do these different macroeconomic behaviors between LF and EM models come from? They are caused by the different attitudes of banks to make loans. Figure 10.12 illustrates behaviors of desired borrowing, bank lending and

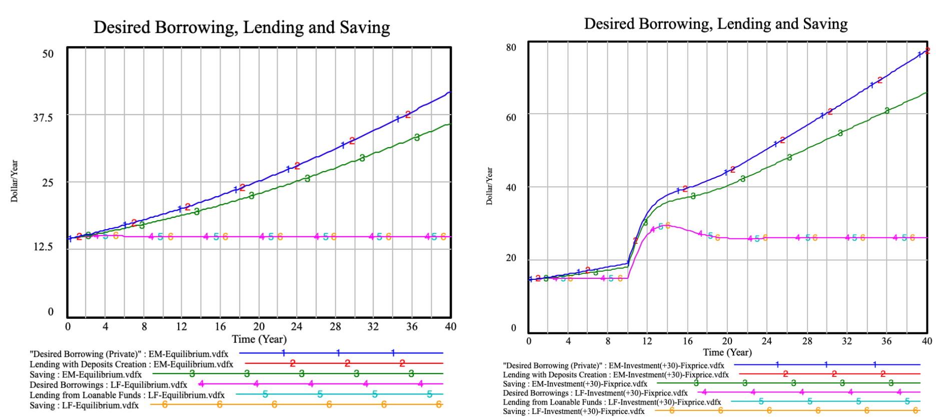

Figure 10.12: Loanable Funds vs Endogenous Money: Desired Borrowing and Saving

saving among EM and LF models. In the EM model, Desired Borrowing (blue line 1) is shown to be always met with Lending with Deposits Creation" (red line 2) without being constrained by the amount of Saving (green line 3). Money is indeed endogenously created to meet the desired investment as indicated by equation (10.29). Saving takes place after these investment decisions are made, as indicated by equation (10.42).

On the other hands, in the LF model, Desired Borrowing (pink line 4) and Lending from Loanable Funds (sky blue line 5) are shown to be constrained all the time by the amount of Saving (orange line 6). These constrained behaviors confirm our mathematical analysis in the previous section. That is, in the LF model, savings become the only sources of desired investment as analyzed by equations (10.18) and (10.22). As a result, the constrained relations all the time hold in the LF model such that "Desired Borrowing = Lending from Loanable Funds = Saving."

Having analyzed the behaviors between LF and EM models, we have to decide which model is appropriate for macroeconomic analysis under the debt money system. In the EM model, income is shown to grow and interest rate to decrease as illustrated by lines 1 and 2 in Figure 10.11. On the other hand, in the LF model money stock does not increase and income is constrained to grow. This is a fatal flaw as a macroeconomic model. In addition, we have rejected the exogenous money IS-LM model in the previous chapter, because it failed to produce the contraction of money stock during the Great Depression. Loanable funds IS-LM model here shares the same flaw as the one in the exogenous money IS-LM model in the previous chapter. Consequently, the LF model has to be similarly rejected here as a model for the macroeconomic analysis of the debt money system in which money is endogenously created and destructed. There is no built-in mechanism of endogenously creating money in the LF model. As discussed in the previous chapter, central bank can only control the amount of base money M_0, but cannot control the amount of M_1 and M_2, or M_3 by its monetary policy. This is a serious design failure of constructing macroeconomic model for the debt money system. Therefore, Keynesian view that money stock is exogenously determined by the central bank and savings (time deposits) become the sources of loanable funds for investment can no longer be supported, This is the reason why we have argued in the previous chapter that there is a need for a paradigm shift in macroeconomics toward the endogenous money IS-LM model.

Public Money as Loanable Funds

Our rejection of the Keynesian loanable funds model as the one for the analysis of debt money system does not mean that it is of no use as a macroeconomic model. We are just claiming that it is not relevant as a macroeconomic model of the debt money system. Convinced by the visions of monetary reform and 100% money by Irving Fisher, as discussed in the previous chapter, **?**, Part V: Public Money System and Yamaguchi and Yamguchi (2016) have developed public money system. In this new macroeconomic system money is constantly put into circulation and withdrawn by the Public Money Administration, and banks only play a role as intermediaries of public money. Accordingly, the Keynesian loanable funds model we have developed so far indeed fits into the economic system of the public money.

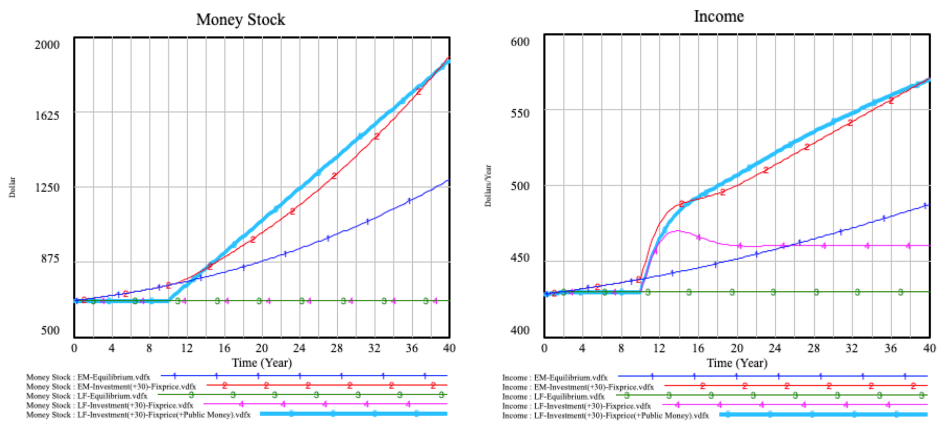

Figure 10.13: Public Money as Loanable Funds

In this sense, the LM model could be a candidate for the macroeconomic model of the public money system, but not the one for the debt money system. As a hypothetical situation, let us assume that the Public Money Administration (previous central bank under the debt money system) has injected public money of \$40 at t=10 for 30 years; that is, \$1,200 in total. That is, money stock (bold line 5) in Figure 10.13 is shown to increase from \$680 to \$1,880 for 30 years. Voila! This amount of money under the public money system is issued at interest-free and without causing government debts! Due to this continued injection of public money, income (bold line 5) in the right diagram now increases as much as the one under the debt money system; that is, almost identical economic growth is attained. This is the essence of the public money system.

In this way, it turned out that the loanable funds IS-LM model could serve as a macroeconomic model only under the public money system; it cannot work effectively as a macroeconomic model of the current debt money system in which money is endogenously determined.

10.6 The Great Depression Revisited

By introducing the endogenous money spending hypothesis, we have successfully reproduced historical behaviors of the Great Depression in the previous chapter. Let us revisit the Great Depression with the EM model developed in this chapter. This time we have not applied PULSE function to fit actual data. Instead, we only used STEP function by setting the parameter values as follows (Δ implies a change): $\Delta C_0 = \Delta I_0 = \Delta \bar{I}_H = -20$ at t = 9, 10, 11, respectively. Change in Ratio Elasticity (Price) is set to be 0.06 for flexible price analysis at t=9. Simulation results thus obtained for the Great Depression analysis are shown in Figure 10.14 through 10.16. Similar behaviors as obtained in the previous chapter are successfully obtained under general settings recession. Table 10.2 explains correspondence between each line in Figure 10.14 through 10.16 and scenarios under which simulations were run. Specifically, the EM model is shown

Endogenous Money IS-LM	Loanable Funds IS-LM
Line 1: EM-Equilibrium	Line 4: LF-Equilibrium
Line 2: EM-Great Depression-Fixprice	Line 5: LF-Great Depression-Fixprice
Line 3: EM-Great Depression-Flexprice	LIne 6: LF-Great Depression-Flexprice

Table 10.2: Legend Names for Simulations under The Great Depression Revisited

to capture the fall in nominal interest rate, rise in real interest rate, rise in real money balance, and destabilizing effects of the deflation on income. Figure 10.16 shows comparative analysis of all simulations in phase diagram where income is taken on the horizontal axis. In the left diagram, nominal interest rate is taken on the vertical axis whereas real interest rate is taken on the right diagram. The reader is advised to visit the analyses in the previous chapter for further details.

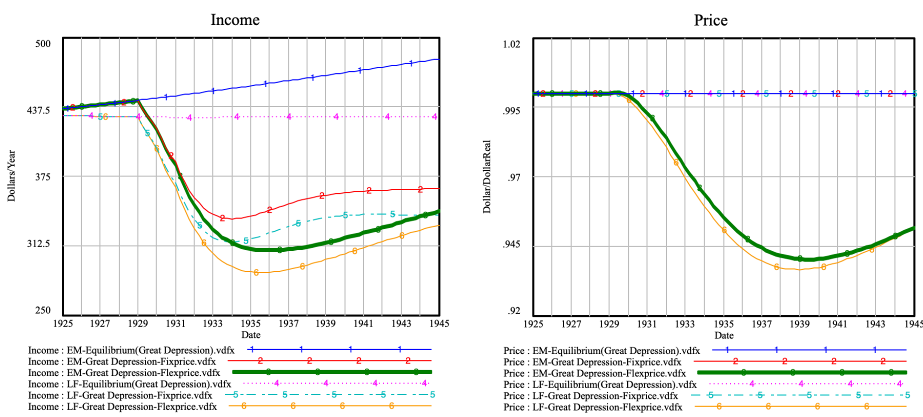

Figure 10.14: The Great Depression Revisited: Income and Price

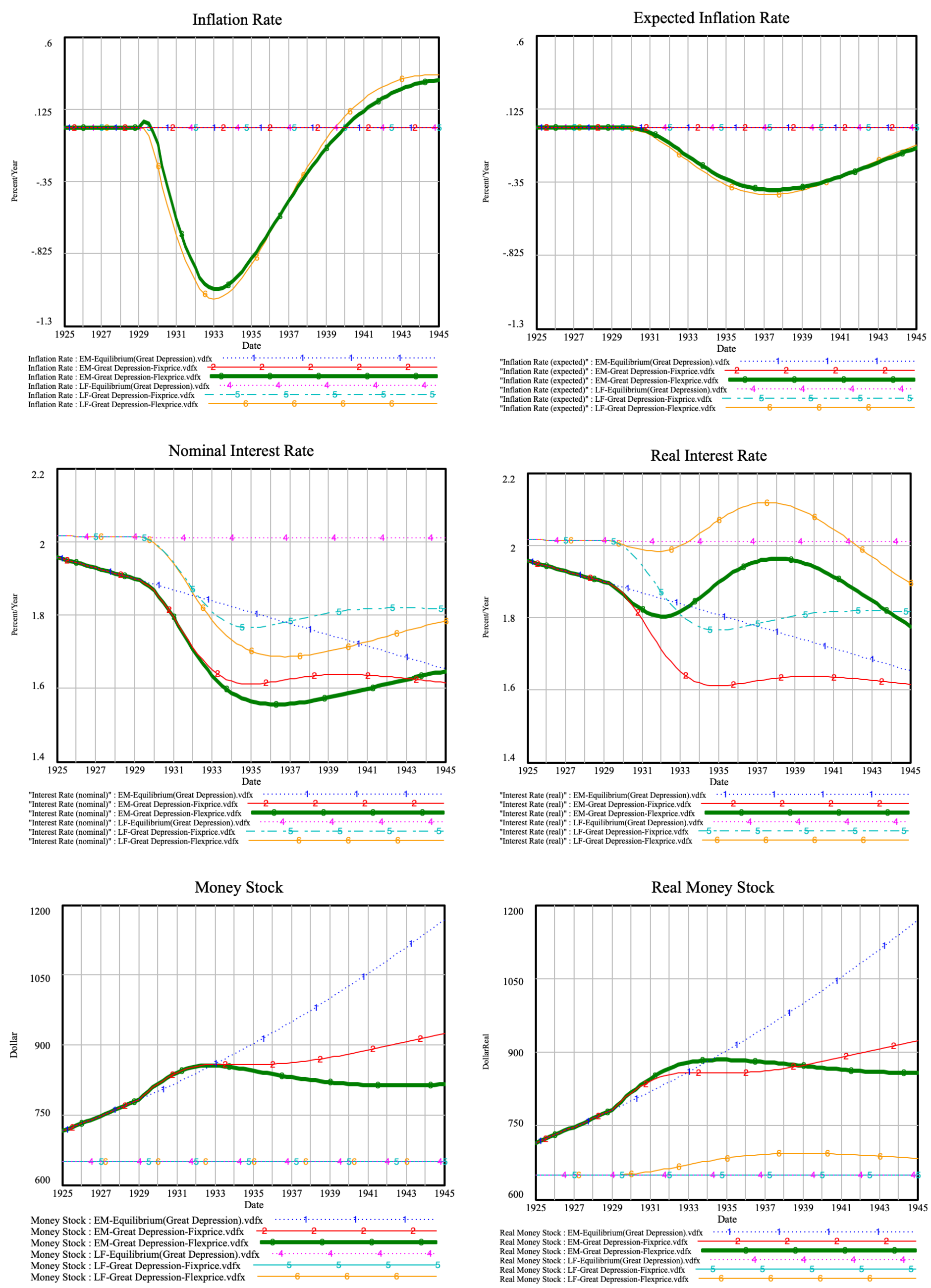

Figure 10.15: The Great Depression Revisited: (Expected) Inflation, (Real) Interest Rate and (Real) Money Stock

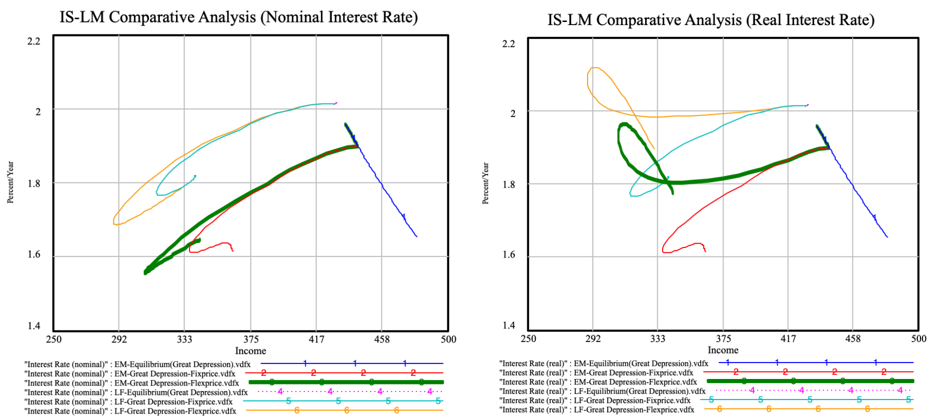

Figure 10.16: The Great Depression Revisited: IS-LM Phase Diagram

10.7 The Analysis of Japan's Lost 30 Years

10.7.1 Lost 30 Years as A Prolonged Great Depression

By introducing the endogenous money spending hypothesis here, we have successfully reproduced the behaviors of the Japan's lost 30 years by setting the parameter values as follows: $\Delta C_0 = -30$ at t=12, $\Delta I_0 = -90$ at t=11, $\Delta \bar{I}_H = -6$ at t=16. $\Delta \bar{G} = 18$ at t=11. Primary balance is set to be 1. Flexible price is assumed by setting Ratio Elasticity (Effect on Price) = 0.06.

Endogenous Money IS-LM	Loanable Funds IS-LM
Line 1: EM-Equilibrium Line 2: EM-Japan's Great Depression Line 3: EM-Japan's Lost 30 Years	(With Fiscal Policy) Line 4: LF-Japan's Lost 30 Years

Table 10.3: Legend Names for Simulations under Japan's Lost 30 Years Case

In Figures 10.17 and 10.18, lines 2 in red color (legend name: EM-Japan's Great Depression) indicate "what if" behaviors without active fiscal policies of the Japanese government during the lost 30 years. In other words, behaviors presented by lines 2 could be interpreted as the prolonged behaviors of the Great Depression over 30 years. Indeed, if they were compressed to those of 10 years, they look like the behaviors of the Great Depression (1929-1939) discussed in the previous chapter. It is observed that behaviors of the Japan's lost 30 years are similar to those of the Great Depression in terms of the underlying behavioral patterns of key macroeconomic variables. Therefore, we may conclude that under the debt money system, many economic recessions, whether the Great Depression, the Japan's lost 30 years, or whatever other recessions, could exhibit similar behaviors observed under the endogenous money spending hypothesis.

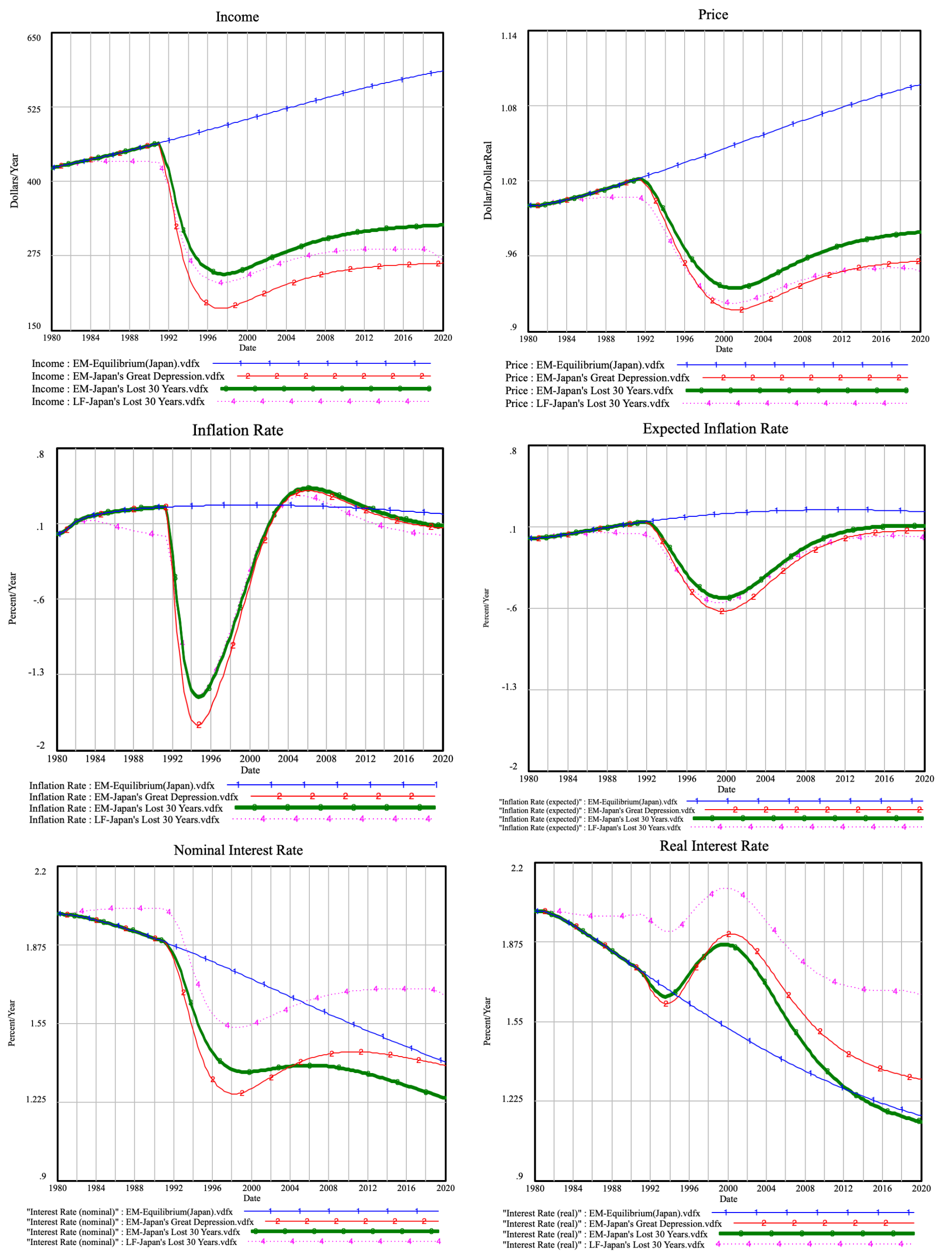

Figure 10.17: Japan's Lost 30 Years as A Prolonged Great Depression

Lines 3 in thick green (legend name: Japan's Lost 30 Years) show the behaviors when fiscal policies are applied under the endogenous money spending hypothesis, Accordingly, lines 2 and 3 provide comparative behaviors of the Japan's recessional cases without or with fiscal policies. For instance, Income

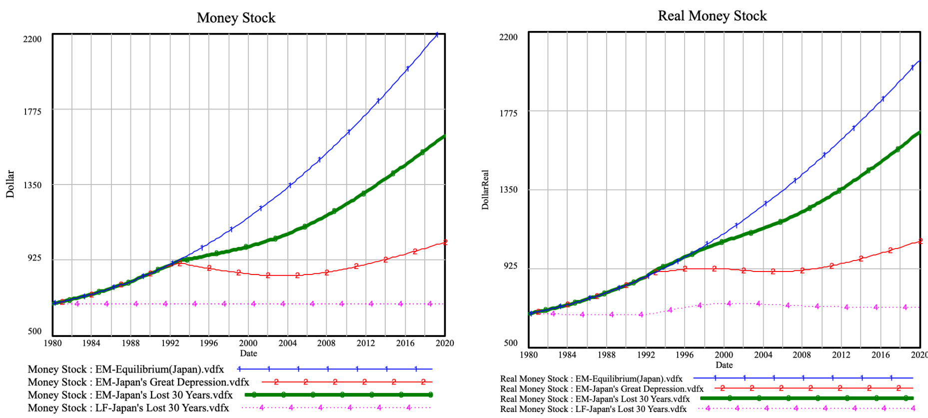

Figure 10.18: Money Stock and Real Money Stock

shown at the top left of Figure 10.17 shows that Japan's GDP would have been reduced significantly, almost to the half in the simulation, if the government did not apply the active spending policy.

10.7.2 Mainstream Myth of the Crowding Out Effect

One of the claims made by the mainstream economics has been such that if Japan continues to accumulate government debts the economy would sooner or later face with a rising interest rate due to the so-called *crowing out effect*, which reduces investment and cancel out the effect of fiscal policy. Yet, such a rise in interest rates did not occur. To examine this claim, we have run simulations under the loanable funds model (lines 4 in Figures 10.17 and 10.18). Indeed, dotted line 4 in the diagram of nominal interest rate in Figure 10.17 shows that nominal interest rate is increasing as the government debts continue to increase under the fiscal policy during the lost 30 years.

On the contrary, nominal interest rate continued to decline during the lost 30 years in Japan. Line 3 of endogenous money IS-LM model in the same diagram illustrates this continued decline of nominal interest rate. This declining nominal interest rate has been a puzzle for the mainstream economists whose mindsets are occupied by the loanable funds model (exogenous money). Our EM model indicates that money stock (line 3 of the money stock diagram in Figure 10.18) continues to increase due to the accumulated debts by the government, which pushes down the nominal interest rate. This is another example of indicating that the mainstream theory of loanable funds is flawed. Interestingly, real interest rate temporarily rises, then continues to decline, even under the loanable funds model. Mainstream theory of exogenous money failed to show this behavior of real interest rate as well.

10.7.3 Money Stock as Total Debts and their Breakdown Relations

Let us continue our analysis of Japan's lost 30 years, using the endogenous money IS-LM model. We have observed three surprising monetary relations as illustrated in the top left diagram of Figure 10.19 (Yamaguchi and Yamaguchi, 2021b). Specifically, we have found the following correlations:

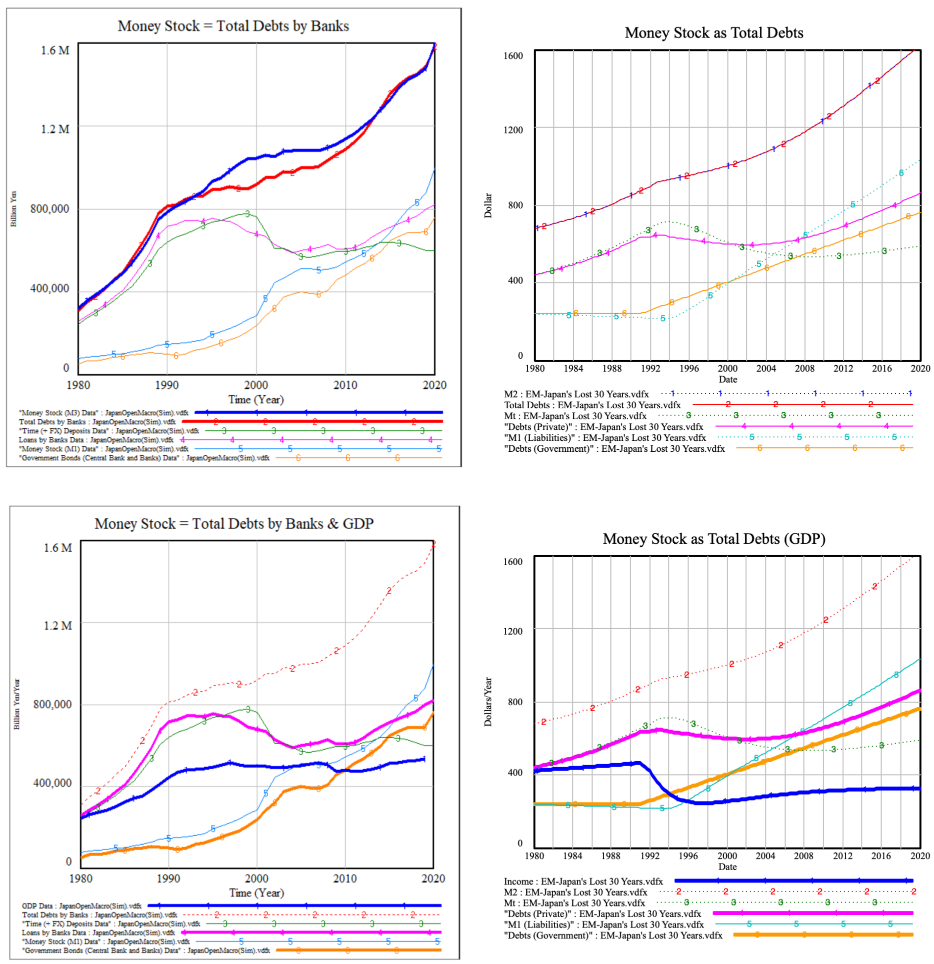

Figure 10.19: Breakdown of Japan's Money Stock as Total Debts

- Money Stock (M_3) $\simeq$ Total Debts (corr.coef = 0.987) (line 1 $\simeq$ line 2 in the top left diagram of Figure 10.19)
- Time Deposits (M_T) $\simeq$ Private Debts (by Producers and Households) (corr.coef = 0.928) (line 3 $\simeq$ line 4 in the same diagram)

- M_1 (= Currency + Demand Deposits) $\simeq$ Government Debts (corr.coef = 0.992) (line 5 $\simeq$ line 6 in the same diagram)

The diagram on top right of Figure 10.19 illustrates that our EM model can successfully produce *money stock as total debts* breakdown relations as observed in Japan. Specifically, money stock (line 1) is shown to be always equal to total debts (line 2) in the model. This confirms that the equation (10.35) we presented above holds true in the EM model of the debt money system. Under the present system, money is created only when producers, households and government come to borrow from banks at interest. Bankers receive interests on those loans that were created as borrowers' deposits out of nothing. The diagram on bottom right of Figure 10.19 can also successfully produce the relations of GDP and debts revealed in Japan as shown in the bottom left diagram.

Our endogenous money IS-LM model can successfully reproduce these macroeconomic relations of money stock such as M_1, M_T, M_2, M_3 and debts by producers, households, and government. Hence, the EM model would also help analyze and identify system structures underlying the macroeconomic behaviors of debt money by manipulating the model parameter values. In this sense, the endogenous money IS-LM model developed in this chapter can be used as a standard IS-LM model for explaining the paradigm shift in macroeconomics we have emphasized in the previous chapter.

10.7.4 Japan's Lost 30 Years as Joint Shifts of IS-LM Curves

For our EM model to be a standard IS-LM model in macroeconomics, it has to be able to solve the limitation of the short-run IS-LM model discussed in the previous chapter. Specifically, we have to be able to produce "point J" indicated in Figure 9.28.

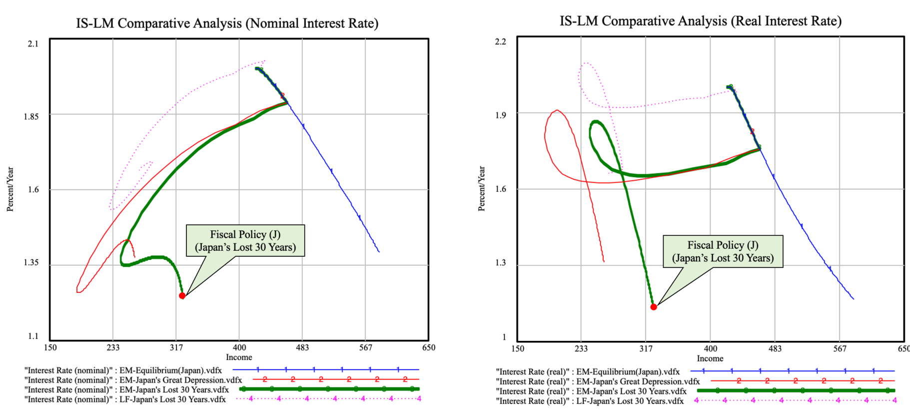

Figure 10.20: Phase Diagram: Income vs Nominal (Real) Interest Rate

Figure 10.20 presents the phase diagrams of the behaviors of Japan's lost

30 years produced by the EM model in terms of nominal (left) and real (right) interest rates, respectively. Lines 3 (bold green) in green indicates that Income or GDP continued to decline in the beginning, but failed to recover in spite of the aggressive fiscal policy applied by the Japanese government later, while interest rate continued to decline against the mainstream claim of the crowding out effect. These model behaviors of line 3 toward the "point J" illustrated in the figure are similar to what have been observed during the last lost 30 years in Japan. Lines 2 (red), on the other hand, indicate how GDP and nominal interest rate would have continued to decline if no fiscal policies were applied in Japan.

Now we have successfully captured the behaviors of Japan's lost 30 years with the endogenous money IS-LM model developed in this chapter. These results seem to show that most macroeconomic recessional behaviors could be produced by this EM model. If so, by calibrating the model behaviors to actual case studies, the model could be used by policy-makers to examine potential impacts of fiscal policy on their economy before its implementation. Indeed, we have obtained a standard macroeconomic model of paradigm shift we have proposed in this and previous chapters, that is, the endogenous money IS-LM model.

Conclusion

In the series of chapters 9 and 10, we have attained the following macroeconomic views against the mainstream Keynesian view.

1. In the previous chapter we have presented Keynesian short-run IS-LM model as mathematical model of equations and its SD model for dynamic simulations. The IS-LM model under the assumptions of exogenous money provided by the central bank and short-run fixprice is shown to be flawed in the sense that it cannot explain typical macroeconomic behaviors such as the Great Depression and Japan's lost 30 years.

2. Its failures is apparently based on the model assumptions. Accordingly, Keynesian short-run IS-LM model in which IS and LM curves are moved separately for macroeconomic policy analysis can no longer hold.

3. On the other hand, the short-run IS-LM model under the assumption of endogenous money and flexible price is shown to explain the data behaviors of the Great Depression successfully. This assumption is also called "endogenous money spending hypothesis" that integrates the spending hypothesis by Keynes and money hypothesis by Fisher (both were proposed in the same year of 1936).

4. IS and LM curves of the short-run IS-LM model under the "endogenous money spending hypothesis" now have to move jointly or simultaneously

in the phase diagram of income and interest rate. This joint move across the whole phase diagram space makes macroeconomic equilibrium point unpredictable.

5. Yet, this endogenous money IS-LM model failed to produce the behaviors of Japan's lost 30 years, another typical macroeconomic event, due to the mechanistic assumption that endogenous money in the model is artificially created according to the growth rate of income.

6. To overcome this limitation in this chapter we have expanded the Keynesian short-run IS-LM model by incorporating budget equations of all macroeconomic sectors as a mathematical model first, then as an ASD (accounting system dynamics) model.

7. The model thus constructed with the assumption of exogenous money is called *loanable funds* IS-LM model. That model again failed to support the Keynesian view that aggregate demand creates its supply (production). At this stage of our research we are convinced that the mainstream Keynesian macroeconomic view of exogenous money can no longer hold in macroeconomics. (It could be effective, in a limited way, only under the public money system).

8. The model constructed next with the "endogenous money spending hypothesis" is called *endogenous money* IS-LM model. It is able to successfully reproduce similar behaviors of the Great Depression as analyzed in the previous chapter without using a mechanistic method of endogenous money creation this time. Then it is shown to produce the "point J" observed in the Japan's lost 30 years.

9. In addition, the model is shown to produce our recent findings of the breakdown relations of "money stock as total debts" observed during the Japan's lost 30 years.

10. In conclusion, the endogenous money IS-LM model we have presented here, with the endogenous money spending hypothesis, can analyze major macroeconomic recessions such as the Great Depression and Japan's lost 30 years, and in this sense could be a new standard macroeconomic model in place of the Keynesian model of exogenous money and loanable funds. The endogenous money ASD model becomes a foundation of paradigm shift in macroeconomics.

Questions for Deeper Understanding

1. Balance sheet of producers in the model: 5 IS-LM (Loanable-vs-Endogenous) .vpmx is slightly different from the simplified corporate balance sheet in Chapter 3 in the way inventory and account receivable are treated. Discuss why?

2. (Limitations of the IS-LM model by the Mainstream Theory)
The IS-LM framework has been the dominant approach to Keynesian macroeconomic theory. Yet, two theoretical limitations have been pointed out recently as follows:

   (a) As a main cause of the Great Depression in 1929, Milton Friedman and Anna Schwartz presented the decline of money stock by 25% from 1929 to 1933. This is a well-acknowledged "money hypothesis". Yet, Mankiw pointed out as follows:

   > "Using the IS-LM model, we might interpret the money hypothesis as explaining the Depression by a contractionary shift in the LM curve. ⋯
   > The second problem for the money hypothesis is the behavior of interest rates. If a contractionary shift in the LM curve triggered the Depression, we should have observed higher interest rates.Yet nominal interest rates fell continuously from 1929 to 1933."
   > – Macroeconomics, 9th edition, 2016, by Gregory Mankiw, page 354 –

   (b) After her bubble burst in mid 1990's, Japanese economy has been suffering from the prolonged recessions of almost 30 years. To get out of the recessions, Japanese government as well as the Bank of Japan have heavily applied the Keynesian monetary policy of increasing money stock which is dubbed as Quantitative Easing policy. As you have run simulations above, this QE policy shifts the LM curve to the right and stimulates GDP. In reality, however, it didn't work as predicted by the theory.

   Consequently, the IS-LM model has failed to explain these two observations of the economic recessions. In other words, there exist some theoretical limitations to the IS-LM model as macroeconomic policy tools. Under the circumstances, answer the following two questions.
   (A) Reproduce the Mankiw's assertion (a) above by running the endogenous money ASD model, and discuss what's wrong with the IS-LM approach of macroeconomic monetary policies.
   Tip: Reduce money stock by - 10 at t = 4.
   (B) Discuss why the shift of LM curve (that is, QE policy) didn't work as expected by the IS-LM model in the Japanese economy.

Appendix: Endogenous Money IS-LM Model

$$Y = AD \quad \text{(Aggregate Demand Equilibrium)} \quad (10.47)$$
$$AD = C + I + G \quad \text{(Aggregate Demand)} \quad (10.48)$$
$$C = C_0 + cY_d \quad \text{(Consumption Decisions)} \quad (10.49)$$
$$Y_d = Y - T \quad \text{(Disposable Income)} \quad (10.50)$$
$$T = T_0 + tY - T_r \quad \text{(Tax Revenues)} \quad (10.51)$$
$$I = \frac{I_0}{r} - \alpha r \quad \text{(Investment Decisions)} \quad (10.52)$$
$$G = \bar{G} \quad \text{(Government Expenditures)} \quad (10.53)$$
$$\frac{M^s}{P}V = L^d \quad \text{(Equilibrium of Money)} \quad (10.54)$$
$$L^d = aY - bi \quad \text{(Demand for Money)} \quad (10.55)$$
$$r = i - \pi^e \quad \text{(Fisher Equation)} \quad (10.56)$$

$$PC + PT + PI_H + S = W + \Pi + \Delta D_H \quad \text{(Households Budgets)} \quad (10.57)$$
$$W + \Pi = PY \quad \text{(Distributed Income)} \quad (10.58)$$
$$PI_H = \Delta D_H \quad \text{(Housing Budgets)} \quad (10.59)$$
$$I_H = \bar{I}_H \quad \text{(Housing Investment)} \quad (10.60)$$
$$W + \Pi + PI_P = PY + \Delta D_P \quad \text{(Producers Budgets)} \quad (10.61)$$
$$I_H + I_P = I \quad \text{(Private Investment)} \quad (10.62)$$
$$PG = PT + \Delta D_G \quad \text{(Government Budget)} \quad (10.63)$$
$$\Delta D_H + \Delta D_P + \Delta D_G = \Delta LF \quad \text{(Loanable Funds of Debts)} \quad (10.64)$$

$$(\Delta LF = S\ ) \quad \text{(Savings as Loanable Funds by Banks)}$$
$$\Delta LF = \Delta M^s \quad \text{(Endogenous Deposits Creation)} \quad (10.65)$$
$$M^s = \int \Delta M^s dt \quad \text{(Endogenous Money Stock)} \quad (10.66)$$

The endogenous money short-run IS-LM model consists of the above 20 equations with 20 unknowns:

$Y, AD, C, I, G, Y_d, T, i, r, L^d, S, I_H, W{+}\Pi, I_P, \Delta D_H, \Delta D_P, \Delta D_G, \Delta LF, \Delta M^s, M^s$

and 14 exogenously determined parameters:

$$C_0,\ c,\ T_0,\ t,\ T_r,\ I_0,\ \bar{G},\ P,\ V,\ \alpha,\ a,\ b,\ \pi^e,\ \bar{I}_H.$$

Chapter 11

Long-Run IS-LM Model

11.1 Endogenous Money Long-run IS-LM Model

Short-run vs Long-run

Chapter 9 started with the presentation of a simple long-run macroeconomic model consisting of equations (9.1) through (9.10). This model is shown to cover both neoclassical and Keynesian views of macroeconomics. Then we have focused on the Keynesian view of short-run IS-LM model, and obtained a view of paradigm shift that our endogenous money IS-LM model can successfully explain macroeconomic behaviors such as the Great Depression and the Japan's lost 30 years as typical macroeconomic behaviors. However, this Keynesian approach has so far entirely neglected neoclassical long-run view of macroeconomics described by three equations (9.8), (9.9) and (9.11) in the simple long-run macroeconomic model.

Now is the time to expand our macroeconomic analysis to the long run model. What is long-run, then, vis-*à*-vis short-run? From a dynamic flow of time, it's very hard to specify how short is a short run, and how long is a long-run. Are we, at this moment, in the short run or in the long run? It depends on when our starting time is specified. This moment could be in the short run to apply Keynesian policies. Or it could be already in the long run.

To avoid such ambiguities, let us define short-run and long-run according to Table 11.1. Short-run is a period in which capital is fixed, and output is produced only by labor. That is, aggregate demand AD determines output and income Y, which determines only the demand for labor L necessary to produce the output. The employed labor does not guarantees full employment. In the short run, price could be fixed, or affected by the inventory gap between desired and current inventories defined in equation (9.55) in Chapter 9. On the other hand, long-run is defined as a period in which capital accumulation takes place and potential production capacity changes; specifically, the period in which capital accumulation of equation (9.8) and production function (9.9) are applied. In the long run, furthermore, price becomes fully flexible due to the

Short-Run	Long-Run
Capital is Fixed $Y = F(\bar{K}, L)$	Capital Accumulates $Y = F(K, L)$
Fixed Price or Flexible Price due to · Inventory Gap	Flexible Price due to · GDP Gap · Inventory Gap

Table 11.1: Definition of Short-run vs Long-run

GDP gap (defined below) and inventory gap. This is our definition of short-run and long-run. Previous two chapters are devoted to the analysis of short-run behaviors. In this chapter long-run macroeconomic behaviors are analyzed.

Endogenous Money Long Run IS-LM Model

As listed in the appendix of the previous chapter, endogenous money IS-LM model consists of 20 equations, (10.47) through (10.66), and 14 parameters. Let us now bring long-run equations of capital accumulation and price adjustment into the list of this endogenous money IS-LM model. Specifically, three long-run equations are to be brought here such as (11.2), (11.3), and (11.4). With the introduction of capital depreciation, disposal income (10.50) must be replaced with the equation (11.1) which is the same as the original equation used in the simple long-run macroeconomic model in Chapter 9. Hence our long-run IS-LM model is expanded to include the following:

$$Y_d = Y - T - \delta K \quad \text{(Disposable Income)} \tag{11.1}$$

$$\frac{dK}{dt} = I - \delta K \quad \text{(Net Capital Accumulation)} \tag{11.2}$$

$$Y_{full} = F(K, L) \quad \text{(Production Function)} \tag{11.3}$$

$$\frac{dP}{dt} = \Psi(Y - Y_{full}) \quad \text{(Flexible Price)} \tag{11.4}$$

Our long-run IS-LM model is complete now. Three equations are newly added to the previous endogenous money IS-LM model with three unknowns: K, Y_{full}[1], and P (P is moved from a parameter to a model variable), and two parameters δ (capital depreciation rate) and L (labor force).

Let us call this expanded model "endogenous money long-run IS-LM model", or simply "long-run IS-LM model" with the understanding that money is implicitly assumed to be endogenously created and destructed in the model without any confusion from now on. To summarize, the long-run IS-LM model consists of the following 23 equations; (10.47) through (10.49), (11.1), (10.51) through

[1] Note that these two variables now have real units here.

(10.66), (11.2) through (11.4), with 23 unknowns such that

$$Y, AD, C, I, G, Y_d, T, i, r, L^d, S, I_H, W + \Pi, I_P,$$
$$\Delta D_H, \Delta D_P, \Delta D_G, \Delta LF, \Delta M^s, M^s, K, Y_{full}, P$$

and 15 exogenously determined parameters:

$$C_0,\ c,\ T_0,\ t,\ T_r,\ I_0,\ \bar{G},\ V,\ \alpha,\ a,\ b,\ \pi^e,\ \bar{I}_H,\ \delta,\ L$$

11.2 Building the ASD Long-Run IS-LM Model

Production Function

The mathematical long-run IS-LM model presented above is now transformed into the ASD model. To do so, we simply specify the production function in equation (11.3) as follows:

$$Y_{full} = e^{\kappa t}\frac{1}{\theta}K \tag{11.5}$$

where κ is an annual increase rate of technological progress, and θ is a capital-output ratio. Furthermore, for simplicity, labor force L is not considered in this model.[2]

With the introduction of production function, income Y or GDP in equation (9.20) has to be revised as follows.

$$Y = \mathrm{Min}(Y_{full},\ Y^D) \tag{11.6}$$

where the desired production Y^D is defined in equation (9.19). Let us define the difference between Y_{full} and Y^D as "GDP Gap". Then, full capacity equilibrium $Y_{full} = Y$ is attained when GDP Gap becomes zero:

$$\text{GDP Gap} \equiv Y_{full} - Y = 0 \text{ (Full Capacity Equilibrium)}^3 \tag{11.7}$$

For the unified analysis of disequilibria, let us introduce ratios of GDP Gap and Inventory Gap as follows.

$$\text{GDP Gap ratio} = \frac{Y_{full} - Y}{Y_{full}} \tag{11.8}$$

$$\text{Inventory Gap ratio} = \frac{I^*_{nv} - I_{nv}}{I^*_{nv}} \tag{11.9}$$

The production process of GDP in our ASD model is illustrated in Figure 11.1.

[2]Labor is still important factor of production. Here we simply assume that output is determined only by the existing capital, and labor is flexibly employed to attain this output level as if our economy is self-employed market economy, not capitalist economy with labor market.

[3]Note that when $Y^D > Y_{full}$, our economy is running beyond full capacity. Yet GDP Gap becomes zero according to our definition, and this excess demand state is regarded as an equilibrium state. When price is flexible in the long run, this excess demand over capacity surely causes price to increase.

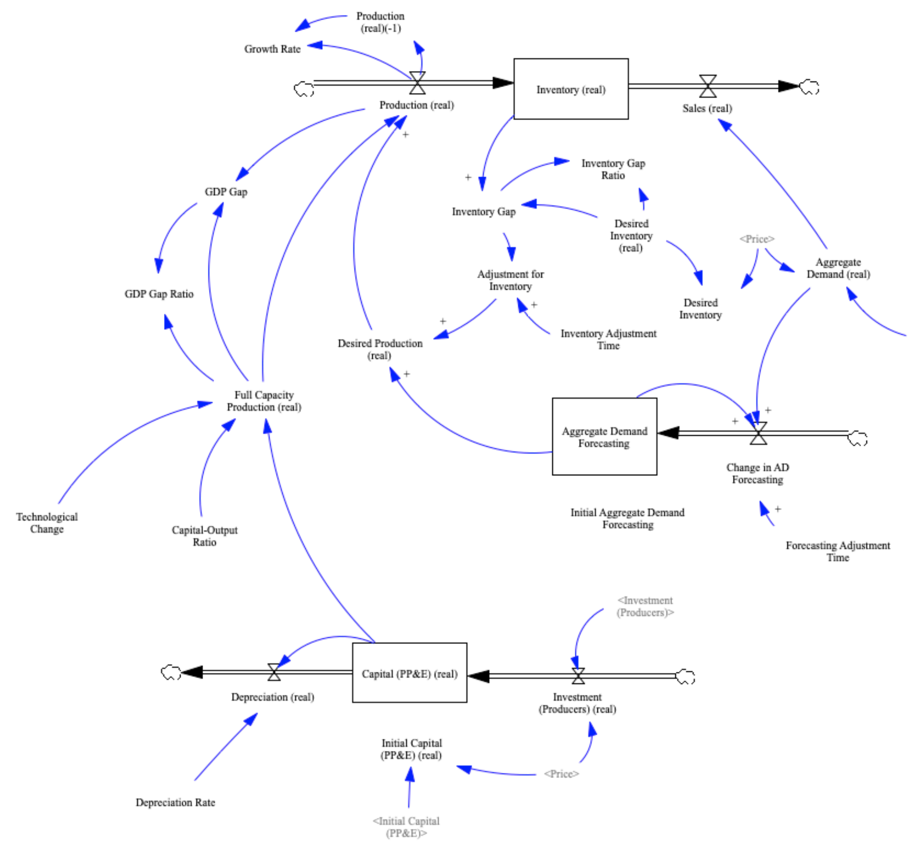

Figure 11.1: Full Capacity Production

Price Adjustment Mechanism

To attain the long-run equilibrium, price is made flexible by introducing equation (11.4). To reflect the GDP gap, Y in the equation must be further replaced with the desired production Y^D such that

$$\frac{dP}{dt} = \Psi(Y^D - Y_{full}). \tag{11.10}$$

In the short-run IS-LM model price adjustment is defined as equation (9.55) to reflect the behaviors of inventory gap.

Hence, we have assumed that price must be made flexible in the long run with the combination of discrepancies between Y^D and Y_{full} (GDP gap) and inventory I_{nv} and its desired inventory I^*_{nv} (inventory gap). That is, our new price adjustment mechanism must be described as

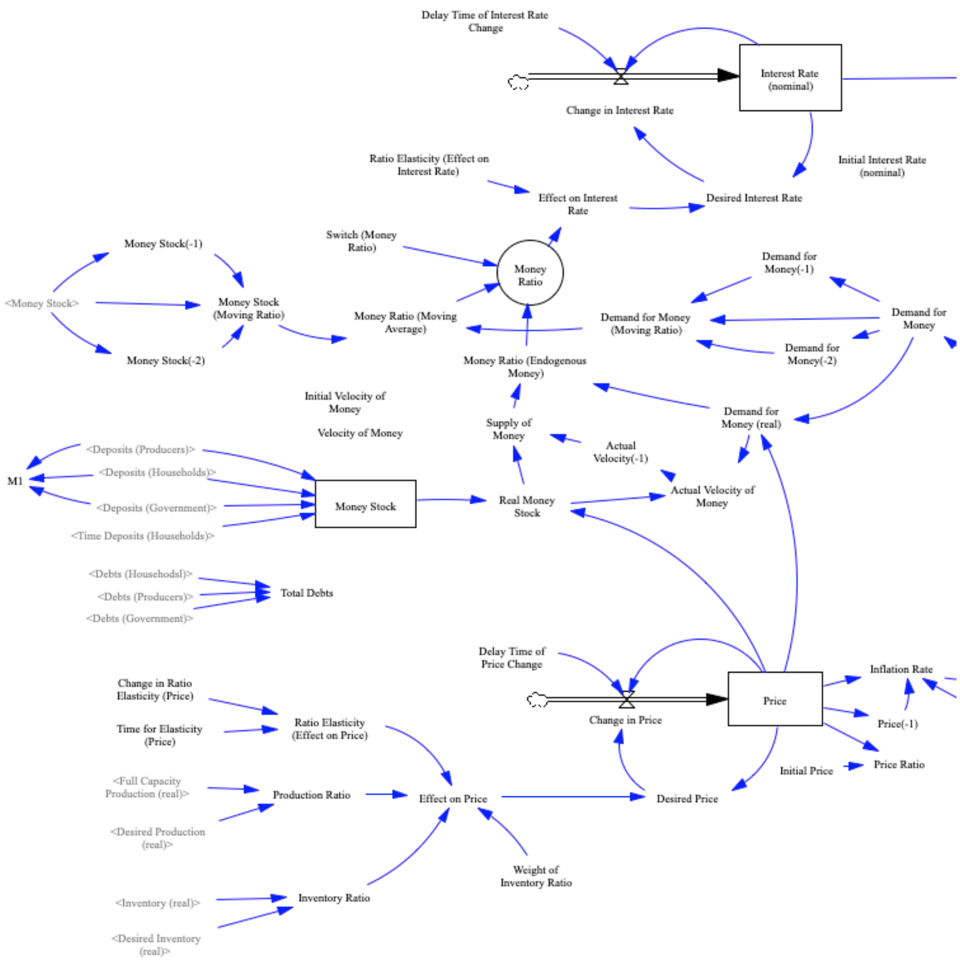

Figure 11.2: Price and Interest Rate Adjustment Processes

$$\frac{dP}{dt} = \Psi(Y^D - Y_{full},\ I^*_{nv} - I_{nv}). \tag{11.11}$$

Let us specify this equation, as in the price equation (9.56), as follows:

$$\frac{dP}{dt} = \frac{P^* - P}{\text{Adjustment Time}} \tag{11.12}$$

in which the desired price P^* is this time calculated as

$$P^* = \frac{P}{\left((1-\omega)\frac{Y_{full}}{Y^D} + \omega\frac{I_{nv}}{I^*_{nv}}\right)^e} \tag{11.13}$$

where $\omega, 0 \leq \omega \leq 1$, is a weight between production and inventory ratios, and e is a desired price elasticity. Figure 11.2 illustrates adjustment processes of price and interest rate.

Revised Consumption Decisions

Consumption is assumed so far to be determined by a constant marginal propensity to consume as expressed in equation (10.49). In the long-run IS-LM model, price is explicitly assumed to be flexible. Accordingly it's appropriate to consider that consumers respond to prices. Specifically, marginal propensity to consume is now assumed to be dependent on a ratio price elasticity of consumption such that

$$c(P) = \frac{c}{\left(\frac{P}{P_0}\right)^e} \tag{11.14}$$

where P_0 is an initial price level and e is a ratio price elasticity of consumption. As a ratio price level goes up, marginal propensity to consume gets smaller. In this way, consumption is affected by the relative size of prices against the initial price and its elasticity. Accordingly, the revised consumption function becomes

$$C(P) = C_0 + c(P)Y_d \tag{11.15}$$

The consumption function thus defined has a feature of a downward-sloping demand function, similar to a demand curve of consumers at a microeconomic level.

Validations of the ASD Model of the IS-LM

Our endogenous money long-run IS-LM model is now complete as [Companion model: 6 IS-LM (long-run).mdl]. Let us now validate the model with the following three validation tests.

(1) Validation of SD Model: Model and Units Check

Built-in model tests performed by the SD simulation software (Vensim) such as "Check Model" and "Units Check" must be all cleared as a legitimate model. Our model have passed both tests. We have pointed out in the previous chapter that the extended IS-LM model with expected inflation presented by Mankiw (2016, Chapter 12) failed this unit check.

(2) Validation of ASD Model: BS and FF Checks

Accounting system requires that balance sheets of all sectors must be in balance. This test is called balance-sheets (B/S) check. Furthermore, the flow-of-funds framework requires that all assets and liabilities (equity) of all transaction items in the model must be in balance across all macroeconomic sectors involved.

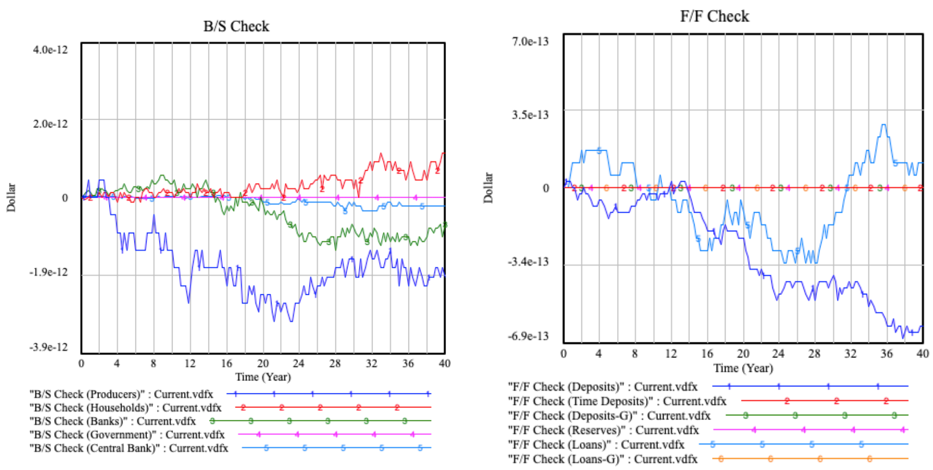

Figure 11.3: Validation (2) - B/S and F/F Checks

This test is called the flow of funds (F/F) check. A left diagram of Figure 11.3 illustrates that, for the Endogenous Money (EM) model, the balance of each sector's balance sheets are almost zero, indicating that the model passes the B/S check for all macroeconomic sectors. The right diagram illustrates that the Flow of Funds are all in balance (almost zero) among transaction items such as deposits, time deposits, reserves, and loans. F/F check on Loanable Fund (LF) model is also confirmed.

(3) Validation of Macroeconomic Model: Debt Money Check

We have mathematically presented in the equation (10.35) that money stock is equal to the total debts under the debt money system. Yamaguchi and Yamaguchi (2021b) reported that, under the current debt money system, the following three relations hold in the Japanese economy between 1980 and 2019 (details are discussed below).

1. Money Stock (M_3) $\simeq$ Total Debts (line 1 $\simeq$ line 2)
2. Time Deposits (M_T) $\simeq$ Private Debts (by Producers and Households) (line 3 $\simeq$ line 4)
3. M_1 (= Currency + Demand Deposits) $\simeq$ Government Debts (line 5 $\simeq$ line 6)

As explained above, Yamaguchi (2021b) found further that the similar relations were observed in the U.S. following the Japanese case. Empirical results show that the first relation must hold in any economy operating under the current debt money system world-wide. Hence, this additional validation test for macroeconomic models is called Debt Money check. Figure 11.4 shows that all

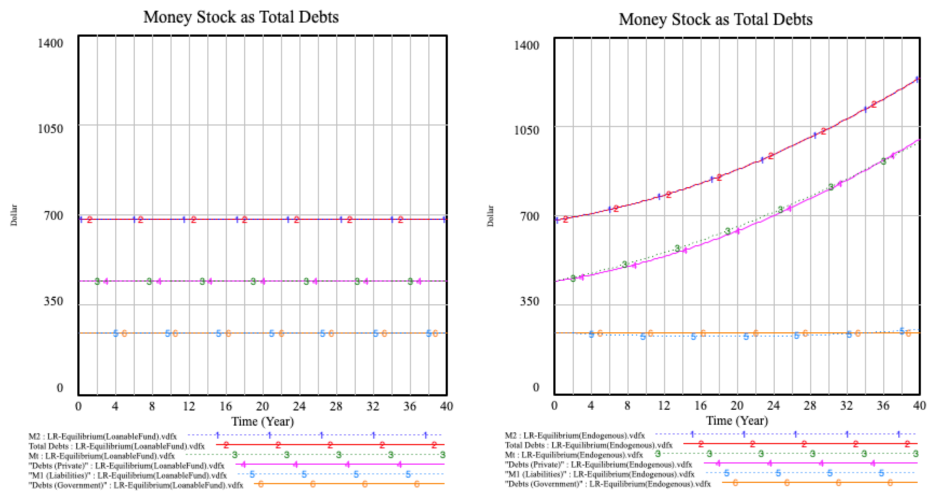

Figure 11.4: Validation (3) - Debt Money Check: Money Stock $\simeq$ Total Debts

three relations of Debt Money Check hold at the equilibrium for the Loanable Fund model (left) and Endogenous Money model (right) in our integrated ASD model of the IS-LM.

The three tests above validate our ASD macroeconomic model as endogenous money long-run IS-LM model. This is one of the most comprehensive macroeconomic model in the sense that macroeconomic controversies between neoclassical and Keynesian schools of economics are uniformly analyzed under the same model only by changing model parameters. So far these controversies have given us an impression that their macroeconomic models are mutually exclusive and cannot be integrated like oil and water. Our ASD approach of macroeconomic model here has finally unified these controversies as if they are just different behaviors caused by the same macroeconomic system structure. Table 11.2 classifies macroeconomic models that have been under controversies so far. Now they are unified as the only ASD macroeconomic model.

	Exogenous Money	Endogenous Money
Short-run - fixprice	Keynesian IS-LM and Loanable Funds model	Endogenou Money IS-LM model
Long-run - growth - flexprice	Neoclassical Growth and Loanable Funds model	ASD Macroeconomic Model (Endogenous Money Long-run IS-LM model)

Table 11.2: Macroeconomic Models Classified

11.3 Behaviors of the Long-Run IS-LM Model

11.3.1 Flexible Price Long-Run Equilibrium

In the long-run price must be flexible. This price flexibility is assumed from the beginning in the model as a default such that Initial Ratio Elasticity (Price)=2. Left diagram of Figure 11.5 demonstrates a long-run equilibrium thus attained; that is, full capacity production (line 1), desired production (line 2) and production (line 3). This long-run equilibrium is attained under another assumption that inventory gap does not affect price fluctuation; that is Weight of Inventory Ratio=0.

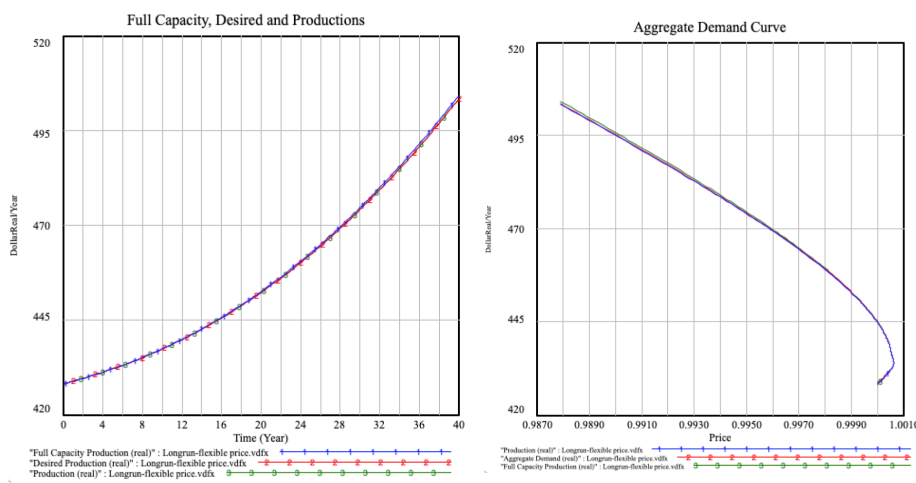

Figure 11.5: Long-run: Flexible Price Equilibria and Aggregate Demand Curves

Aggregate Demand Curve

It is now clear that the Keynesian theory of aggregate demand equilibria is imperfect from a SD model-building point of view, because price level is assumed to be sticky and there exists no built-in mechanism to restore a full capacity production equilibrium unless fiscal policies are carried out as discussed below.

In fact, let us rewrite the simple IS-LM equilibrium of GDP obtained in equation (9.33) as a function of price:

$$Y^*(P) = A + B\frac{M^s}{P}V \tag{11.16}$$

where A and B are combined constant amounts. Then it becomes clear that this equation only provides a relation between Y^* and P. Hence, Y^* is called an aggregate demand function of price. It is obvious that, unless price is flexible, there exists no mechanism to attain a true equilibrium such that

$$Y_{full} = Y^*(P) \tag{11.17}$$

Let us confirm the existence of such aggregate demand function under the above flexible price equilibrium. Right diagram of Figure 11.5 proves the existence of aggregate demand curve (line 2) as well as full capacity (line 1) and production (line 3) curves that are attained under the long-run flexible price equilibria.

11.3.2 Stability of Long-Run Equilibria

Long-run equilibrium attained under price flexibility can be shown to be stable. That is, any outside shocks can be absorbed in the long run as neoclassical theory claims. Let us consider outside shocks of investment increase and decrease such that $\Delta I = \pm 20$ from the initial level of $I = 60$. Left diagram of Figure 11.6 shows how off-equilibria caused by outside shocks of investment increase (lines 1,2,3) and investment decrease (lines 4,5,6) are restored to equilibria in the long run. In a similar way, let us consider off-equilibria caused by outside shocks of MPC (marginal propensity to consume) increase and decrease such that $\Delta mpc = \pm 0.05$ from the initial level of $mpc = 0.6$. Right diagram shows how equilibria are restored from the outside shocks of mpc increasae (lines 1,2,3) and mpc decrease (lines 4,5,6) in the long run.

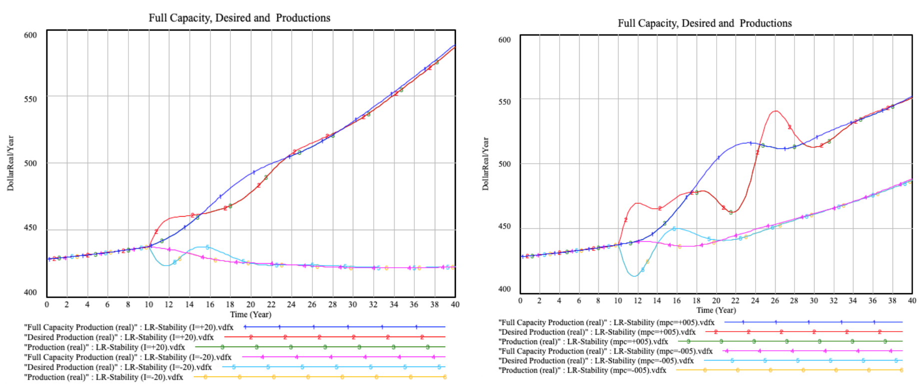

Figure 11.6: Stability of Long Run Equilibria under Flexible Price

In this way, our long-run IS-LM model is able to attain a long-run stability. That is, it can successfully cover neoclassical growth model as well.

11.3.3 Flexible Price Long-Run Disequilibria

Price flexibility does not always guarantee long-run equilibrium if price is partly affected by the inventory gap. Price flexibility is assumed to be obtained by the linear combination of GDP and inventory gaps in equation (11.13). In the above long-run equilibrium case, price is assumed to be only affected by the GDP gap.

Now suppose price is 20% affected by the inventory gap; that is, Weight of Inventory Ratio=0.2. Then, as the right diagram of Figure 11.7 shows, GDP

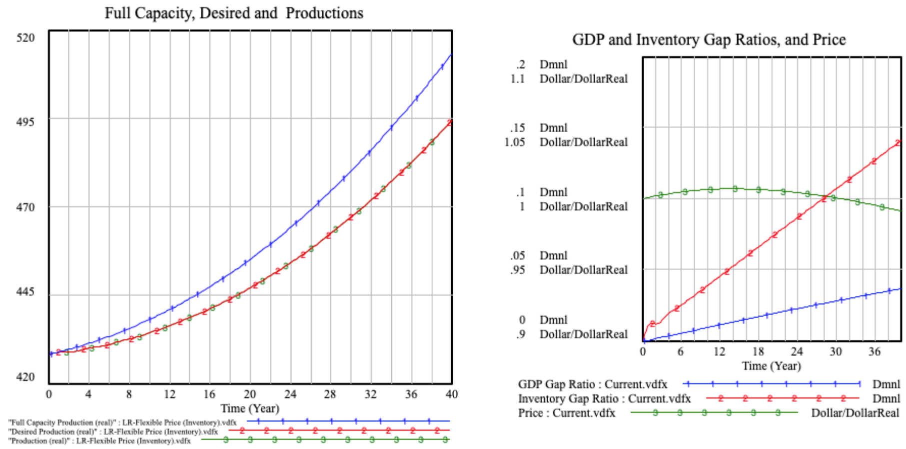

Figure 11.7: Flexible Price Disequilibria caused by Inventory Gap

Gap (line 1) starts to increase. In the left diagram, this disequilibrium is shown as a gap between full capacity production (line 1) and production (line 3) (as well as desired production (line 2)).

This is an unexpected off-equilibrium behavior under price flexibility in the long run. Price flexibility caused by inventory gap can be interpreted partly as short-run price flexibility. Our simulation here indicates that this short-run price flexibility triggers long-run disequilibria. Traditional neoclassical theory seems to have neglected the impact of this short-run price flexibility on the long-run equilibrium.

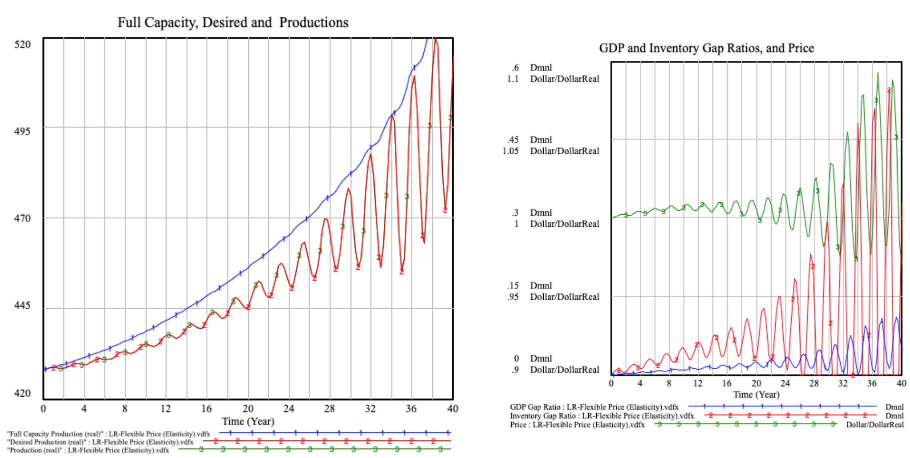

Figure 11.8: Flexible Price Disequilibria fixed by Price Elasticity

If long-run price flexibility cannot exclude the influence of short-run price flexibility caused by the inventory gap, how can we restore the long-run equilibrium? We have tried many simulations to attain it unsuccessfully. As a last resort, we have increased the value of Initial Ratio Elasticity (Price) from 2 to 5. Left diagram of Figure 11.8 illustrates that long-run equilibrium can only be attained cyclically. Right diagram shows that price as well as GDP and inventory gap ratio all fluctuate.

Is it possible, then, to avoid a price fluctuation caused by inventory gap in our real economy? In a real economy, price is affected by a linear combination of inventory gap and GDP gap, and it becomes impossible to separate them one another as a cause of price fluctuation. This implies that our long-run macroeconomic behaviors are destined to produce economic recessions with short-period business cycles. If this is the real case, our long-run IS-LM model demonstrates for the first time in macroeconomics, to the best of our knowledge, that business cycles are normal behaviors of the economy in the long run. In other words, long-run equilibrium is an illusion of neoclassical theory. This is an unexpected finding in this chapter.

A Remark on Public Money as Exogenous Money

Business cycles of this type may not be avoided even under the public money. Yet if labor market is not linked with full capacity production, no problem of unemployment occurs under public money. Unemployment is an issue of capitalism, linked with recessions, under debt money.

11.3.4 Fixprice Disequilibria

One of the core views of the Keynesian theory is that "aggregate demand creates it own income (or GDP)" against the classical view that "supply creates its own demand". We have so far demonstrated that this Keynesian view holds only under the endogenous money in the short-run. Hence, our concern here is that whether this Keynesian view still holds in the long run in which capital accumulation takes place and production capacity grows exponentially along with technological progress. In other words, we are interested in examining if our macroeconomy has a built-in mechanism of creating the aggregate demand that incessantly catches up with production capacity.

Left diagram of Figure 11.9 illustrates long-run behaviors of production when price is fixed; that is, Initial Ratio Elasticity (Price)=0. Right diagram indicates that GDP gap ratio (line 1) begins to increase at t=21. Beyond the year t=21, full capacity production (line 1 in the left diagam) begins to grow faster than desired production (line 2) and production (line 3). We have tried to find out a long-run equilibrium under fixprice condition by manipulating all possible combinations of parameter values unsuccessfully. This implies that desired production (and aggregate demand) fails to catch up with the full capacity production level under fixprice in the long run

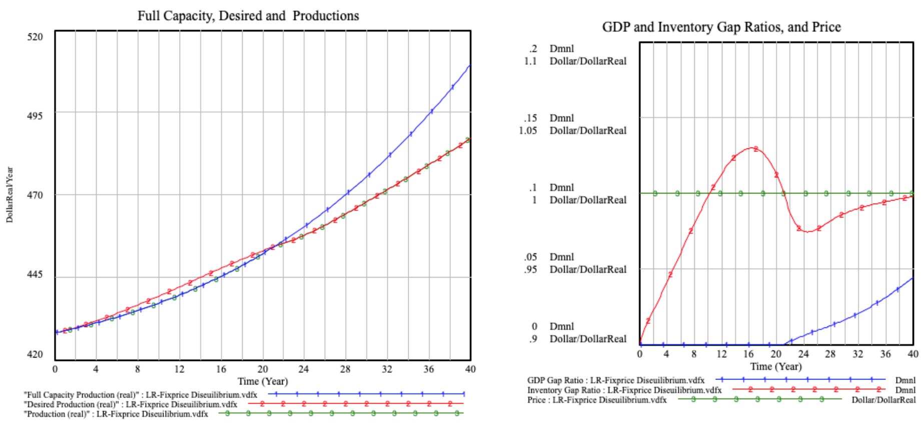

Figure 11.9: Long-run: Fixprice Disequilibria with GDP gap

Fiscal Policy for fixing Fixprice Disequilibria

Faced with this short-run disequilibrium caused by fixprice disequilibrium, let us now introduce Keynesian fiscal stimulus policy to see if it can overcome this built-in recession under fixprice. Specifically, let us introduce an increase in government spending of 4 (billion) dollars at t=21. As a result, Figure 11.10 shows that GDP gap is now eliminated (line 1 in the right diagram)[4] and we can again attain full capacity output level; that is, line 1 = line 3 in the left diagram. To be precise, it is observed in the left diagram that desired production (line

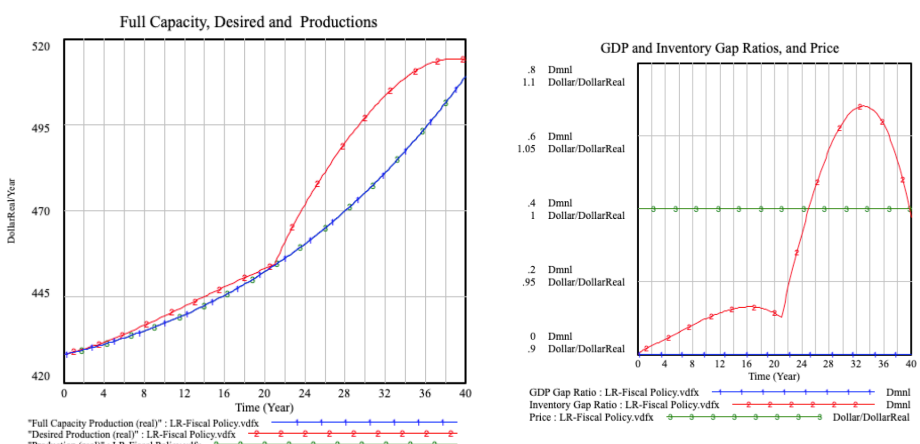

Figure 11.10: Long-run: Fiscal Policy

2) overshoots full capacity production (line 1), and production is constrained

[4]Note that the scale of Inventory Gap Ratio is increased "between 0 and 0.8" in this diagram, compared with "between 0 and 0.2" in Figure 11.9.

by the smaller amount of full capacity output. As a result, inventory gap ratio jumps (widens) as illustrated by line 2 in the right diagram, because inventory decreases due to the increase in aggregate demand by the increase in government expenditure. Remember we have defined this case as equilibrium in equation (11.7).

In this way Keynesian fiscal policy is shown to attain a long-run equilibrium under fixprice. But this fiscal policy is not without price. First, it triggers the accumulated government debts as Figure 11.11 indicates (line 2). This becomes a side effect of fiscal policy which mainstream macroeconomic models have neglected. To be precise, they failed to produce this behavior of accumulating government debts due to their modeling limitation.

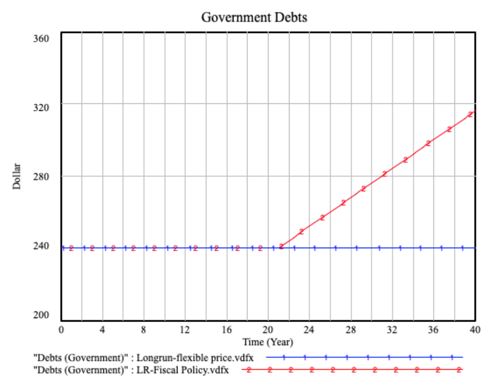

Figure 11.11: Accumulated Debts

11.3.5 Japan's Lost 30 Years Revisited

So far we have demonstrated macroeconomic behaviors of endogenous money long-run IS-LM model that incorporates macroeconomic features of long-run and endogenous money. In this sense, this ASD model could be our standard macroeconomic model under a new paradigm shift in macroeconomics. Our final question here is if this standard model can reproduce structurally similar behaviors of Japan's lost 30 years as well as the Great Depression as we did in the previous chapter. Demonstration of the Great Depression is relatively easy and left to the reader. Here we try to reproduce Japan's lost 30 years.

We have managed to reproduce Japan's lost 30 years qualitatively by manipulating parameter values as follows. $\Delta C_0 = -20$ at t=12, $\Delta I_0 = -60$ at t=10, $\Delta I_H = -10$ at t=16, $\Delta G = 6$ at t=11, and Price Elasticity of Consumption = 3 (from 2). Starting time is set to be 1980.

Left diagram of Figure 11.12 illustrates the behaviors of Japan's lost 30 years whichi the same as Figure 10.19 in the previous chapter. Right diagram shows behaviors thus obtained here. These two diagrams look qualitatively very similar to one another, though variable scales are different. In this way we have demonstrated here again the behaviors of Japan's lost 30 years (as well as the Great Depression) in the endogenous money long-run IS-LM model.

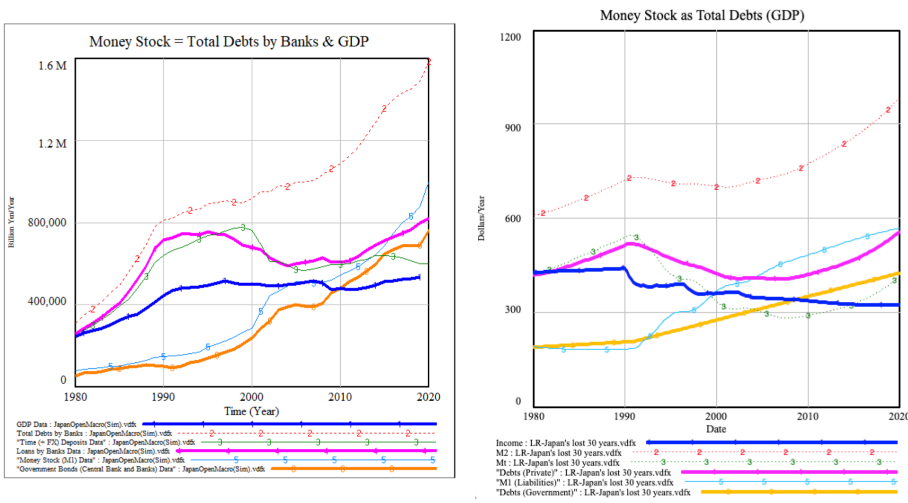

Figure 11.12: Japan's Lost 30 Years

11.4 Conclusion

This is the last chapter of our trilogies of IS-LM analysis. In Chapter 9, we have presented Keynesian short-run IS-LM model as mathematical model of equations and SD model of simulation. In Chapter 10, we have expanded the Keynesian short-run IS-LM model by incorporation budget equations of all macroeconomic sectors, as mathematical model and ASD (accounting system dynamics) model. Finally in this chapter we have further expanded the endogenous money short-run IS-LM model to the long-run IS-LM model by incorporating production function and potential capacity of output.

In this trilogies two historical events of economic recessions such as the Great Depression in 1929 and Japan's lost 30 years in 1990 through 2020 have been examined. And in this chapter we have reconfirmed that our long-run IS-LM model can handle the behaviors of these events successfully. In conclusion, our macroeconomic IS-LM models presented in this trilogy chapters could be new standard macroeconomic foundations in the sense of ASD modeling framework and endogenous money approach to the current debt money system. This is our paradigm shift in macroeconomics.

Appendix: Endogenous Money Long Run IS-LM Model

$$
\begin{aligned}
Y &= AD && \text{(Aggregate Demand Equilibrium)} && (11.18)\\
AD &= C + I + G && \text{(Aggregate Demand)} && (11.19)\\
C &= C_0 + cY_d && \text{(Consumption Decisions)} && (11.20)\\
Y_d &= Y - T - \delta K && \text{(Disposable Income)} && (11.21)\\
T &= T_0 + tY - T_r && \text{(Tax Revenues)} && (11.22)\\
I &= \frac{I_0}{r} - \alpha r && \text{(Investment Decisions)} && (11.23)\\
G &= \bar{G} && \text{(Government Expenditures)} && (11.24)\\
\frac{M^s}{P}V &= L^d && \text{(Equilibrium of Money)} && (11.25)\\
L^d &= aY - bi && \text{(Demand for Money)} && (11.26)\\
r &= i - \pi^e && \text{(Fisher Equation)} && (11.27)
\end{aligned}
$$

$$
\begin{aligned}
\frac{dK}{dt} &= I - \delta K && \text{(Net Capital Accumulation)} && (11.28)\\
Y_{full} &= F(K, L) && \text{(Production Function)} && (11.29)\\
\frac{dP}{dt} &= \Psi(Y - Y_{full}) && \text{(Flexible Price)} && (11.30)
\end{aligned}
$$

$$
\begin{aligned}
PC + PT + PI_H + S &= W + \Pi + \Delta D_H && \text{(Households Budgets)} && (11.31)\\
W + \Pi &= PY && \text{(Distributed Income)} && (11.32)\\
PI_H &= \Delta D_H && \text{(Housing Budgets)} && (11.33)\\
I_H &= \bar{I}_H && \text{(Housing Investment)} && (11.34)\\
W + \Pi + PI_P &= PY + \Delta D_P && \text{(Producers Budgets)} && (11.35)\\
I_H + I_P &= I && \text{(Private Investment)} && (11.36)\\
PG &= PT + \Delta D_G && \text{(Government Budget)} && (11.37)\\
\Delta D_H + \Delta D_P + \Delta D_G &= \Delta LF && \text{(Loanable Funds of Debts)} && (11.38)
\end{aligned}
$$

$$
\begin{aligned}
(\Delta LF &= S\ ) && \text{(Savings as Loanable Funds by Banks)}\\
\Delta LF &= \Delta M^s && \text{(Endogenous Deposits Creation)} && (11.39)\\
M^s &= \int \Delta M^s dt && \text{(Endogenous Money Stock)} && (11.40)
\end{aligned}
$$

The endogenous money short-run IS-LM model consists of the above 23 equations with 23 unknowns such that

$$Y, AD, C, I, G, Y_d, T, i, r, L^d, S, I_H, W + \Pi, I_P,$$

$$\Delta D_H, \Delta D_P, \Delta D_G, \Delta LF, \Delta M^s, M^s, K, Y_{full}, P$$

and 15 exogenously determined parameters:

$$C_0,\ c,\ T_0,\ t,\ T_r,\ I_0,\ \bar{G},\ V,\ \alpha,\ a,\ b,\ \pi^e,\ \bar{I}_H,\ \delta,\ L$$

Part IV

Macroeconomic Systems of Debt Money

Chapter 12

A Macroeconomic System

In the previous three chapters, monetary and real parts of macroeconomies are built separately. In this chapter[1], these three separate models are integrated to present a complete macroeconomic dynamic model consisting of real and monetary parts of macroeconomies. The integrated model is aimed to be generic, out of which diverse macroeconomic behaviors are shown to emerge. Specifically equilibrium growth path, business cycles and government debt issues are discussed in this chapter.

12.1 Macroeconomic System Overview

This chapter tries to integrate real and monetary parts of the macroeconomy that have been so far analyzed separately in the previous chapters [Companion model: Nominal GDP.vpmx]. For this purpose, at least five sectors of the macroeconomy have to play macroeconomic activities simultaneously; that is, producers, consumers, banks, government and central bank. Figure 12.1 illustrates the overview of a macroeconomic system in this chapter, and shows how these macroeconomic sectors interact with one another and exchange goods and services for money. Foreign sector is still excluded from the current analysis.

The reader will be reminded that the integrated model to be developed in this chapter is a generic one by its nature, and does not intend to deal with some specific issues our macroeconomy is currently facing. Once such a generic macroeconomic model is built, we believe, any specific macroeconomic issue could be challenged by bringing real data in concern to this generic model without major structural changes in this integrated model.

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[1]This chapter is partly based on the paper: Integration of Real and Monetary Sectors with Labor Market – SD Macroeconomic Modeling (3) – in "Proceedings of the 24th International Conference of the System Dynamics Society", Nijmegen, The Netherlands, July 23 - 27, 2006. (ISBN 978-0-9745329-5-0)

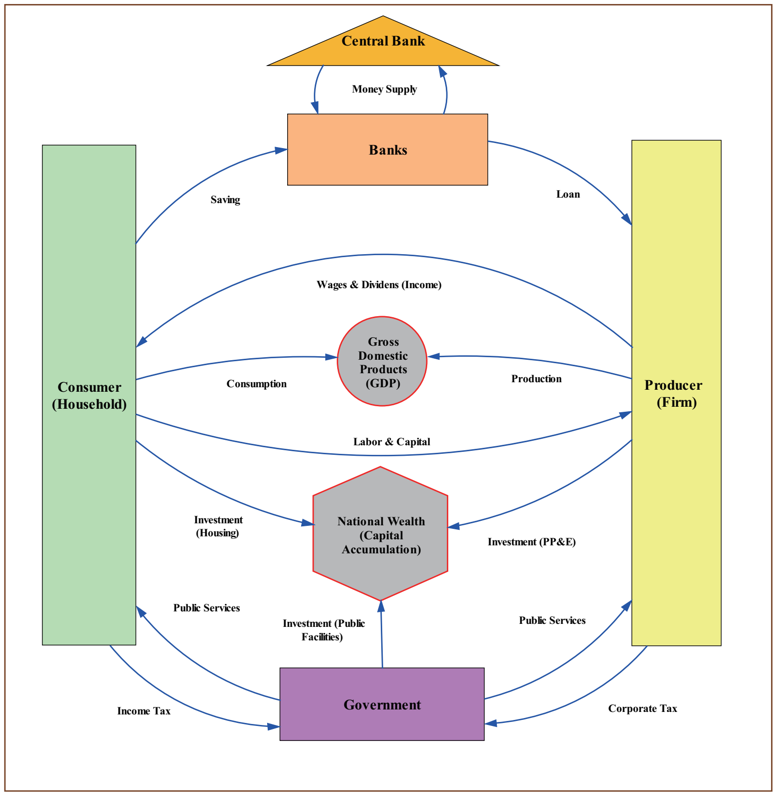

Figure 12.1: Macroeconomic System Overview

12.2 Changes for Integration

Let us now start by explaining some major changes made to the previous models in order to integrate them.

Nominal and Real Units

In the previous models, all macroeconomic variables are assumed to have a dollar unit without specifically distinguishing nominal and real terms. In other words, GDP and other variables in the real sector of the previous model are implicitly interpreted as having real value of dollar.

In the integrated model of real and monetary sectors, variables in real production sector such as output and capital stock must have physical unit (which is specified as DollarReal in this chapter), while all market transactions among all sectors are made in terms of nominal unit of money; that is, Dollar. To convert a physical unit to a monetary unit for transactions between real and monetary sectors, price P is used that has a unit of Dollar/DollarReal.

Nominal and Real Interest Rates

With the introduction of real and nominal terms, interest rate introduced in the previous chapter has also to be reinterpreted as a real interest rate, meanwhile interest rate used for market transactions has to be nominal. The relationship between these two interest rates are shown by the following relation[2].

$$\text{Nominal interest rate} = \text{Real interest rate} + \text{Inflation rate} \tag{12.1}$$

Investment Order Placement and Delay

To reflect the fact that investment process takes time, a capital stock under construction is newly added to the capital accumulation process. That is, new investment is accumulated to the capital stock under construction, out of which capital stock (property, plant & equipment) is accumulated after a completion of capital under construction. This revision is illustrated in Figure 12.2.

Investment Function

The amount of desired investment is obtained as the difference between desired and actual capital stock plus depreciation such that

$$I(i) = \frac{K^*(i) - K}{\textit{Time to Adjust Capital}} + \delta K \tag{12.2}$$

where δ is a depreciation rate. Desired capital stock could be approximated by

$$K^* = \frac{\alpha(1-t)Y^*}{i+\delta} \tag{12.3}$$

where α is exponent on capital, and t is excise tax rate[3]. Furthermore, desired output Y^* is represented by the variable: Aggregate Demand Forecasting (Long-run) as illustrated in Figure 12.2.

The new investment function obtained above replaces our previous investment function that is determined by the interest rate:

$$I(i) = \frac{I_0}{i} - ai \tag{12.4}$$

where a was defined there as an interest sensitivity of investment. Surely, our model is open to any type of investment function which the reader considers to be more appropriate.

---

[2]This formulation is the so-called Fisher effect; to be precise, nominal rate of interest is the sum of real interest, inflation rate and their cross product. See (Yamaguchi, 1988, pp. 320-323) for the detailed discussion on the real rate of interest in relation with the uniform rate of profit.

[3]For the derivation of this equation, see the section of production function in the next chapter.

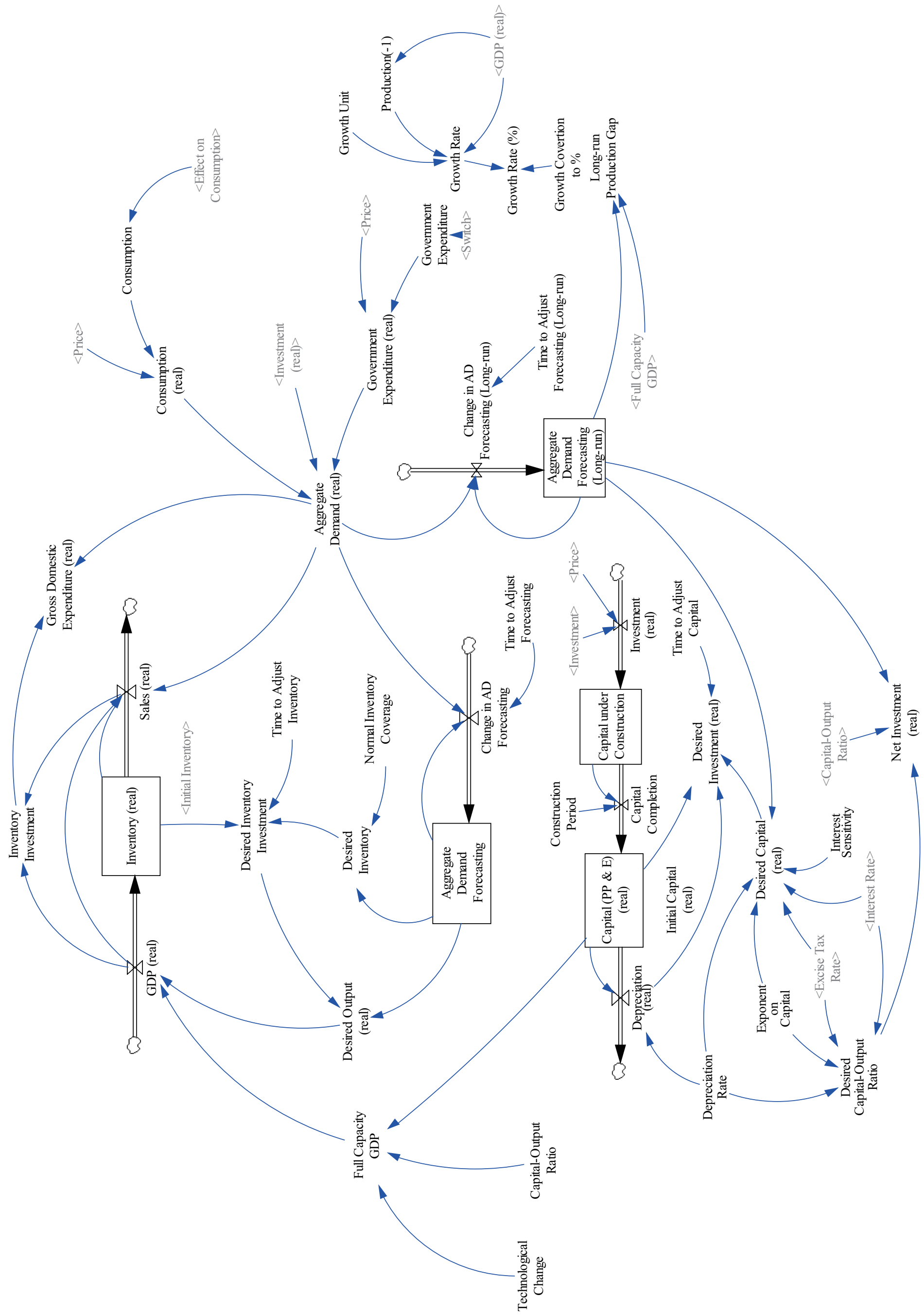

Figure 12.2: Real Production of GDP

Consumption Function

In the previous model, consumption is assumed to be determined by a constant marginal propensity to consume as expressed in equation (9.3). Now that nominal price is explicitly used in the integrated model, it's appropriate to consider that consumers respond to a price level. Specifically, marginal propensity to consume is now assumed to be dependent on a relative price elasticity of consumption such that

$$c(P) = \frac{c}{\left(\frac{P}{P_0}\right)^e} \tag{12.5}$$

where P_0 is an initial price level and e is a relative price elasticity of consumption. As a relative price level goes up, marginal propensity to consume gets smaller. In this way, consumption is affected by the relative size of prices and its elasticity.

Accordingly, the revised consumption function becomes

$$C(P) = C_0 + c(P)Y_d \tag{12.6}$$

The consumption function thus defined has a feature of a downward-sloping demand function, similar to a demand curve of consumers at a microeconomic level.

Money Stock and Demand for Money

The integrated model here intends to be a complete system of macroeconomy, and money stock and demand for money have to be sought *within the system itself*. This revision is partly made in the previous chapter under the section of "A Comprehensive IS-LM Model".

Let us consider money stock first. In the previous model it is treated as exogenously fixed parameter, because there exists no mechanism to change money stock within the system. With the introduction of the central bank, money stock is now created within the system. It is here defined as follows[4]:

$$\text{Money Stock} = \text{Currency in Circulation} + \text{Deposits} \tag{12.7}$$

Currency in circulation may be represented by the sum of cash stocks held by consumers, producers, government and banks, while deposits are the amount of money consumers deposit with banks. For instance, whenever consumers purchase consumption goods from producers, the ownership of money changes hands from consumers to producers, and in the model this movement is represented as a decrease in consumers' stock of cash and a simultaneous increase in producers' stock of cash. In this way currency in circulation keeps moving among the cash stocks of consumers, producers, government and banks, decreasing one cash stock and increasing another cash stock simultaneously.

[4]In our simple model, it may not be needed to classify monetary aggregates further into M1, M2 and M3.

On the other hand, demand for money consists of three motives: transaction, precautionary and speculative motives, according to the standard textbooks such as Hall and Taylor (1997). In our previous IS-LM model (equation (9.40)), real demand for money is formalized as consisting of transaction motives and speculative motives. Money demanded for market transactions in our integrated model is nothing but cash outflows by consumers, producers, government and banks. Consumers need cash to buy consumption goods, and producers need cash to make investment. And these needs for transaction have to be met out of their cash stocks.

As to a speculative motive, demand for cash is assumed to move back and forth freely between deposits and cash stocks of consumers to maintain a certain level of currency ratio (= Cash / Deposits).

$$\text{Cash Demand} = \frac{\text{Currency Ratio * Deposits - Cash}}{\text{Cashing Time}} \tag{12.8}$$

Currency ratio in turn is assumed to be determined by nominal interest rate. Specifically, whenever nominal interest rate drops, currency ratio tends to rise so that consumers increase their demand for cash. As an extreme case if nominal interest rate drops to the level of a so-called liquidity trap (almost close to zero per cent in late 1990s in Japan), currency ratio is assumed to become one so that no deposits are made. In this way, speculative demand for cash is made dependent on the nominal interest rate in the model.

Demand for money (nominal) thus interpreted has a unit of dollar/year, while money stock as a stock of cash has a unit of dollar. Therefore, money stock has to be multiplied by its velocity that has a unit 1/year, to secure unit equivalence in SD model as already formalized in the equation (**??**)[5].

Figure 12.3 illustrates our revised model of money supply and demand for money. It also shows adjustment processes of real interest rate and price level, which is already discussed in the section of a comprehensive IS-LM model in the previous chapter.

Discount Loans by the Central Bank

In this integrated model, banks are assumed to make loans to producers as much as desired so long as their vault cash is available. Thus, they are persistently in a state of shortage of cash as well as producers. In the case of producers, they could borrow enough fund from banks. From whom, then, should the banks borrow in case of cash shortage?

In a closed economic system, money or currency has to be created within the system. Under the current financial system, only the central bank is endowed with a power to create currency within the system, and make loans to the

[5]This part of treatment for demand and supply of money corresponds to the Quantity Equation:

$$\text{Money (M) * Velocity (V) = Price (P) * Transaction (T),}$$

where V is called transaction velocity of money in (Mankiw, 2016, p. 82).

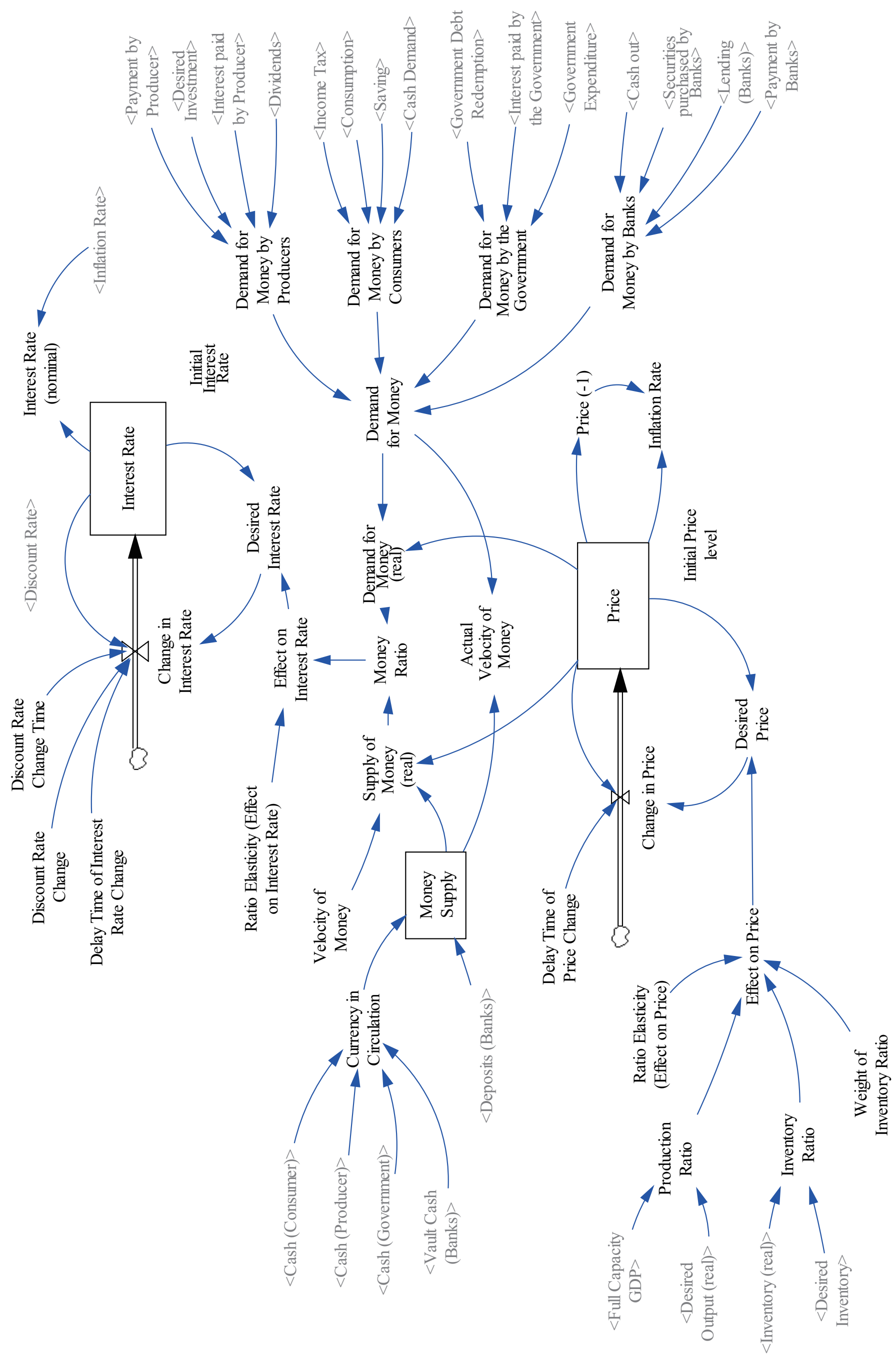

Figure 12.3: Interest Rate and Price Adjustments

commercial banks as a last resort of currency provider to avoid bankruptcies of the whole economic system. This process of lending money by creating (or printing) currency is known as *money out of nothing*.

Figure 12.4 indicates unconditional amount of annual discount loans and its growth rate by the central bank at the request of desired borrowing by banks. In other words, currency has to be incessantly created and put into circulation in order to sustain an economic growth under mostly equilibrium states. Roughly speaking, a growth rate of credit creation has to be in average equal to or slightly greater than the economic growth rate as suggested by the right hand diagram of Figure 12.4.

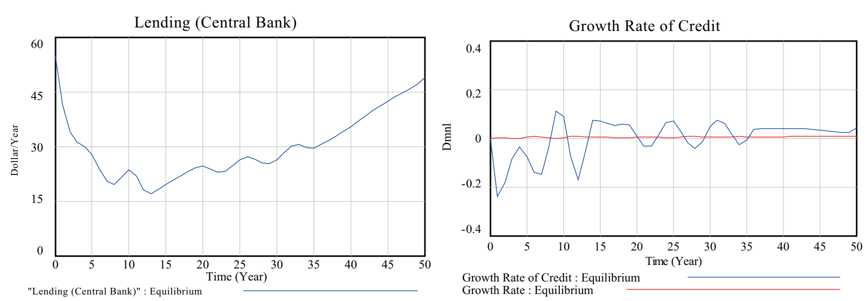

Figure 12.4: Lending by the Central Bank and its Growth Rate

In this way, the central bank begins to exert an enormous power over the economy through its credit control. What happens if the central bank fails to supply enough currency intentionally or unintentionally? An influential role of the central bank which caused economic bubbles and the following burst in Japan during 1990's was completely analyzed by Warner in Werner (2003, 2005). Our macroeconomic model might provide an analytical foundation to support his findings in the role of the central bank.

Four Types of Interest Rates

Due to the introduction of the central bank a fraction of bank deposits have to be reserved as required reserve with the central bank. This is called *a fractional reserve banking system*. Accordingly, the amount of loans banks can make to producers becomes less than that of deposits by consumers, and, if the same interest rate is applied as in the previous model, their interest income from loans becomes less than their interest payment against deposits. To avoid this negatively retained earnings of the banks, a higher interest rate has to be applied to the loans, which is already called *a prime rate* in Chapter 7.

$$\text{Prime rate} > \text{Nominal interest rate} \tag{12.9}$$

The difference between these two interest rates is made large enough to avoid negatively retained earnings of banks. Moreover, it is assumed here that positive earnings, if any, will be completely distributed among bank workers as consumers.

With the introduction of credit loan by the central bank, another type of interest rate needs to be applied to the transaction, which is called *a discount rate* in Chapter 7. The central bank is given a power to set its rate as a part of its monetary policies whenever making loans to commercial banks. It is set to be 0.8%, or 0.008 in our model.

Now the economy has four different types of interest rates; discount rate, real rate of interest, nominal rate of interest, and prime rate[6]. How are they related one another? It is assumed that the initial value of the real rate of interest (which is set to be 0.02 in our model) is increased by the amount of discount rate such that

$$\text{Initial interest value} = \text{initial interest rate} + \text{discount rate} \tag{12.10}$$

Nominal rate of interest and prime rate are assumed to be determined in our previous models as

$$\text{Interest rate (nominal)} = \text{real interest rate} + \text{inflation rate} \tag{12.11}$$

and

$$\text{Prime rate} = \text{interest rate (nominal)} + \text{prime rate premium}, \tag{12.12}$$

where prime rate premium is set to be 0.03 in our model to attain positive profits to the banks. Accordingly, discount rate affect all of the other three types of interest rate, giving a legitimacy of monetary policies to the central bank.

12.3 Transactions Among Five Sectors

Let us now describe some transactions by the central bank that is additionally brought to the model here. For the convenience to the reader, let us also repeat some of the transactions, with some revisions, by producers, consumers, government and banks that were already presented in the previous chapters.

Producers

Major transactions of producers are, as illustrated in Figure 12.5, summarized as follows.

- Out of the GDP revenues producers pay excise tax, deduct the amount of depreciation, and pay wages to workers (consumers) and interests to the banks. The remaining revenues become profits before tax.

[6]To be precise, an overnight rate needs to be added, which is called a federal fund rate in the United States, or a call rate in Japan. It is the interest rate applied to the loans of reserved fund at the central bank by commercial banks. Current monetary policy is said to use this rate as a target rate so that it could influence all the other interest rates. In this model, it is represented by the discount rate for simplicity.

- They pay corporate tax to the government out of the profits before tax.
- The remaining profits after tax are paid to the owners (that is, consumers) as dividends.
- Producers are thus constantly in a state of cash flow deficits. To continue new investment, therefore, they have to borrow money from banks and pay interest to the banks.

Consumers

Transactions of consumers are illustrated in Figure 12.6, some of which are summarized as follows.

- Consumers receive income as wages and dividends from producers.
- Financial assets of consumers consist of bank deposits and government securities, against which they receive financial income of interests from banks and government. (In this chapter, no corporate shares are assumed to be held by consumers).
- In addition to the income such as wages, interests, and dividends, consumers receive cash whenever previous securities are partly redeemed annually by the government.
- Out of these cash income as a whole, consumers pay income taxes, and the remaining income becomes their disposal income.
- Out of their disposal income, they spend on consumption. The remaining amount are either saved or spent to purchase government securities.

Government

Transactions of the government are illustrated in Figure 12.7, some of which are summarized as follows.

- Government receives, as tax revenues, income taxes from consumers and corporate taxes from producers as well as excise tax on production.
- Government spending consists of government expenditures and payments to the consumers for its partial debt redemption and interests against its securities.
- Government expenditures are assumed to be endogenously determined by either the growth-dependent expenditures or tax revenue-dependent expenditures.
- If spending exceeds tax revenues, government has to borrow cash from banks and consumers by newly issuing government securities.

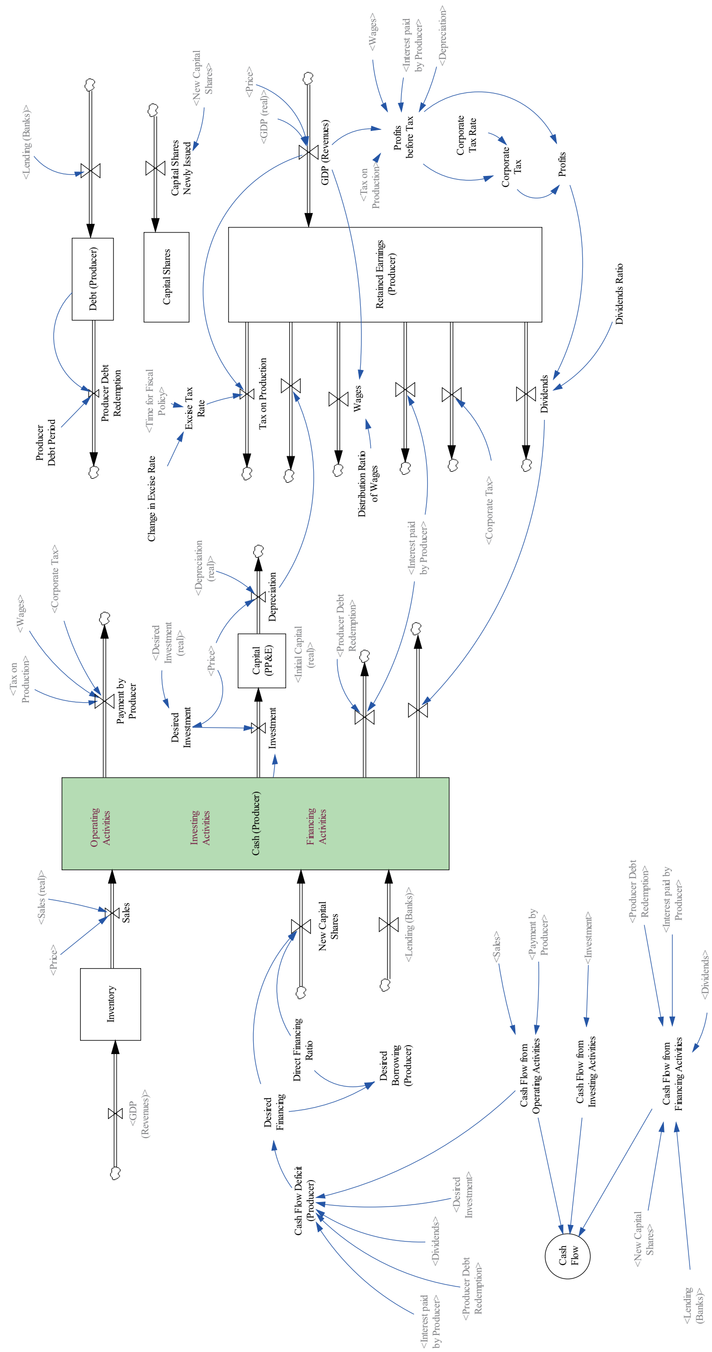

Figure 12.5: Transactions of Producers

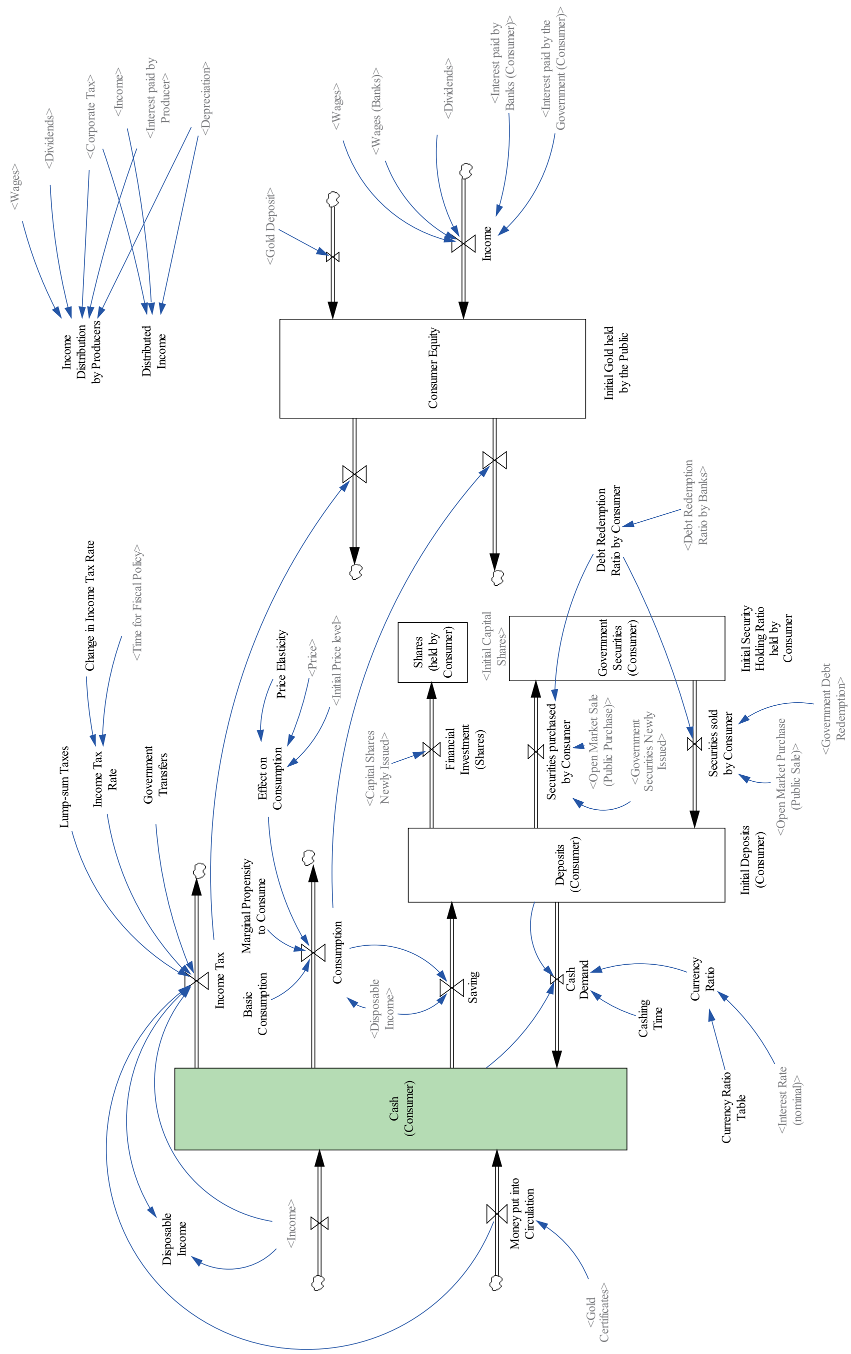

Figure 12.6: Transactions of Consumer

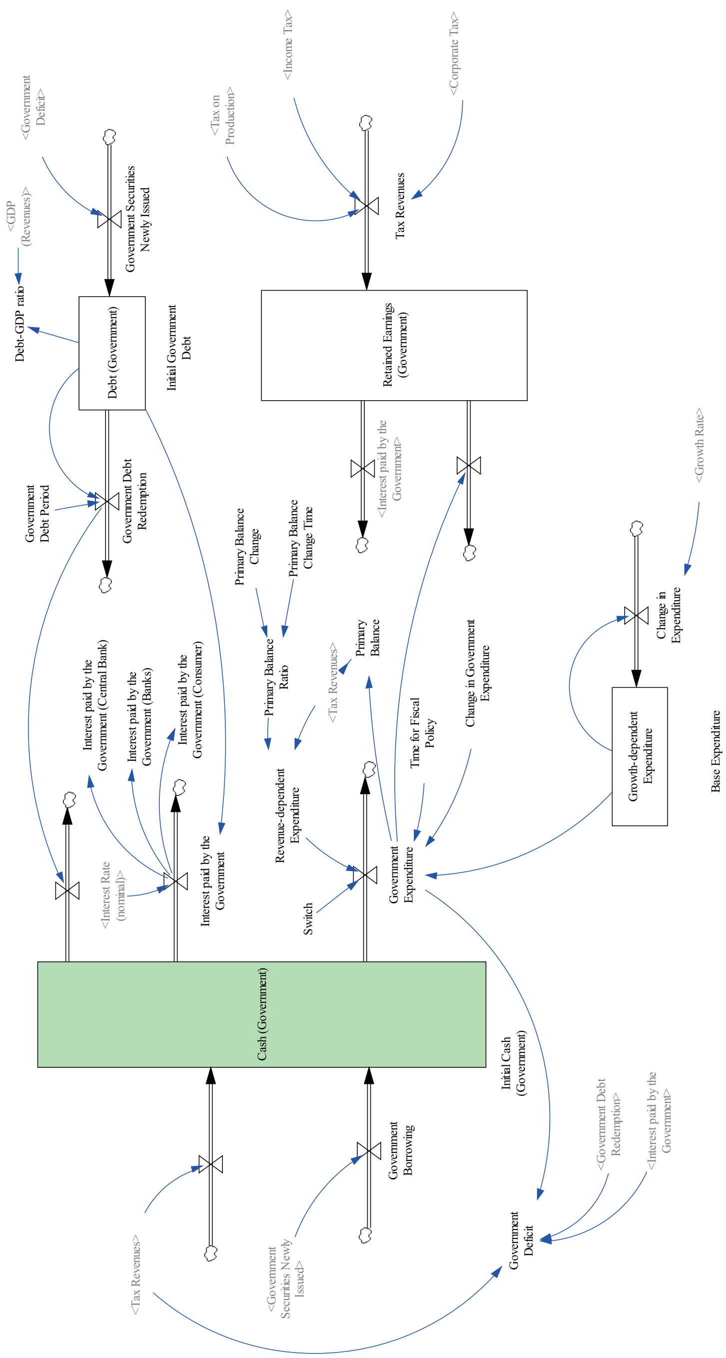

Figure 12.7: Transactions of Government

Banks

Transactions of banks are illustrated in Figure 12.8, some of which are summarized as follows.

- Banks receive deposits from consumers, against which they pay interests.
- They are obliged to deposit a fraction of the deposits as the required reserves with the central bank (which is called *a fractionalreserve banking system*).
- Out of the remaining deposits they purchase government securities, against which interests are paid from the government.
- Then, loans are made to producers and they receive interests for which a prime rate is applied.
- Their retained earnings thus become interest receipts from producers and government less interest payment to consumers. Positive earning will be distributed among bank workers as consumers.

Central Bank

In this integrated model, the central bank plays a very important role of providing a means of transactions and store of value; that is, currency. To make a story simple, its sources of assets against which currency is issued are confined to gold, discount loans and government securities. The central bank can control the amount of money stock through the amount of monetary base consisting of currency outstanding and reserves over which it has a direct power of control. This is done through monetary policies such as a manipulation of required reserve ratio and open market operations as well as direct lending control.

Transactions of the central bank are illustrated in Figure 12.9, some of which are summarized as follows.

- The central bank issues currency or money (historically gold certificates) against the gold deposited by the public.
- It can also issue currency by accepting government securities through open market operation, specifically by purchasing government securities from the public (consumers) and banks. Moreover, it can issue currency by making discount loans to commercial banks. (These activities are sometimes called *money out of nothing*.)
- It can similarly withdraw currency by selling government securities to the public (consumers) and banks, and through debt redemption by banks.
- Banks are required by law to reserve a certain fraction of deposits with the central bank. By controlling this required reserve ratio, the central

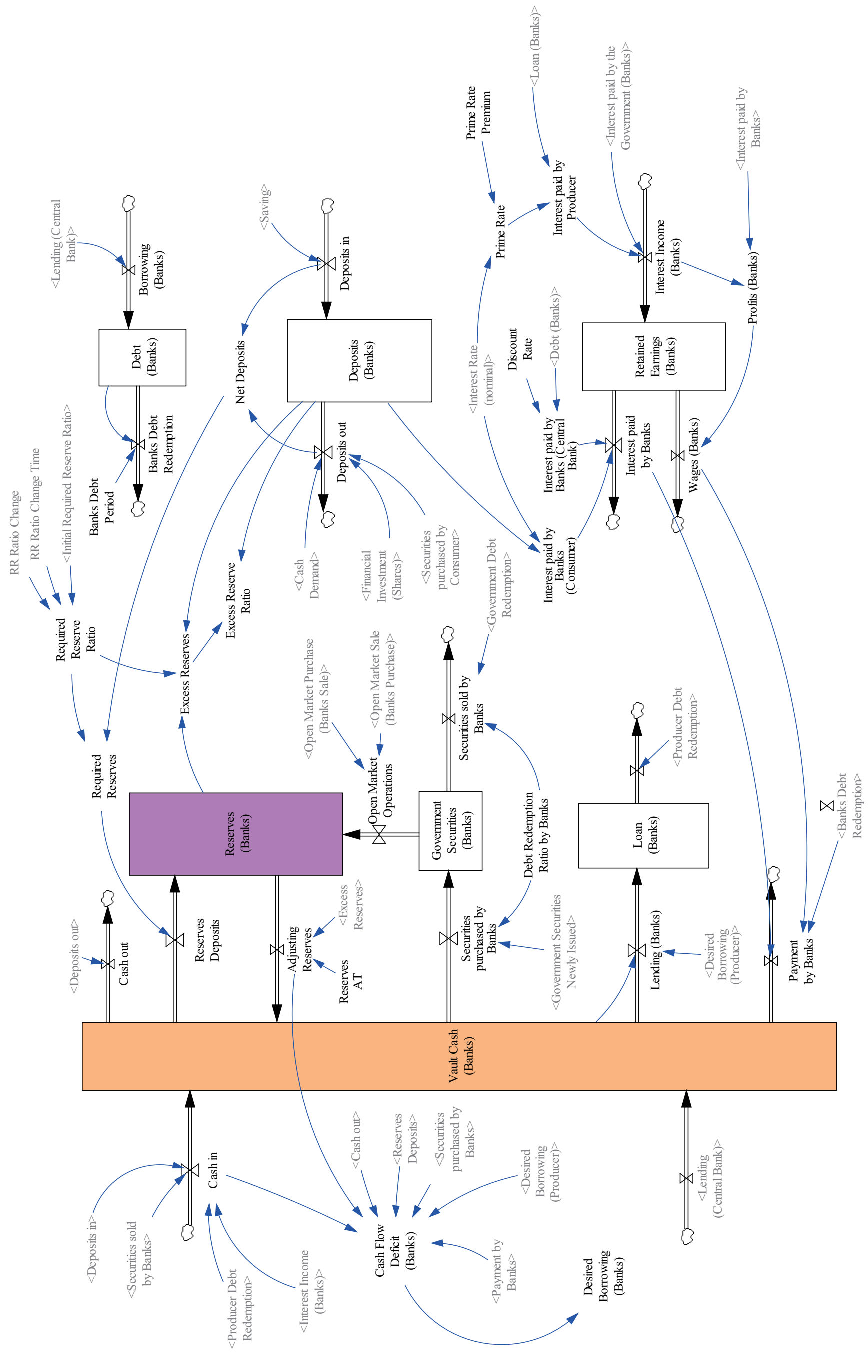

Figure 12.8: Transactions of Banks

bank can control the monetary base directly. The central bank can, thus, control the amount of money stock through monetary policies such as open market operations, reserve ratio and discount rate.

- Another powerful but hidden control method is through its direct influence over the amount of discount loans to banks (known as *window guidance* in Japan.)

12.4 Behaviors of the Integrated Model

Mostly Equilibria in the Real Sector

The integrated model is now complete. It is a generic model, out of which diverse macroeconomic behaviors will be produced. Let us start with an equilibrium growth path of the macroeconomy. In the previous IS-LM model, Keynesian aggregate demand equilibrium is defined as an equilibrium state where aggregate demand is equal to production. Moreover, it is also emphasized that the Keynesian aggregate demand equilibrium is not a full capacity equilibrium.

Let us call an equilibrium state *a full capacity equilibrium* if the following equilibrium condition is met:

$$\text{Full Capacity GDP} = \text{Desired Output} \tag{12.13}$$

When the economy is not in the equilibrium state, actual GDP is determined by

$$\text{GDP} = \text{MIN (Full Capacity GDP, Desired Output)} \tag{12.14}$$

In other words, if desired output is greater than full capacity GDP, then actual GDP is constrained by the production capacity, meanwhile in the opposite case, GDP is determined by the amount of desired output which producers wish to produce, leaving the capacity idle.

Does the equilibrium state, then, exist in the sense of full capacity GDP? To answer the question, let us define GDP gap as the difference between full capacity GDP and actual GDP, and its ratio to the full capacity GDP as

$$\text{GDP Gap (Full Capacity) Ratio} = \frac{\text{Full Capacity GDP} - \text{GDP}}{\text{Full Capacity GDP}}. \tag{12.15}$$

By trial and error, mostly equilibrium states are acquired in the integrated model when a ratio elasticity of the effect on price e is 1, and a weight of inventory ratio ω is 0.1, as illustrated in Figure 12.10.

The reader may wonder why this is a state of mostly equilibria, because growth rates and inflation rates still fluctuate as shown in Figure 12.11. Specifically, growth rates fluctuates between 0.8% and - 0.2%, and inflation rates between 0.2% and - 0.2%. Our heart pulse rate, even that of a healthy person, fluctuates between 60 and 70 per minute. This is a normal state. In a similar

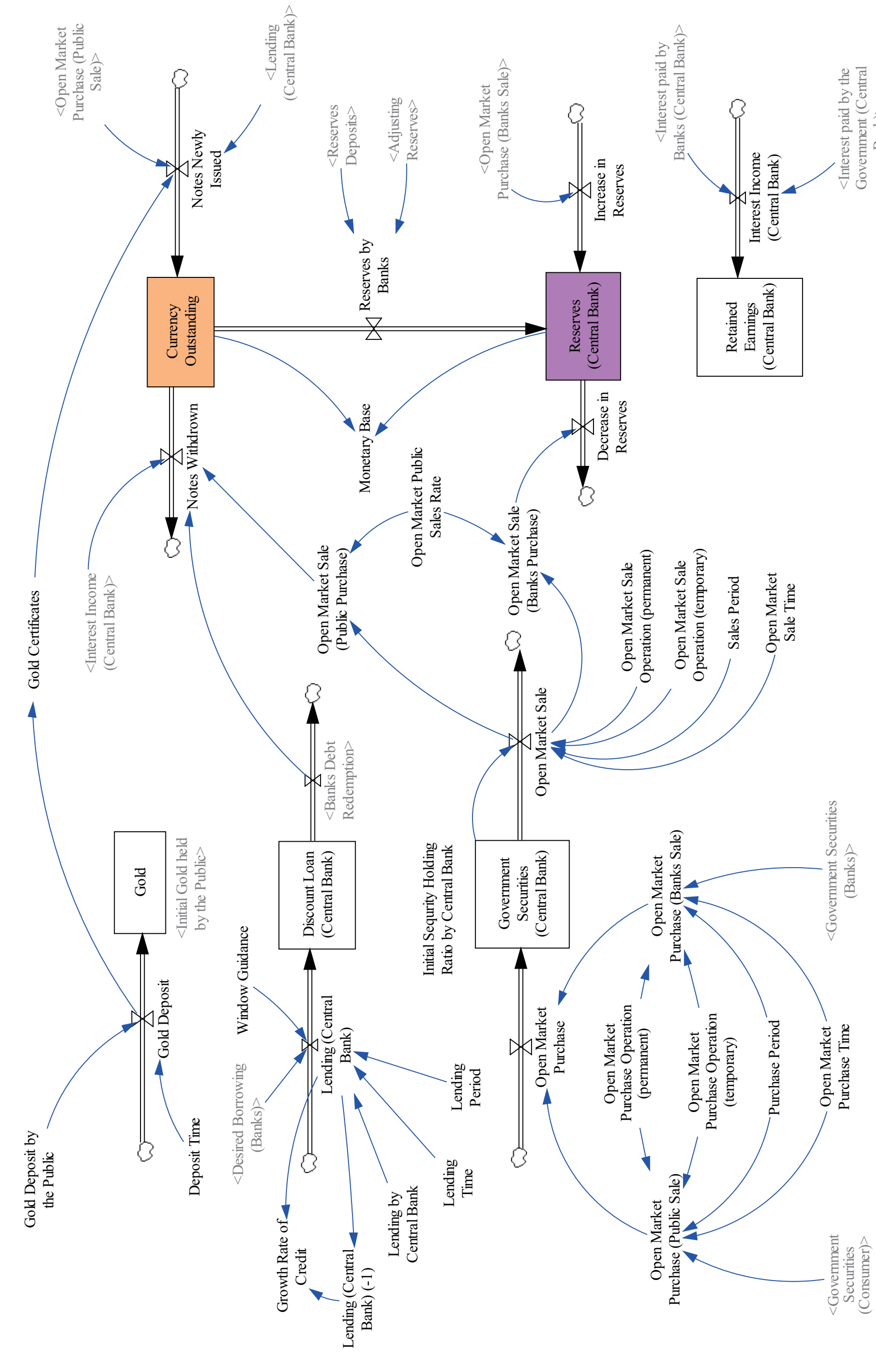

Figure 12.9: Transactions of Central Bank

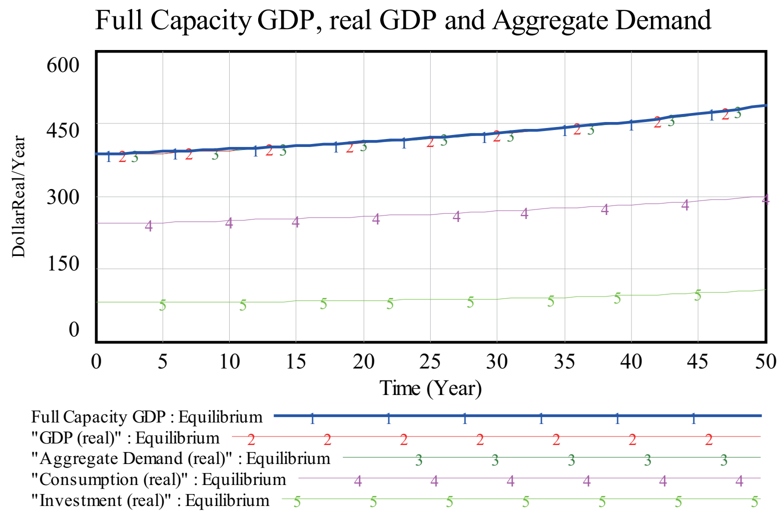

Figure 12.10: Mostly Equilibrium States

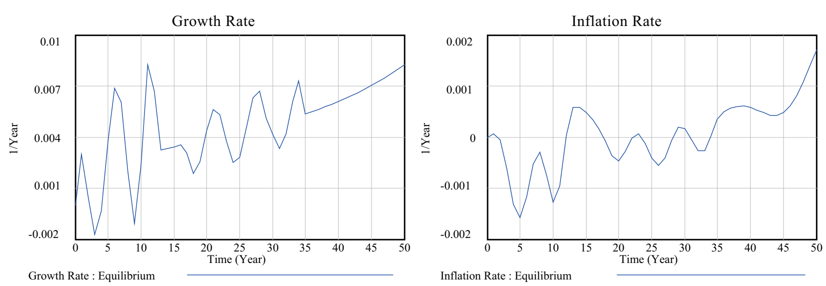

Figure 12.11: Growth and Inflation Rates of Mostly Equilibrium States

fashion, it is reasonable to consider these fluctuations as normal equilibrium states.

In what follows, these equilibrium states are used as benchmarking states of comparative analysis, and illustrated by line 2 or red lines in the Figures below.

Fixprice Disequilibria

We are now in a position to make some analytical simulations for the model. First, let us show that without price flexibility it's hard to attain mostly equilibrium states. When price is fixed; that is, ratio elasticity of the effect on price is set to be zero, disequilibria begin to appear all over the period. Figure 12.12 illustrates how fixprice causes disequilibria everywhere. The economy seems to stagger; that is, economic growth rates become lower than the equilibrium ones over many periods.

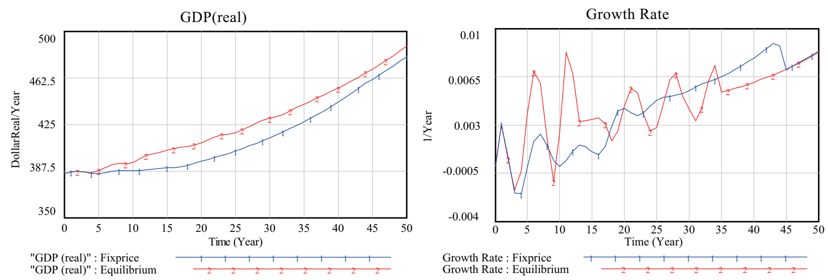

Figure 12.12: Fixprice and Mostly Equilibrium States

Business Cycles by Inventory Coverage

From now on, let us assume the mostly equilibrium path. One of the interesting questions is to find out a macroeconomic structure that may produce economic fluctuations or business cycles. How can the above equilibrium growth path be broken and business cycles will be triggered?

Our integrated model can successfully produce at least two ways of causing macroeconomic fluctuations. First, they can be caused by increasing normal inventory coverage period, Specifically, suppose the normal inventory coverage period increases from 0.25 or 3 months to 0.42 or about 5 months. The economy, then, begins to be troubled with short business cycles of about 9 years as Figure 12.13 portrays.

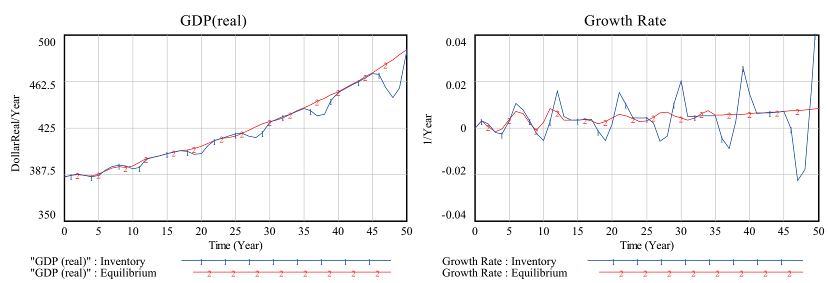

Figure 12.13: Business Cycles by Inventory Coverage

Business Cycles by Elastic Price Fluctuation

Secondly, the equilibrium growth path can also be broken and business cycle is triggered, though, in a totally different fashion. This time let us assume that a price response to the excess demand for products and inventory gap becomes more sensitive so that ratio elasticity now becomes elastic with a value of 1.3 from 1, and a weight of inventory ratio to production ratio becomes 0.6 from 0.1. Again, the economy is thrown into business cycle of between 5 and 8 years as depicted in Figure 12.14.

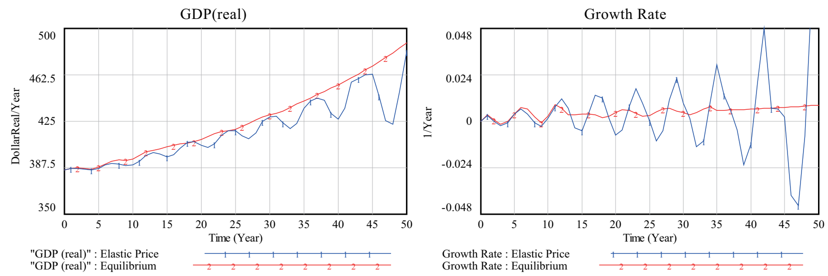

Figure 12.14: Business Cycles by Elastic Price Fluctuation

In this way, two similar business cycles are triggered, out of the same equilibrium growth path, by two different causes; one by an increase in inventory coverage period, and the other by the elasticity of price changes. The ability to produce these different behaviors of business cycles and economic fluctuations indicates a richness of our integrated generic model.

Recessions by Credit Crunch (Window Guidance)

With the introduction of discount credit loans to banks, the central bank seems to have acquired an almighty power to control credit. This hidden exerting power has been known in Japan as “window guidance”.

To demonstrate how influential the power is, let us suppose that the central bank reduces the amount of credit loans by 10%; that is, window guidance value is reduced to 0.9 from 1. In other words, banks can borrow only 90% of the desired amount of borrowing from the central bank.

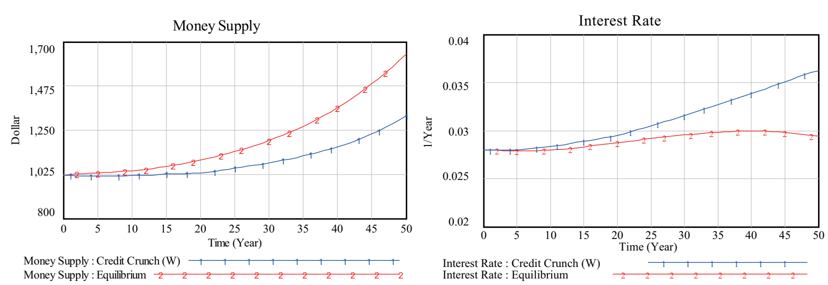

Figure 12.15: Supply of Money and Interest Rate by Credit Crunch

Figure 12.15 illustrates how supply of money shrinks and, accordingly, interest rate increases by the credit crunch caused by the central bank. Figure 12.16 illustrates the economy is now deeply triggered into recession in the sense that the GDP under credit crunch is always below the equilibrium GDP, and its economic growth rates seem to be lower in average than those of equilibrium with dwindling short-period business cycles. It is unexpected to see that the

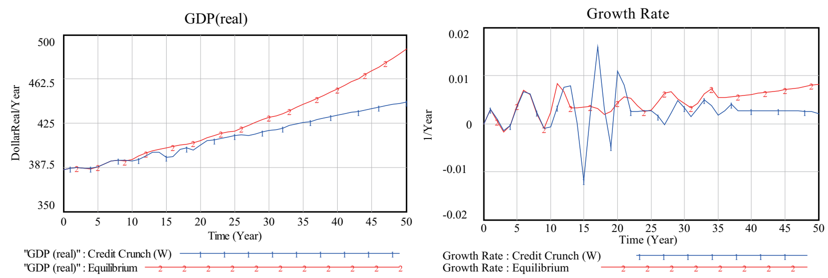

Figure 12.16: Economic Recession by Credit Crunch

economic recession is provoked by the credit crunch rather than the business cycles as shown above. Economic recessions caused by the credit crunch can be said to be worse than the recessions caused by other business cycles.

Depressions by Credit Crunch (Window Guidance & Currency Ratio)

Credit crunch can be alternatively caused if the public rush to the banks to withdraw their deposits, a so-called *bank run*. In our model this can be confirmed if a change in currency ratio is increased by 0.15 at the year 1, whose simulation is left to the reader. A more interesting case is when this bank run is triggered by the above economic recessions.

To see this impact, let us consider the above economic recessions triggered by the above credit crunch of window guidance (=0.9), in which economic growth rate plunges to - 1.18% at the year 15. Under such a recession, let us further assume that bunk runs arise all over. In our model this can be simulated by increasing a currency ratio by 0.15 at the year 15. Figure 12.17 illustrates how currency in circulation jumps (line 3) and deposits plummets (line 3), compared with equlibrium states (lines 2) and credit crunch (lines 1).

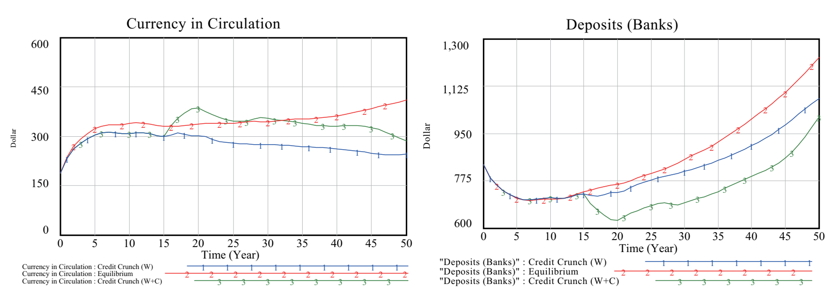

Figure 12.17: Currency in Circulation and Deposits by Bank Run

These changes affect overall behavior of supply of money, specifically it is decreased as indicated by the left diagram of Figure 12.18 (line 3), which in turn worsens the GDP growth and causes depressions as shown by the right diagram of Figure 12.18 (line 3).

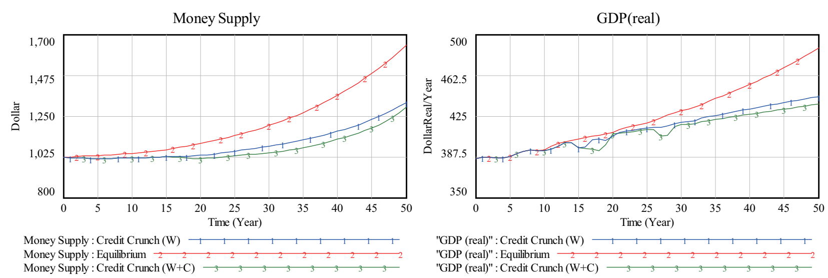

Figure 12.18: Supply of Money and Depression by Bank Run

During the Great Depression in 1930s, currency in circulation continued to increase from 4.52 $ billion in 1930 to 5.72 $ billion in 1933, while demand deposits continued to decline from 22.0 $ billion to 14.8 $ billion during the same period. As a result, money stock of M1 (about the sum of currency in circulation and demand deposits) also continued to decline from 25.8 $ billion to 19.9 $ billion. Our simulation results may support these monetary behaviors of the Great Depression.

Growing economy needs new currencies to be incessantly put into circulation. If the central bank, instead of the government, is historically endowed with this important role, savvy control of credits by the central bank with the avoidance of bank run becomes crucial for the stability and growth of macroeconomy as demonstrated here by the integrated model.

Monetary and Fiscal Policies for Equilibrium

So far, we have examined several states of disequilibria caused by fixprice, business cycles by inventory coverage and elastic price fluctuation, and credit crunch. Can we restore equilibrium, then ? According to the Keynesian theory, the answer is affirmative if monetary and fiscal policies are appropriately applied.

Let us consider the case of fixprice disequilibria and apply monetary policy, first. Suppose the central bank increases the purchase of government securities by 12% for 5 years starting at the year 6 (see the top left diagram of Figure 12.19). Then, money stock continues to grow gradually, and interest rate eventually starts to decrease (see top right and bottom left diagrams.). These changes in the monetary sector will eventually restore full capacity aggregate demand equilibrium (GDP=420.08) at the year 24 through the year 38 for 15 years (see the bottom right diagram). It takes 18 years for this open market operation to take its effect. Moreover, it is interesting to observe that during this period of sustained equilibrium due to the increased money stock, desired output (line 2 of the bottom right diagram) is higher than the real GDP. This does not cause inflation here due to the assumption of fixprice. Once this assumption is dropped, surely inflation arises. In this sense, monetary policy of open market purchase can be said to be inflationary by its nature.

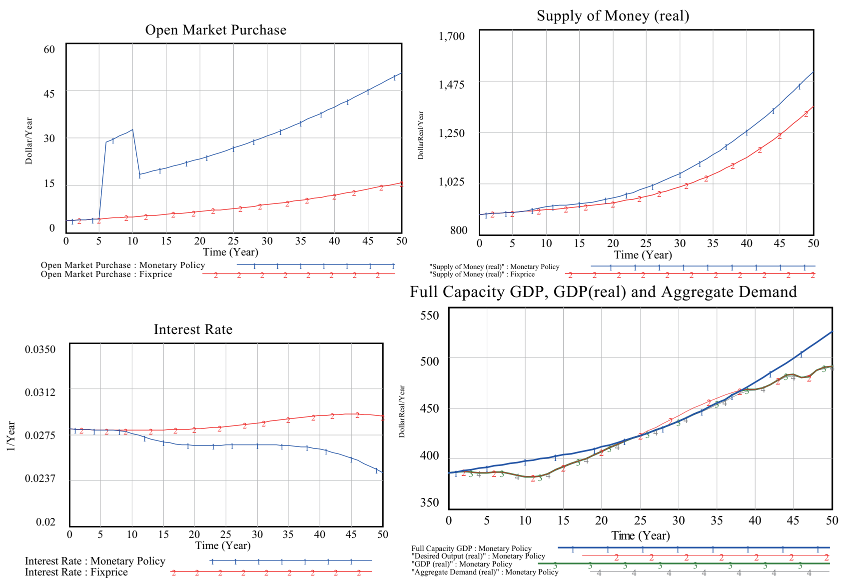

Figure 12.19: Monetary Policy: Open Market Purchase and GDP

Second scenario of restoring the equilibrium is to apply fiscal policy. In our model quite a few tools are available for fiscal policy such as changes in income tax rate, lump-sum taxes, excise rate, corporate tax rates and government expenditures. We employ here income tax rate. The reader can try other policy tools by running the model.

Facing the fixprice disequilibria, the government now decides to introduce an increase in income tax rate by 3%; that is, from the original 10% to 13 %, at the year 6 (see top left hand diagram in Figure 12.20). Under the assumption of balanced budget, or a unitary primary balanced ratio, an increase in income tax also becomes the same amount of increase in government expenditure (see top right diagram). This causes the increase in interest rate, which crowds out investment. Even so, aggregate demand is spontaneously stimulated to restore the equilibrium (GDP = 393.89) at the year 7 through the year 26 for 20 years (see the bottom right diagram). This equilibrium is attained by a slightly higher desired output (line 2), which,however, does not trigger inflation due to the assumption of fixprice recession. Compared with the monetary policy, the effect of fiscal policy appears quickly from the next year.

In this way, our integrated generic model can provide effective scenarios of sustaining full capacity aggregate demand equilibrium growth path through monetary and fiscal policies.

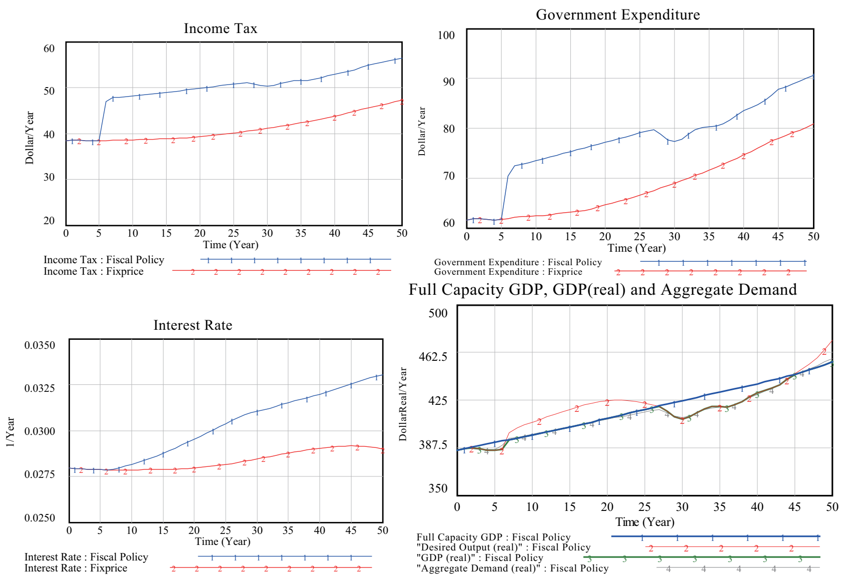

Figure 12.20: Fiscal Policy: Change in Income Tax Rate and Interest Rate

Government Debt

So long as the equilibrium path in the real sector is attained by fiscal policy, no macroeconomic problem seems to exist. Yet behind the full capacity aggregate demand growth path attained in Figure 12.20, government debt continues to accumulate as the left diagram of Figure 12.21 illustrates. Primary balance ratio is initially set to one and balanced budget is assumed in our model; that is, government expenditure is set to be equal to tax revenues, as lines 1 and 2 overlap in the diagram. Why, then, does the government continue to suffer from the current deficit?

In the model government deficit is defined as

$$\text{Deficit} = \text{Tax Revenues - Expenditure - Debt Redemption - Interest} \quad (12.16)$$

Therefore, even if balanced budget is maintained, the government still has to keep paying its debt redemption and interest. This is why it has to keep borrowing and accumulating its debt. Initial GDP in the model is obtained to be 386, while government debt is initially set to be 200. Hence, the initial debt-GDP ratio is around 0.52 year (similar to the current ratios among EU countries). The ratio continues to increase to 1.98 years at the year 50 in the model as illustrated in the right diagram of Figure 12.21. This implies the government debt becomes 1.98 years as high as the annual level of GDP (which is comparable to the Japanese debt ratio of 1.97 in 2010).

Can such a high debt be sustained? Absolutely no. Eventually this runaway accumulation of government debt may cause nominal interest rate to increase, because the government may be forced to pay higher and higher interest rate in order to keep borrowing, which may in turn launch a hyper inflation[7].

On the other hand, a higher interest rate may trigger a sudden drop of government security price, deteriorating the value of financial assets of banks, producers and consumers. The devaluation of financial assets may force some banks and producers to go bankrupt eventually. In this way, under such a hyper inflationary circumstance, financial crisis becomes inevitable and government is destined to collapse. This is one of the hotly debated scenarios about the consequences of the abnormally accumulated debt in Japan, whose current debt-GDP ratio is about 1.97 years; the highest among OECD countries!

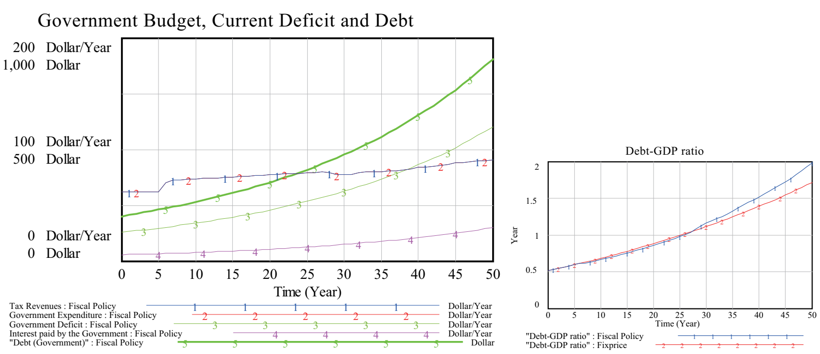

Figure 12.21: Accumulation of Government Debt

Let us now consider how to avoid such a financial crisis and collapse. At the year 6 when fiscal policy is introduced to restore a full capacity aggregate demand equilibrium in the model, the economy seems to have gotten back to the right track of sustained growth path. And most macroeconomic textbooks emphasize this positive side of fiscal policy. A negative side of fiscal policy is the accumulation of debt for financing the government expenditure. Yet most macroeconomic textbooks neglect or less emphasize this negative side, partly because their macroeconomic framework cannot handle this negative side effect properly as our integrated model does here. In our example the debt-GDP ratio is 0.61 years at the introduction year of fiscal policy.

At the face of financial crisis as discussed above, suppose that the government is forced to reduce its debt-GDP ratio to around 0.6 by the year 50, To attain this goal, a primary balance ratio has to be reduced to 0.9 in our economy. In other words, the government has to make a strong commitment to repay its debt annually by the amount of 10 percent of its tax revenues. Let us assume that this reduction is put into action around the same time when fiscal policy is introduced; that is, the year 6. Under such a radical financial reform, as illustrated in Figure 12.22, debt-GDP ratio will be reduced to around 0.64 (line 1 in the right diagram) and the accumulation of debt will be eventually curved

[7]This feedback loop from the accumulating debt to the higher interest rate is not yet fully incorporated in the model.

(left diagram).

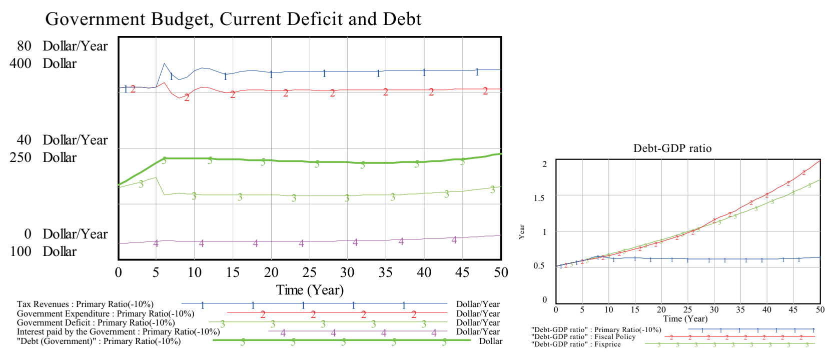

Figure 12.22: Government Debt Deduction

Even so, this radical financial reform becomes very costly to the government and its people as well. At the year of the implementation of 10 % reduction of a primary balance ratio, growth rate is forced to drop to minus 4.1 %, and the economy fails to sustain a full capacity aggregate demand equilibrium as illustrated in the left diagram of Figure 12.23. In other words, the reduction of the primary balance ratio by 10% nullifies the attained full capacity aggregate demand equilibrium by fiscal policy. The right diagram compares three states of GDP; line 3 is when price is fixed, line 2 is when fiscal policy is applied, and line 1 is when primary balance ratio is reduced by 10 %.

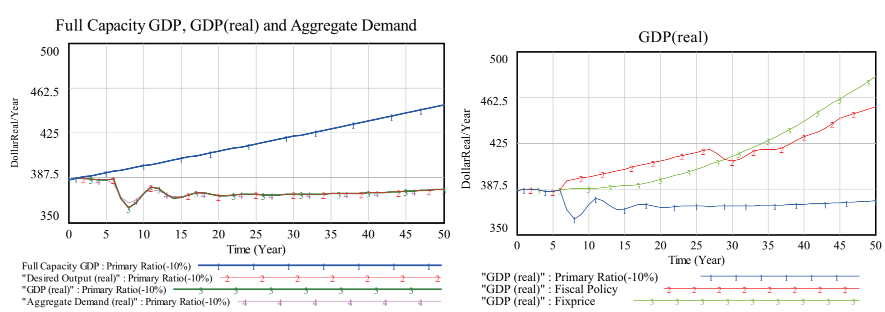

Figure 12.23: Effect of Government Debt Deduction

Price Flexibility

Is there a way to reduce government debt without sacrificing equilibrium? Monetary and fiscal policies above are applied to the disequilibria caused by fixprice. Let us make price flexible again by setting price elasticity to be 0.7 under the above fiscal situation of primary balance deduction. Left diagram of Figure 12.24 shows that equilibrium is attained at the peaks of business cycle, while right diagram shows that government debt is reduced by 10 % deduction of primary balance ratio.

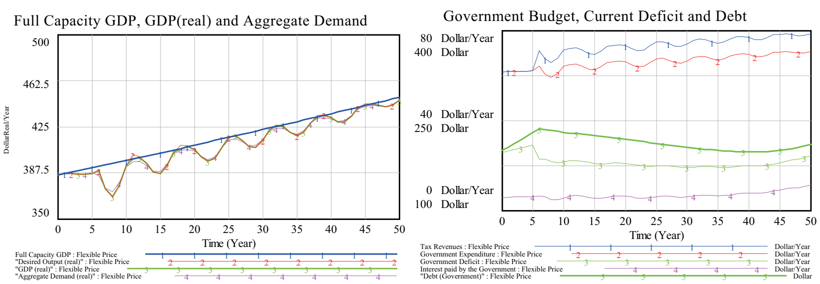

Figure 12.24: Price Flexibility, Business Cycles and Debt Reduction

In this way, the reduction of the government debt by diminishing a primary balance ratio is shown to be possible without causing a sustained recession by introducing flexible price. Yet, a financial reform of this radical type seems to allude to the only soft-landing solution path for a country with a serious debt problem such as Japan, so long as our SD simulation suggests, if a sudden collapse of the government and macroeconomy is absolutely to be avoided. Its success depends on how people can endure getting *worse before better*.

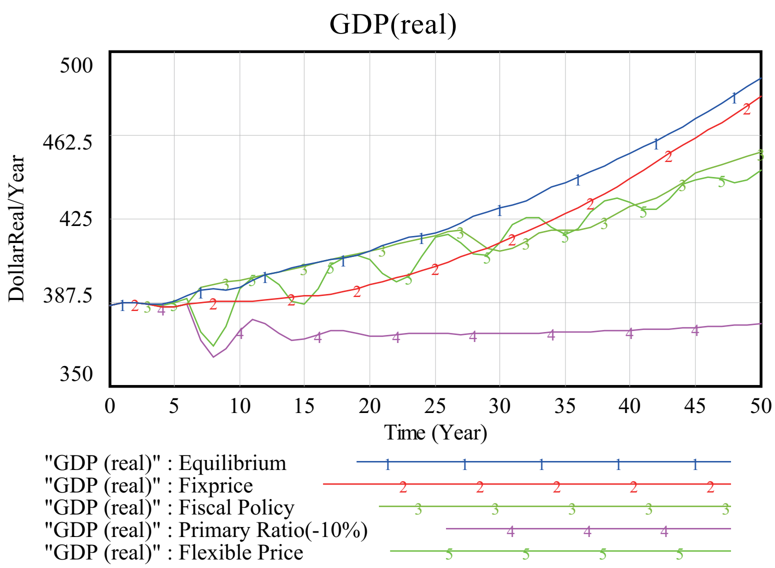

Figure 12.25: Comparison of GDP paths

Figure 12.25 compares growth paths of the economy under five different situations such as almost equilibrium, fixprice, fiscal policy, fiscal policy with debt deduction, and fiscal policy with flexible price. Compared with the almost equilibrium path (line 1), debt-reducing path with flexible price causes a business cycle. Yet, compared with another debt-deduction path (line 4), this seems a better path.

Remember in our model labor market is not introduced. In other words, economic equilibrium and government debt reduction are shown to be possible under market price flexibility. This gives us an important clue for the working of market economy without labor market (or capitalist economy). Our society needs an economic production system for its survival. Market economy needs not be a capitalist market economy with labor market. Market economy without labor market here is shown to be an efficient system, which I called *MuRatopian Economy*(Yamaguchi (1988)). Now is time to analyze a capitalist market economy with labor market in the next chapter.

12.5 Conclusion

The integration of the real and monetary sectors in macroeconomy is attained from the previously developed macroeconomic models. For this integration, five macroeconomic sectors are brought to the model such as producers, consumers, government, banks and the central bank. Moreover, several major changes are made to the previous models, among which distinction between nominal and real outputs and interest rates are the most crucial one.

The integrated macroeconomic model could be generic in the sense that diverse macroeconomic behaviors will be produced within the same model structure. To show such a capability, some macroeconomic behaviors are discussed. First, the existence of mostly equilibria is shown. And disequilibria are triggered by fixprice and business cycles by two different causes; inventory coverage period and price sensitivity.

Then, Keynesian monetary and fiscal policies are applied to the disequilibria caused by fixprice. Finally accumulating government debt issue is explored. As shown by these, the integrated generic model presented here, we believe, will provide a foundation for the analysis of diverse macroeconomic behaviors.

To make the model furthermore complete, however, at least the following fine-tuning revision has to be incorporated to the model: a feedback loop of the accumulating government debt to the interest rate.

Questions for Deeper Understanding

1. The macroeconomic model: Nominal GDP.vpmx in this chapter modifies Keynesian ASD macroeconomic models in Chap. 7 by integrating real and monetary economies. Although it still lacks labor market (Chap. 9) and overseas sector (Chap. 11), it can successfully simulate various types of macroeconomic disequilibria and business cycles which are frequently observed in our real economy.
   Briefly summarize main features of the Nominal GDP.vpmx model in comparison with the GDP (IS-LM).vpmx model in Chapter 7.

2. Two limitations of the IS-LM model are pointed out in Question 6 for Deeper Understanding in Chapter 7. Discuss if the first limitation pointed out by Mankiw is overcome in the Nominal GDP.vpmx model here; that is, a paradox of the contraction of money stock and lower interest rate.

3. Bank runs under recessions among consumers are successfully exposed in the Nominal GDP model by increasing Currency Ratio. Show how bank runs further worsen the recessions in terms of GDP, money stock, interest rate and price.

4. Create a recession by reducing the Window Guidance (Central Bank) to 0.8, then try to restore this recession by increasing "Lending by Central Bank" and "Lending Period". This Keynesian monetary policy is recently called "Quantitative Easing" policy by the Central Banks. Demonstrate the QE policy works in the Nominal GDP model as in the IS-LM model.

5. As pointed out in Question 6 for Deeper Understanding in Chapter 7, the QE policies applied to the Japanese economy has failed to restore equilibrium. This implies that both IS-LM and Nominal GDP models cannot simulate the failures of QE policies. This is the second limitation of the Keynesian models presented so far. Discuss how the Nominal GDP model can be further modified to overcome this limitation.

Chapter 13

A Macroeconomic System of Employment

In the previous chapter, monetary and real parts of macroeconomies are integrated to present a macroeconomic dynamic model. In this chapter[1], population dynamics and labor market is to be brought to make the integrated model complete. This complete model is aimed to be generic, out of which diverse macroeconomic behaviors are shown to emerge.

13.1 Macroeconomic System Overview

This chapter tries to bring population and labor market to the stage to make the integrated model complete [Companion model: MacroSystem.vpmx]. For this purpose, at least five sectors of the macroeconomy have to play macroeconomic activities simultaneously as in the previous integrated model; that is, producers, consumers, banks, government and central bank. Figure 13.1 illustrates the overview of a macroeconomic system in this chapter, and shows how these macroeconomic sectors interact with one another and exchange goods and services for money. Foreign sector is still excluded from the current analysis.

The reader will be reminded that the complete macroeconomic model to be developed below is a generic one by its nature, and does not intend to deal with some specific issues our macroeconomy is currently facing. Once such a generic macroeconomic model is build, we believe, any specific macroeconomic issue could be challenged by bringing real data in concern to this generic model without major structural changes in this integrated model.

[1]This chapter is based on the paper: Integration of Real and Monetary Sectors with Labor Market – SD Macroeconomic Modeling (3) – in "Proceedings of the 24th International Conference of the System Dynamics Society", Nijmegen, The Netherlands, July 23 - 27, 2006. (ISBN 978-0-9745329-5-0)

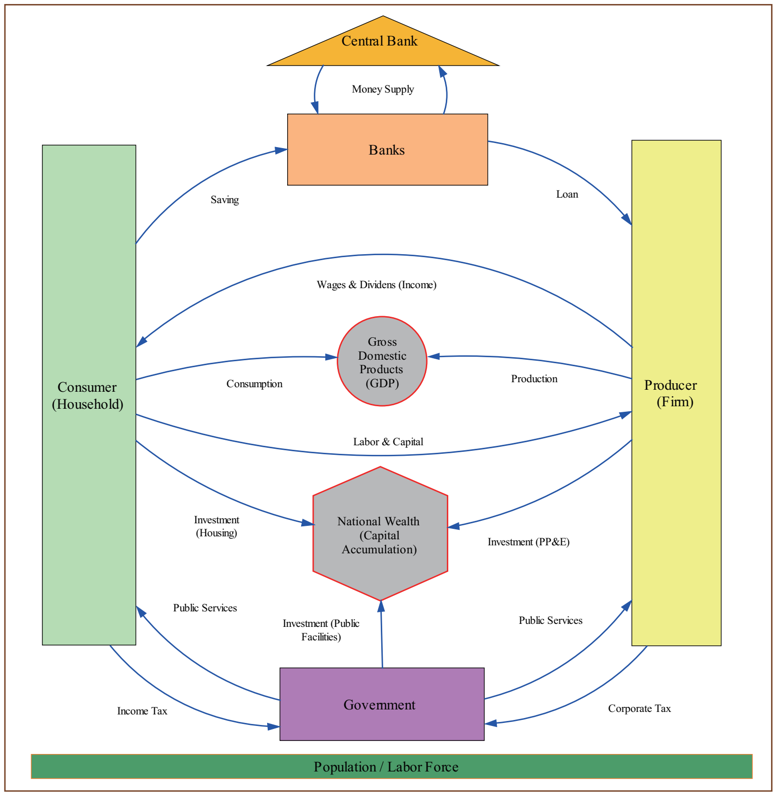

Figure 13.1: Macroeconomic System Overview

13.2 Production Function

In the previous model, full capacity output level is specified as follows:

$$Y_{full} = e^{\kappa t} \frac{1}{\theta} K \tag{13.1}$$

where κ is an annual increase rate of technological progress, and θ is a capital-output ratio. In order to fully consider the role of employed labor L, it needs to be replaced with Cobb-Douglas production function:

$$Y_{full} = F(K, L, A) = AK^{\alpha} L^{\beta} \tag{13.2}$$

where A is a factor of technological change, and α and β are exponents on capital and labor, respectively. GDP thus produced is redefined as full capacity GDP.

With the introduction of the employed labor and totally available labor force, it also becomes possible to define potential output or GDP as

$$Y_{potential} = F(K, LF, A) = AK^{\alpha} LF^{\beta} \tag{13.3}$$

where LF is the total amount of labor force which is defined as the sum of the employed and unemployed labor.

Accordingly, the desired price P^* defined in equation (9.57) needs be slightly revised to reflect the gap between potential GDP and desired output Y^D as

$$P^* = \frac{P}{\left((1-\omega)\frac{Y_{potential}}{Y^D} + \omega \frac{I_{inv}}{I^*_{inv}}\right)^e} \tag{13.4}$$

where $\omega, 0 \leq \omega \leq 1$, is a weight between production and inventory ratios, and e is an elasticity.

Let us assume that productivity due to technological progress grows exponentially such that

$$A = \bar{A}e^{\kappa t} \tag{13.5}$$

where κ is an annual increase rate of technological progress, which may be possible to be endogenously determined within the system. Following the method by Nathan Forrester Forrester (1982), let us normalize this production function with the initial potential GDP at $t = 0$:

$$\bar{Y}_{potential} = F(\bar{K}, \bar{LF}, \bar{A}) = \bar{A}\bar{K}^{\alpha}\bar{LF}^{\beta} \quad \text{(Initial Potential Output)} \tag{13.6}$$

Then, we have

$$Y_{full} = e^{\kappa t}\bar{Y}_{potential}\left(\frac{K}{\bar{K}}\right)^{\alpha}\left(\frac{L}{\bar{LF}}\right)^{\beta} \tag{13.7}$$

Now let us define profits after tax. In our integrated model, three types of taxes are levied: tax on production (excise tax), corporate tax and income tax. The former two taxes are paid by producers (Figure 13.5), while income tax, consisting of lump-sum tax and a proportional part of income tax, is paid by consumers (Figure 13.6). With these into consideration, profits after tax Π are now defined as

$$\Pi = ((1-t)PY_{full} - (i+\delta)P_K K - wL)(1-t_c) \tag{13.8}$$

where t is an excise tax rate, t_c is a corporate profit tax rate, i is a real interest rate, δ is a depreciation rate, and w is a nominal wage rate.

One remark may be appropriate for the definition of capital cost $iP_K K$. The amount of capital against which interests are paid are the amount of debt outstanding by producers (which is the same as the outstanding loan by banks) in the integrated model, yet at an abstract theoretical level it is regarded the same as the book value of capital from which depreciation is deducted. Our model based on double-booking accounting system enables to handle this distinction. Specifically, capital cost (= interest paid by producers) are calculated in the model as

$$iP_K K \approx \text{Prime Rate x Loan (or Debt by producers)} \tag{13.9}$$

First order condition for profit maximization with respect to capital stock is calculated by partially differentiating profits with respect to capital as

$$\begin{aligned}
\left(\frac{1}{1-t_c}\right)\frac{\partial \Pi}{\partial K} &= \alpha(1-t)Pe^{\kappa t}\left(\frac{\bar{Y}_{full}}{\bar{K}}\right)\left(\frac{K}{\bar{K}}\right)^{\alpha-1}\left(\frac{L}{\bar{\bar{L}}}\right)^{\beta} - (i+\delta)P_K \\
&= \frac{\alpha(1-t)Pe^{\kappa t}\left(\frac{\bar{Y}_{full}}{\bar{K}}\right)\left(\frac{K}{\bar{K}}\right)^{\alpha}\left(\frac{L}{\bar{L}}\right)^{\beta}}{\frac{K}{\bar{K}}} - (i+\delta)P_K \\
&= \frac{\alpha(1-t)PY_{full}}{K} - (i+\delta)P_K \\
&= 0 \qquad (13.10)
\end{aligned}$$

The demand function for capital is thus obtained as

$$K = \frac{\alpha(1-t)PY_{full}}{(i+\delta)P_K} \qquad (13.11)$$

At a macroeconomic level of one commodity, price of output P is treated with the same as the price of capital stock P_K. Hence, a desired level of capital stock K^* could be approximately calculated by desired output Y^* as

$$K^*(i) = \frac{\alpha(1-t)Y^*}{i+\delta} \qquad (13.12)$$

In our model desired output Y^* is represented by the variable: Aggregate Demand Forecasting (Long-run) as illustrated in Figure 13.2 (see also Forrester (1982)).

The amount of desired investment is now obtained as the difference between desired and actual capital stock such that

$$I(i) = \frac{K^*(i) - K}{\text{Time to Adjust Capital}} + \delta K \qquad (13.13)$$

Furthermore, let us define desired capital-output ratio as follows:

$$\theta^*(i) = \frac{K^*}{Y^*} = \frac{\alpha(1-t)}{i+\delta} \qquad (13.14)$$

Then, the above investment function can be rewritten as[2]

$$I(i) = \frac{(\theta^*(i) - \theta)Y^*}{\text{Time to Adjust Capital}} + \delta K \qquad (13.15)$$

The new investment function obtained above replaces our previous investment function in equation (**??**) that is determined by the interest rate:

$$I(i) = \frac{I_0}{i} - ai \qquad (13.16)$$

where a is an interest sensitivity of investment.

[2] To be precise, this reformulation cannot be used as an alternative investment function without minor behavioral changes. Hence equation (13.13) is used in this model.

First order condition for profit maximization with respect to labor is calculated as follows:

$$\begin{aligned}
\left(\frac{1}{1-t_c}\right)\frac{\partial \Pi}{\partial L} &= \beta(1-t)Pe^{\kappa t}\left(\frac{\bar{Y}_{full}}{\bar{L}}\right)\left(\frac{K}{\bar{K}}\right)^{\alpha}\left(\frac{L}{\bar{L}}\right)^{\beta-1} - w \\
&= \frac{\beta(1-t)Pe^{\kappa t}\left(\frac{\bar{Y}_{full}}{\bar{L}}\right)\left(\frac{K}{\bar{K}}\right)^{\alpha}\left(\frac{L}{\bar{L}}\right)^{\beta}}{\frac{L}{\bar{L}}} - w \\
&= \frac{\beta(1-t)PY_{full}}{L} - w \\
&= 0
\end{aligned} \tag{13.17}$$

Demand for labor is thus obtained as

$$L^d = \frac{\beta(1-t)PY_{full}}{w}. \tag{13.18}$$

Specifically, it is a decreasing function of real wage rate such that $R = w/P$.

From this demand function for labor, desired level of labor L^* could be approximately obtained by desired output Y^* and expected wage rate w^e as

$$L^*(Y^*, w^e) = \frac{\beta(1-t)PY^*}{w^e} \tag{13.19}$$

The expected wage rate is assumed to be determined as

$$w^e = w(1 + \text{inflation rate}) \tag{13.20}$$

The determination of the wage rate will be discussed in the following section.

Net employment decision is now made according to the difference between desired and actual amount of labor such that

$$E(Y^*, w^e) = \frac{L^*(Y^*, w^e) - L}{\text{Time to Adjust Labor}} \tag{13.21}$$

Net employment thus defined has a downward-sloping shape such that

$$\frac{\partial E}{\partial w^e} = -\frac{\beta(1-t)Y^*}{\text{Time to Adjust Labor}}\frac{1}{(w^e)^2} < 0. \tag{13.22}$$

The amount of wages to be paid by producers is determined by

$$W = wL \tag{13.23}$$

as illustrated in Figure 13.5.

With the above first-order conditions, profits after tax are now rewritten as

$$\begin{aligned}
\Pi &= ((1-t)PY_{full} - (i+\delta)P_K K - wL)(1-t_c) \\
&= ((1-t)PY_{full} - \alpha(1-t)PY_{full} - \beta(1-t)PY_{full})(1-t_c) \\
&= (1-t)(1-t_c)(1-\alpha-\beta)PY_{full}
\end{aligned} \tag{13.24}$$

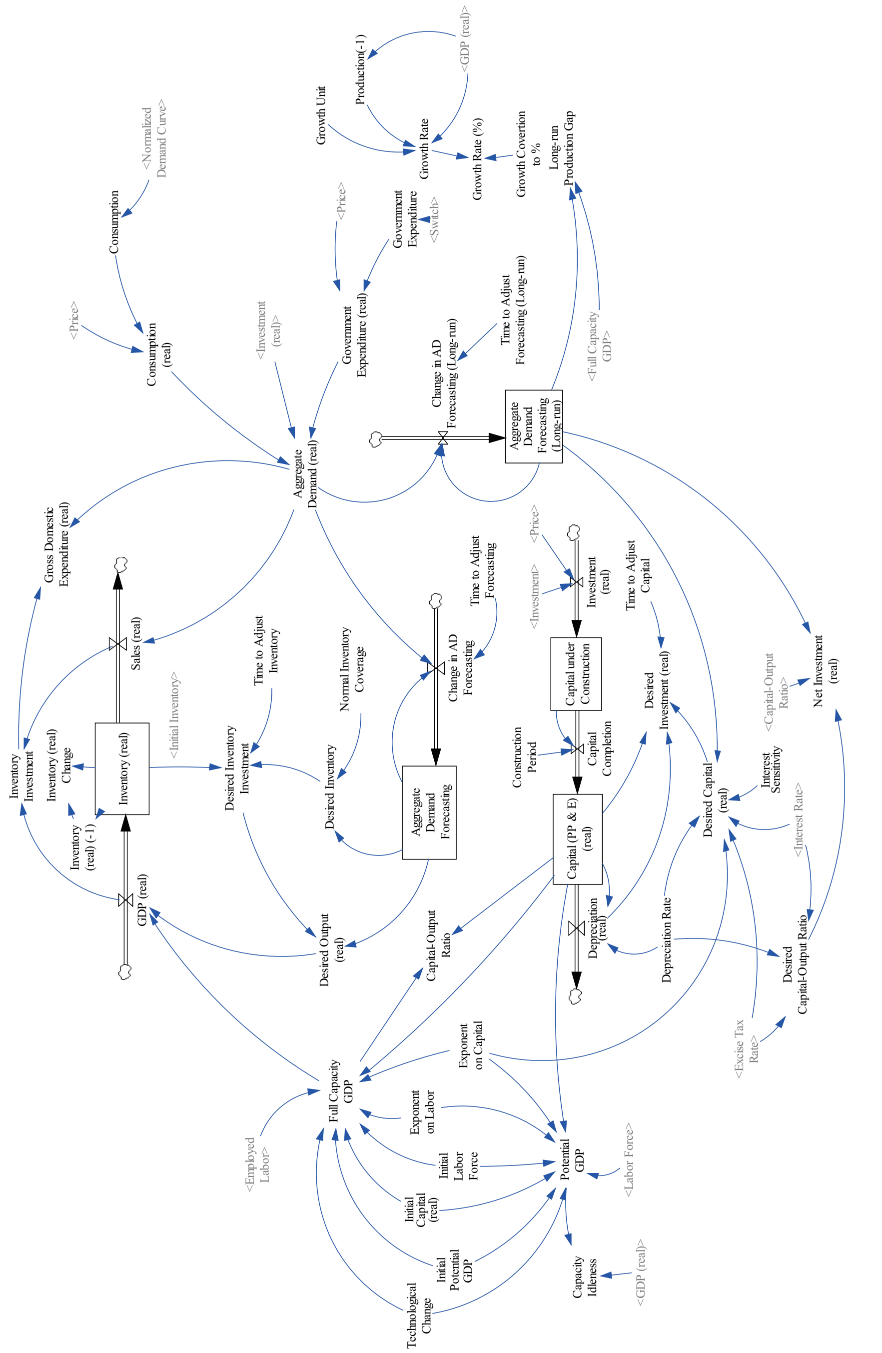

Figure 13.2: Real Production of GDP

Hence, if constant returns to scale is assumed as production technology, as often done; that is, $\alpha + \beta = 1$, then no profits after tax are made available, out of which dividends have to be paid to shareholders. Accordingly, a diminishing returns to scale is assumed in our model; that is, $\alpha = 0.4$ and $\beta = 0.5$ so that $\alpha + \beta < 1$.

13.3 Population and Labor Market

Labor Market and Wage Rate Adjustment

So far labor demand is assumed to be fully met as the equation (13.21) indicates. To determine the real wage rate in the labor market, it is necessary to introduce the availability of labor supply, and the population dynamics of the economy by which labor supply is constrained.

Population dynamics is modeled according to the World3 model[3]. It consists of five cohorts of age groups, and two population cohorts between age 15 to 44 and 45 to 64 are considered to be a productive population cohort.

In this macroeconomic model, the productive population cohort is further broken down into five categorically-different subgroups: high school, college education, voluntary employed, employed labor, and unemployed labor, as illustrated by Figure 13.3. Employed and unemployed labor constitutes a total labor force, by which potential GDP is calculated together with the amount of capital.

Nominal wage rate is now determined in the labor market as follows:

$$\frac{dw}{dt} = \phi(L^* - L^s) \tag{13.25}$$

where L^* denotes demand for desired labor, while L^s indicates supply of labor forces. Labor demand (and net employment) is in return determined by a real wage rate in equation (13.18).

Let us further specify the wage rate equation, as in the interest rate and price equations, as follows:

$$\frac{dw}{dt} = \frac{w^* - w}{\text{DelayTime}} \tag{13.26}$$

where the desired wage rate w^* is obtained as

$$w^* = \frac{w}{\left(\frac{L^s}{L^*}\right)^e} \tag{13.27}$$

where e is a labor ratio elasticity.

These features are reflected in Figure 13.4.

[3]Vensim version of the World3 model is provided in the vendor's's sample models by Ventana Systems, Inc.

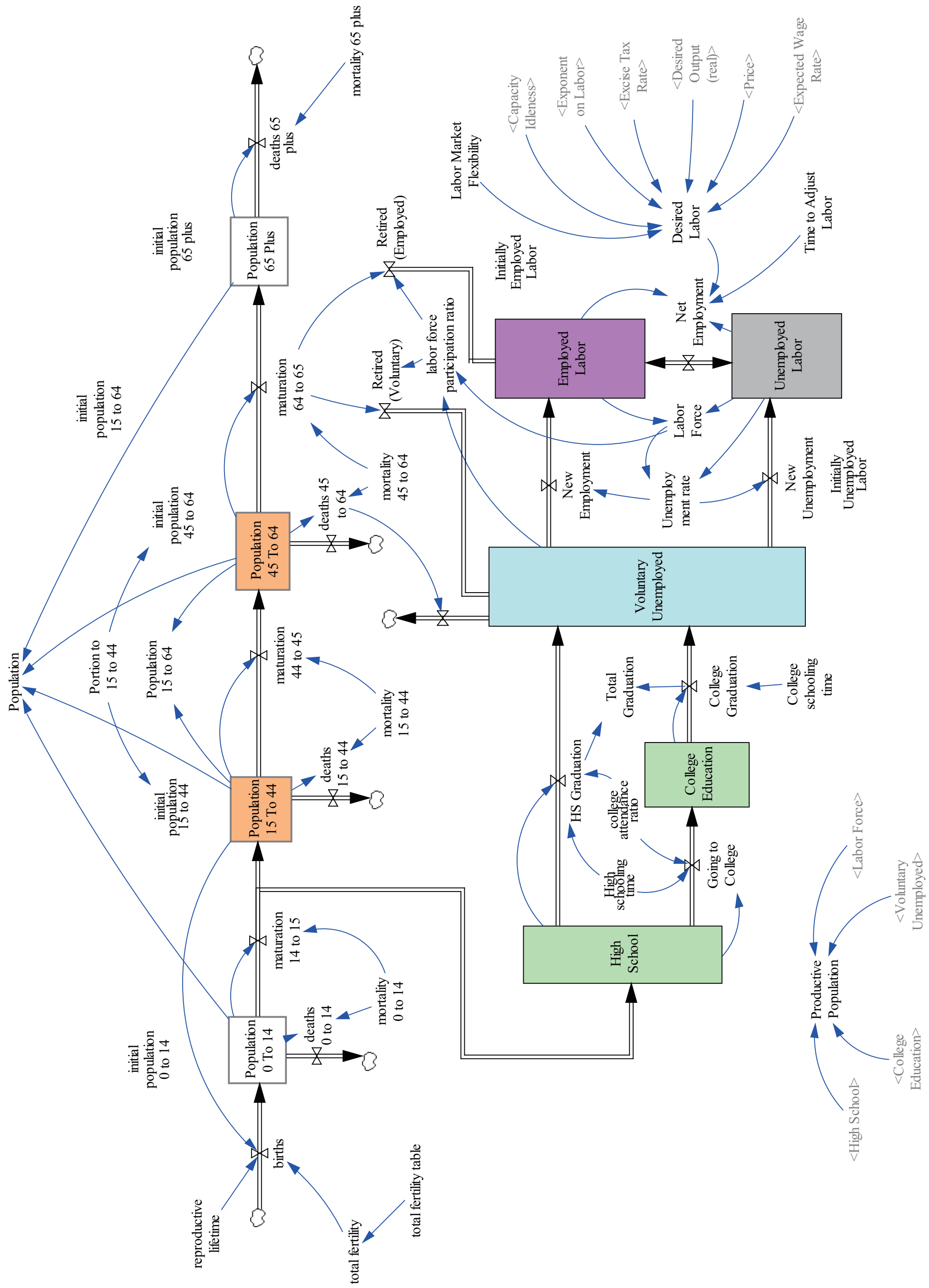

Figure 13.3: Population and Labor Market

Price Adjustment by Cost-push Force

In the model, price is assumed to be adjusted by the demand-pull forces generated by discrepancies between desired aggregate demand and potential GDP, and between inventory gap such that

$$\frac{dP}{dt} = \Psi(Y^D - Y_{potential}, I^*_{inv} - I_{inv}). \tag{13.28}$$

With the introduction of wage determination in equation (13.26), it now becomes possible to add cost-push forces to the price adjustment process. Theses forces are represented by a change in the nominal wage rate such that

$$w_g = \frac{d\ log(w)}{dt} \tag{13.29}$$

The price adjustment process is now influenced by demand-pull and cost-push forces as well such that

$$\frac{dP}{dt} = \Psi_1(Y^D - Y_{potential}, I^*_{inv} - I_{inv}) + \Psi_2(w_g) \tag{13.30}$$

Figure 13.4 illustrates our revised model for adjustment processes of price and wage rate as well as interest rate.

13.4 Transactions Among Five Sectors

Let us now describe some major transactions by producers, consumers, government, banks and central bank, most of which are already described in the previous chapter. For the convenience to the reader, they are repeated here.

Producers

Major transactions of producers are, as illustrated in Figure 13.5, summarized as follows.

- Out of the GDP revenues producers pay excise tax, deduct the amount of depreciation, and pay wages to workers (consumers) and interests to the banks. The remaining revenues become profits before tax.
- They pay corporate tax to the government out of the profits before tax.
- The remaining profits after tax are paid to the owners (that is, consumers) as dividends.
- Producers are thus constantly in a state of cash flow deficits. To continue new investment, therefore, they have to borrow money from banks and pay interest to the banks.

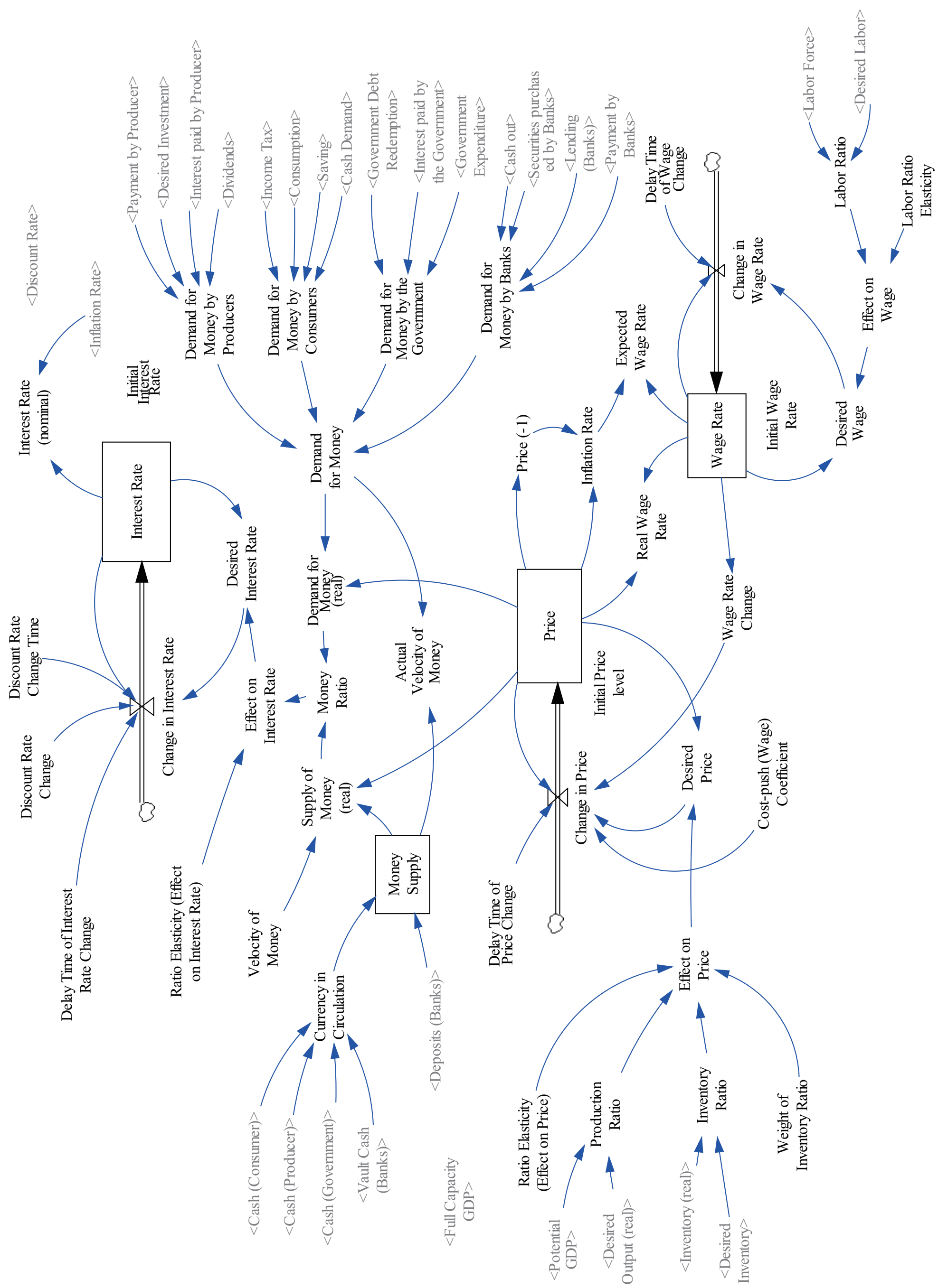

Figure 13.4: Interest Rate, Price and Wage Rate

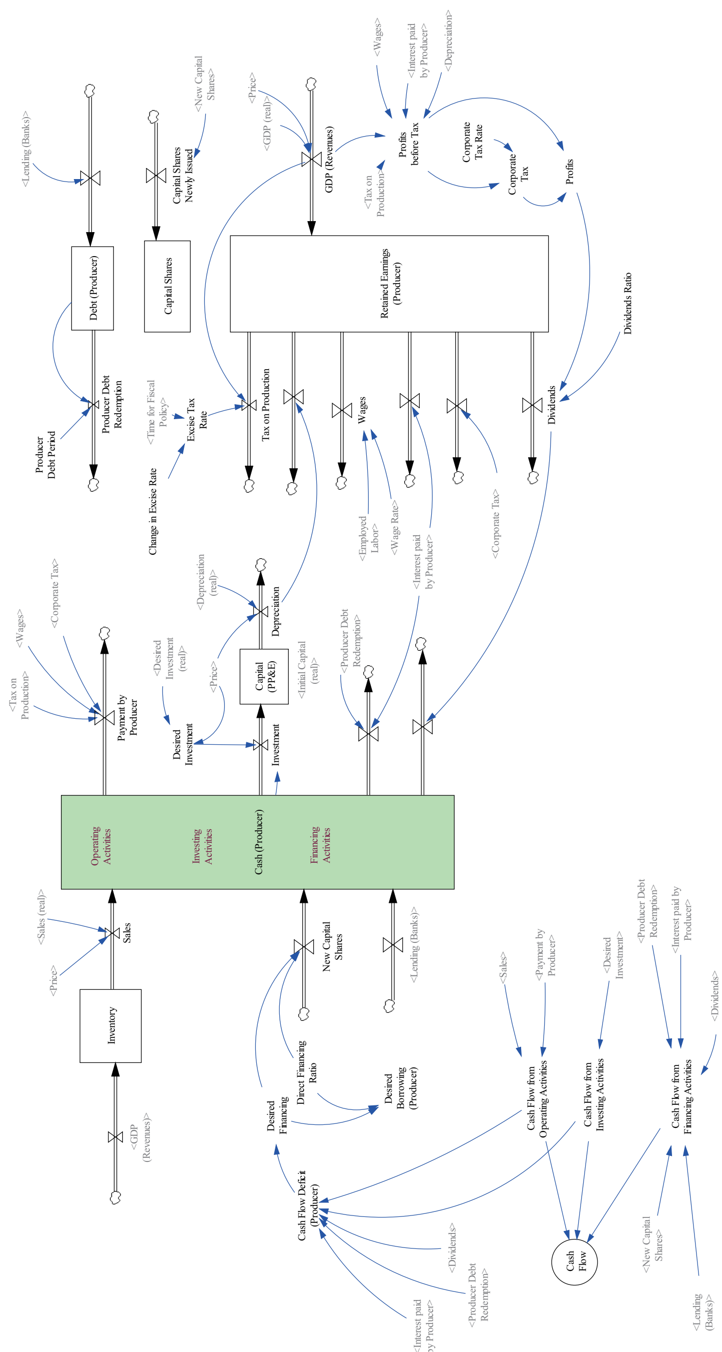

Figure 13.5: Transactions of Producers

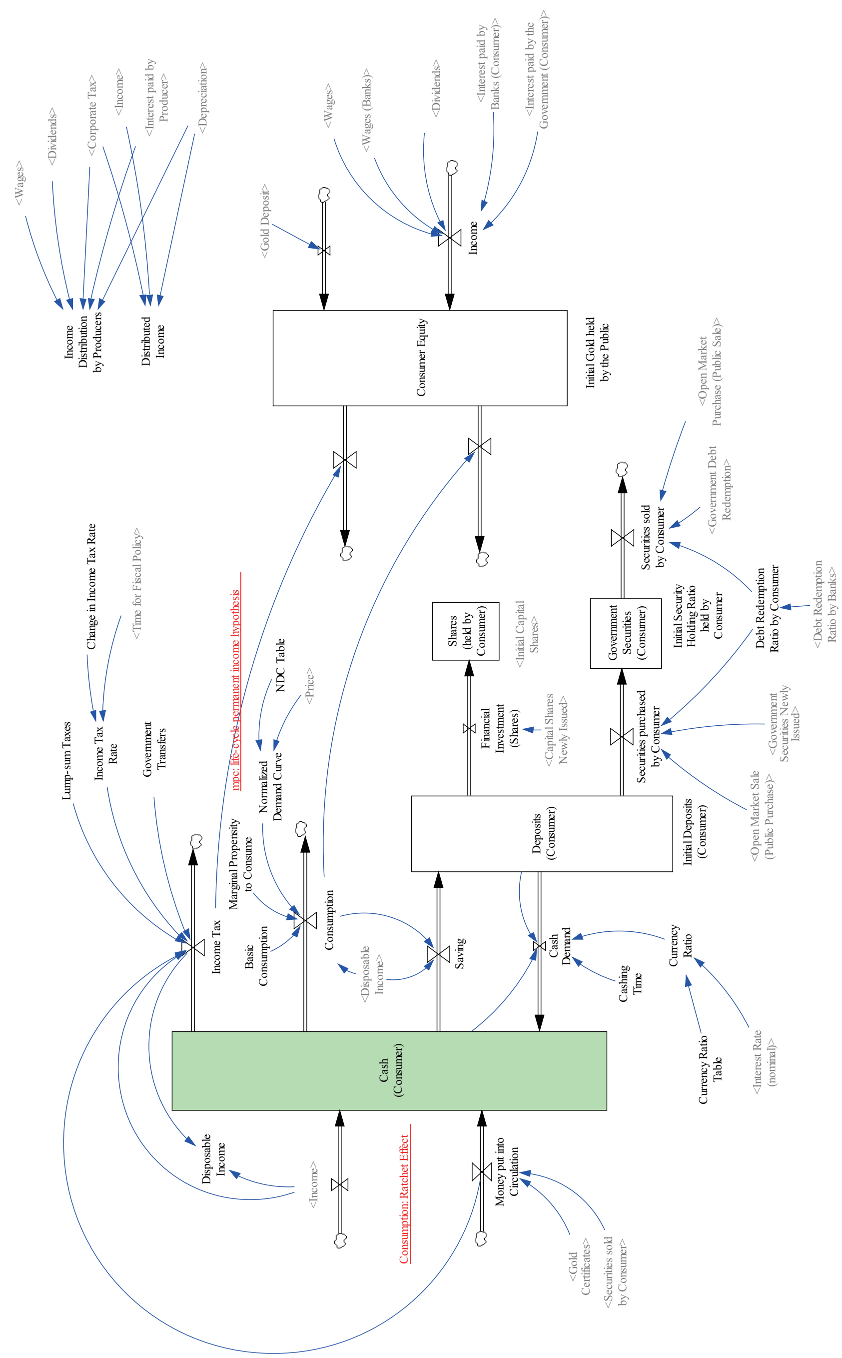

Figure 13.6: Transactions of Consumer

Consumers

Transactions of consumers are illustrated in Figure 13.6, some of which are summarized as follows.

- Consumers receive wages and dividends from producers.
- Financial assets of consumers consist of bank deposits and government securities, against which they receive financial income of interests from banks and government. (No corporate shares are assumed to be held by consumers).
- In addition to the income such as wages, interests, and dividends, consumers receive cash whenever previous securities are partly redeemed annually by the government.
- Out of these cash income as a whole, consumers pay income taxes, and the remaining income becomes their disposal income.
- Out of their disposal income, they spend on consumption that is determined by their marginal propensity to consume and price elasticity. The remaining amount are either spent to purchase government securities or saved.

Government

Transactions of the government are illustrated in Figure 13.7, some of which are summarized as follows.

- Government receives, as tax revenues, income taxes from consumers and corporate taxes from producers as well as excise tax on production.
- Government spending consists of government expenditures and payments to the consumers for its partial debt redemption and interests against its securities.
- Government expenditures are assumed to be endogenously determined by either the growth-dependent expenditures or tax revenue-dependent expenditures.
- If spending exceeds tax revenues, government has to borrow cash from banks and consumers by newly issuing government securities.

Banks

Transactions of banks are illustrated in Figure 13.8, some of which are summarized as follows.

- Banks receive deposits from consumers, against which they pay interests.

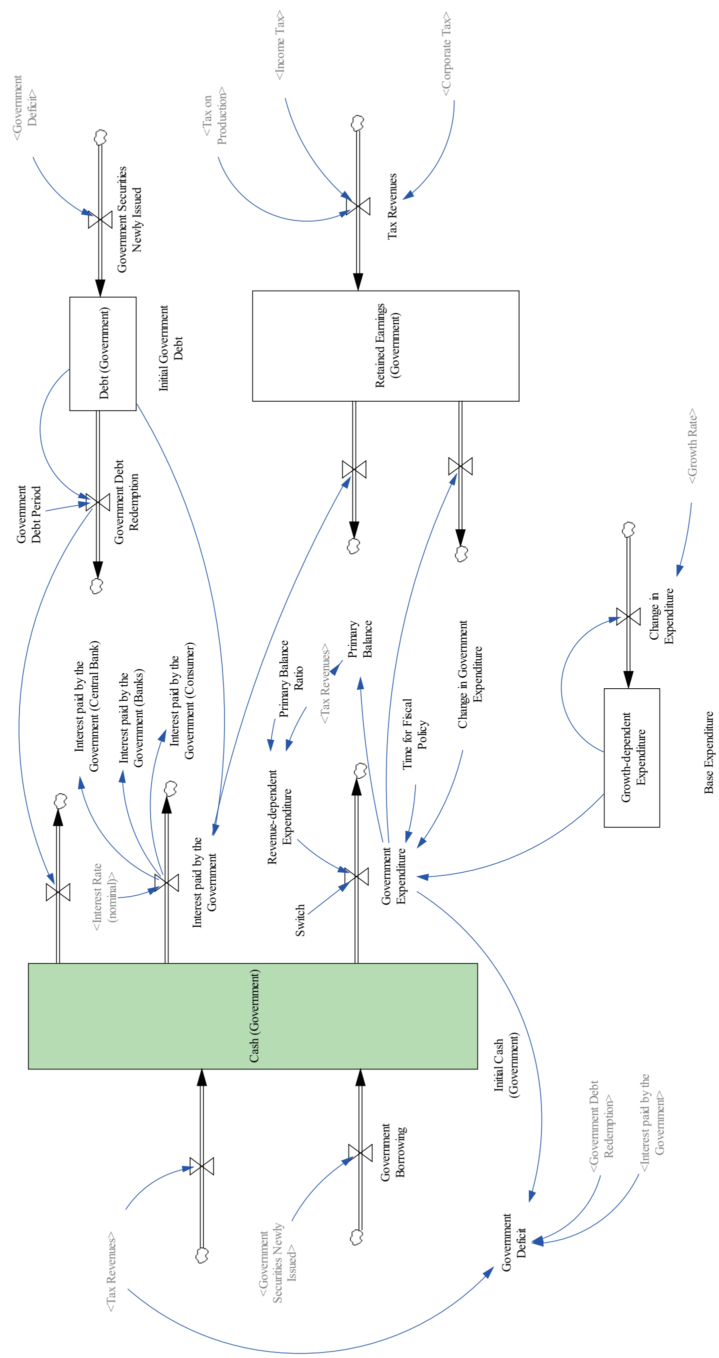

Figure 13.7: Transactions of Government

- They are obliged to deposit a portion of the deposits as the required reserves with the central bank (which is called *a fractional banking system*).
- Out of the remaining deposits they purchase government securities, against which interests are paid from the government.
- Then, loans are made to producers and they receive interests for which a prime rate is applied.
- Their retained earnings thus become interest receipts from producers and government less interest payment to consumers. Positive earning will be distributed among bank workers as consumers.

Central Bank

In this complete macroeconomic model, the central bank plays a very important role of providing a means of transactions and store of value; that is, money or currency. To make a story simple, its sources of assets against which currency is issued are confined to gold, loan and government securities. In short, money is mostly issued as debt by the government and commercial banks. The central bank can control the amount of money stock through the amount of monetary base consisting of currency outstanding and reserves over which it has a direct power of control. This is done through monetary policies such as a manipulation of required reserve ratio and open market operations as well as direct lending control.

Transactions of the central bank are illustrated in Figure 13.9, some of which are summarized as follows.

- The central bank issues currency or money (historically gold certificates) against the gold deposited by the public, though this practice is currently insignificant and only reflects its historical origin of modern banking system.
- It can now mainly issue currency by accepting government securities through open market operation, specifically by purchasing government securities from the public (consumers) and banks. Moreover, it can issue currency by making discount loans to commercial banks. (These activities are sometimes called *money out of nothing*.)
- It can similarly withdraw currency by selling government securities to the public (consumers) and banks, and through debt redemption by banks.
- Banks are required by law to reserve a certain amount of deposits with the central bank. By controlling this required reserve ratio, the central bank can also control the monetary base or currency in circulation directly. The central bank can, thus, control the amount of money stock through monetary policies such as open market operations, reserve ratio and discount rate.

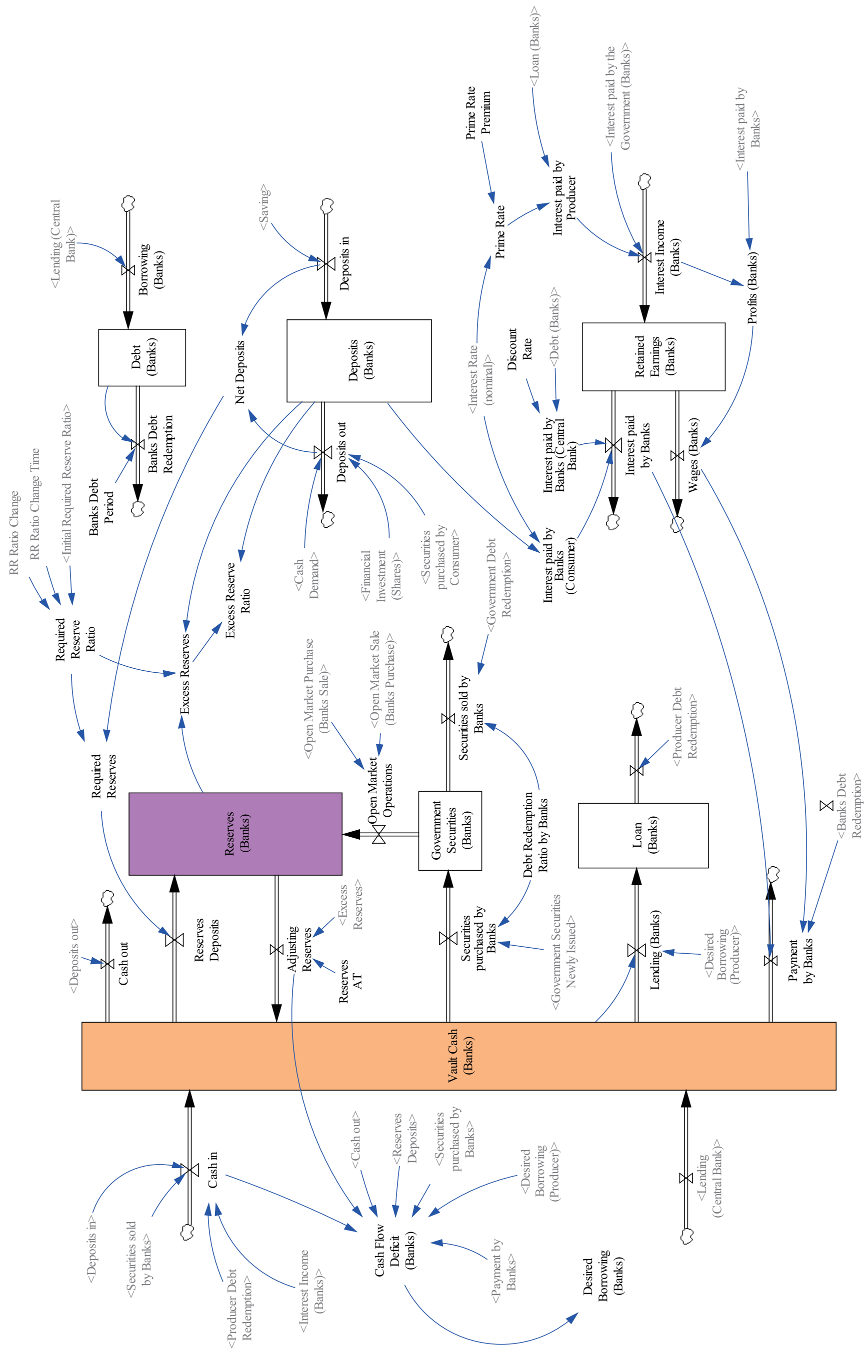

Figure 13.8: Transactions of Banks

- Another powerful but hidden control method is through its direct influence over the amount of credit loans to banks (known as *window guidance* in Japan.)

13.5 Behaviors of the Complete Macroeconomic Model

Mostly Equilibria in the Real Sector

The integrated model is now complete. It is a generic model, out of which diverse macroeconomic behaviors will be produced. Let us start with an equilibrium growth path of the macroeconomy. As in the previous model, let us call an equilibrium state *a full capacity equilibrium* if the following equilibrium condition is met:

$$\text{Full Capacity GDP} = \text{Desired Output} \tag{13.31}$$

When the economy is not in the equilibrium state, actual GDP is determined by

$$\text{GDP} = \text{MIN (Full Capacity GDP, Desired Output)} \tag{13.32}$$

In other words, if desired output is greater than full capacity GDP, then actual GDP is constrained by the production capacity, meanwhile in the opposite case, GDP is determined by the amount of desired output which producers wish to produce, leaving the capacity idle, and workers being laid off.

Even though, full capacity GDP is attained, full employment may not be realized unless

$$\text{Potential GDP} = \text{Full Capacity GDP} \tag{13.33}$$

Does the equilibrium state, then, exist in the sense of full capacity GDP and full employment? To answer these questions, let us define GDP gap as the difference between potential GDP and actual GDP, and its ratio to the potential GDP as

$$\text{GDP Gap Ratio} = \frac{Y_{potential} - \text{GDP}}{Y_{potential}} \tag{13.34}$$

By trial and error, mostly equilibrium states are acquired in the complete macroeconomic model whenever price is flexibly adjusted by setting its coefficient to be 1, together with all other adjusted parameters, as illustrated in Figure 13.10.

Labor market is newly introduced in this model. Therefore, our analyses in what follows are focused on the behaviors of GDP gap and unemployment. Figure 13.11 illustrates detailed behaviors of the GDP gap ratio and unemployment rate at the almost equilibrium states. Both figures tend to converge less than 1% after the year 5, and can be well regarded as the states of almost equilibria.

In what follows, these equilibrium states are used as benchmarking states of the comparison, and illustrated by line 2 or red lines in Figures.

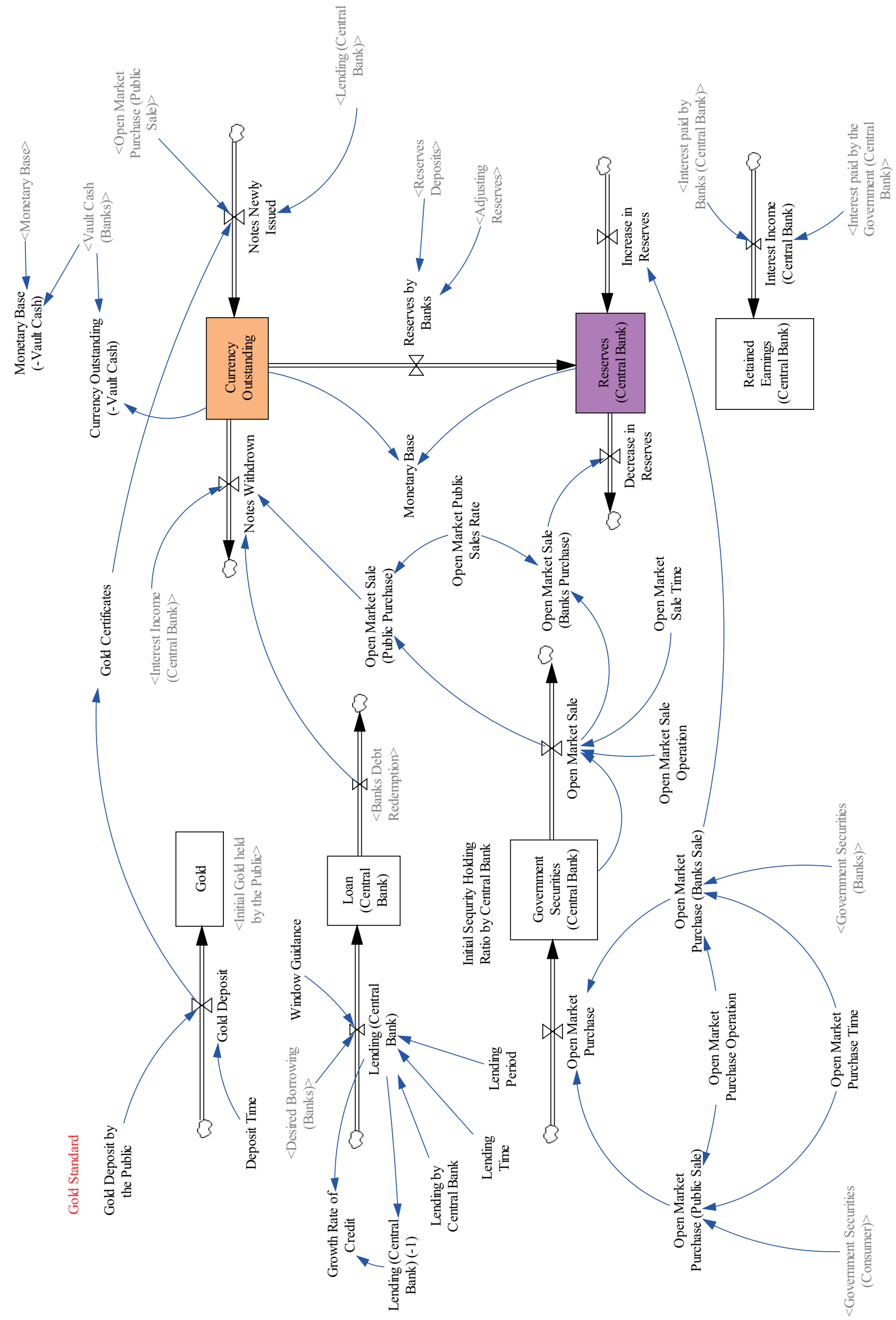

Figure 13.9: Transactions of Central Bank

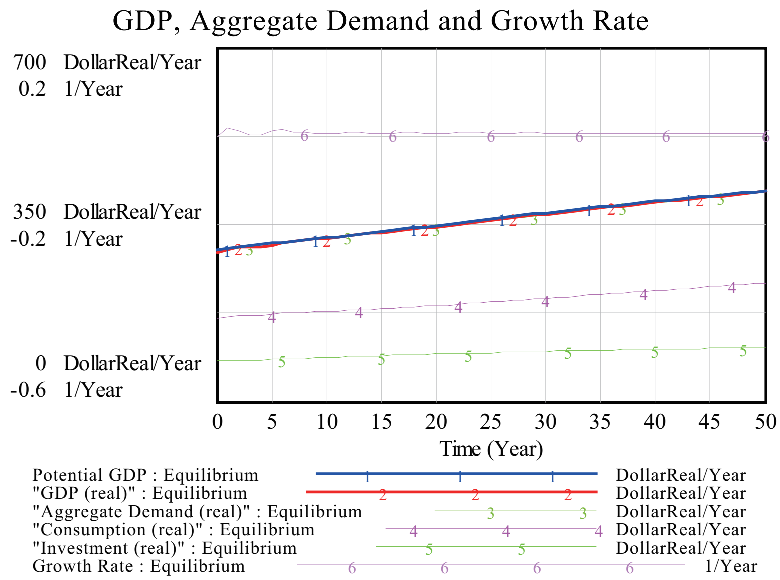

Figure 13.10: Mostly Equilibrium States

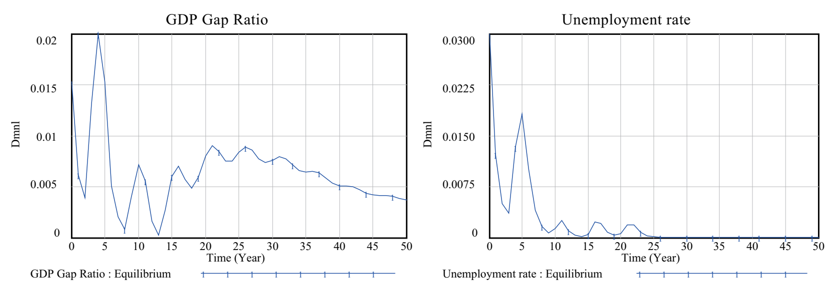

Figure 13.11: GDP Gap Ratio and Unemployment Rate of the Equilibrium States

Fixprice Disequilibria

We are now in a position to make some analytical simulations for the model. First, let us show that without price flexibility it's hard to attain mostly equilibrium states. When price is fixed; that is, price coefficient is set to be zero, disequilibria begin to appear all over the period. Left-hand diagram of Figure 13.12 illustrates how fixprice causes to expand GDP gap to 17% at the year 50. Right-hand diagram shows the unemployment rate fluctuates with its peak of 3.8% at the year 7. In this way under fixprice the economy seems to stagger.

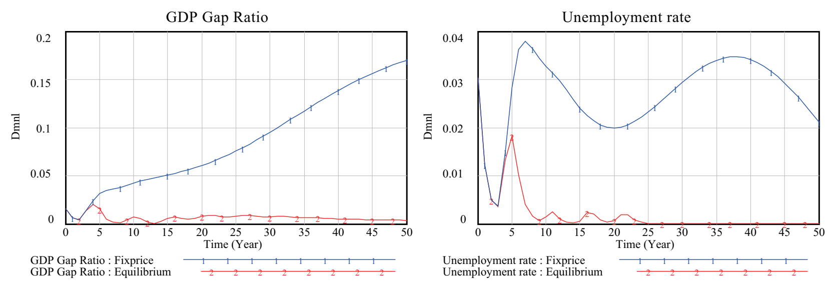

Figure 13.12: Fixprice and Mostly Equilibrium States

Business Cycles by Inventory Coverage

From now on, let us start our analyses with the mostly equilibrium path. One of the interesting questions is to find out a macroeconomic structure that may produce economic fluctuations or business cycles. How can the mostly equilibrium growth path be broken and business cycles will be triggered?

Our complete macroeconomic model can successfully produce at least two different ways of causing macroeconomic fluctuations as in the previous chapter; that is, changes in inventory coverage and price fluctuation. Firstly, they can be caused by increasing normal inventory coverage period. Specifically, suppose the normal inventory coverage now increases to 0.5 or 6 months instead of the initial value of 0.1 or 1.2 month. The economy, then, begins to be troubled with short period's business cycles of 6 or 7 years as Figure 13.13 portrays.

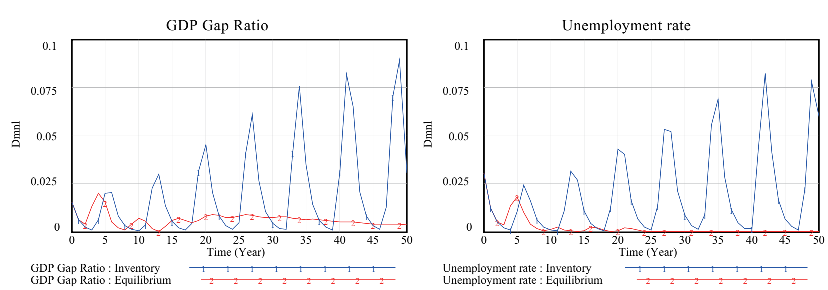

Figure 13.13: Business Cycles caused by Inventory Coverage

Business Cycles by Elastic Price Fluctuation

Secondly, the equilibrium growth path can also be broken and business cycle is triggered, in a totally different fashion, by price fluctuation. Price can be fluctuated by changes in its elasticity and cost-push factor such as changes in wage rate. Let us consider the former first by assuming that a price response to the excess demand for products becomes more sensitive so that output ratio elasticity now becomes elastic with a value of 1.6 from 1, and a weight of inventory ratio to the effect on price becomes 0.6 from 0.1. Again, the economy is thrown into business cycle as depicted in Figure 13.14.

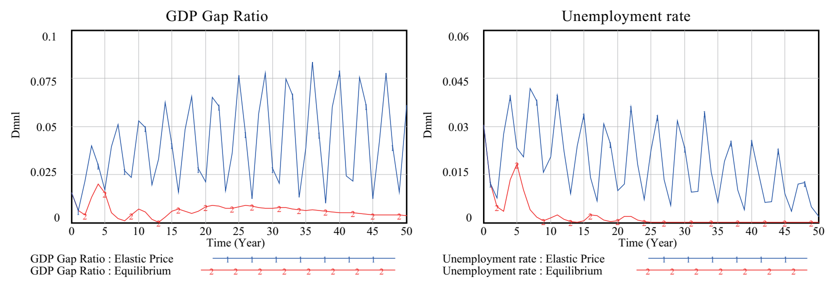

Figure 13.14: Business Cycles caused by Elastic Price Fluctuation

Business Cycles by Cost-push Price

Since price adjustment process is revised in equation (13.30), there exists another way to affect price fluctuation, this time, by the cost-push changes in nominal wage rate. Specifically, cost-push(wage) coefficient is now set to be 0.18 from 0. Again, the economy is thrown into business cycle as depicted in Figure 13.15.

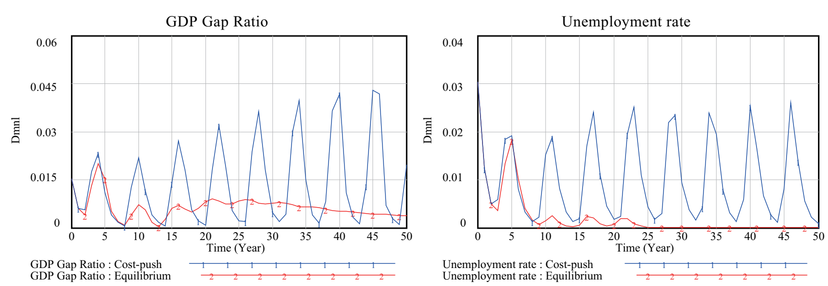

Figure 13.15: Business Cycles caused by Cost-push Price

It would be worth examining this case of business cycle furthermore. Figure 13.16 illustrates the fluctuations of price, nominal wage rate and unemployment rate triggered by cost(wage)-push fluctuations. Price and wage rate fluctuate in the same direction, while GDP gap and unemployment rate fluctuate counter-cyclically against price and wage fluctuations. In other words, when price and wage rates increase, GDP gap and unemployment rate decrease, and vise versa. Moreover, it is observed that GDP gap cycle is always followed by unemployment rate cycle.

In standard textbooks, these relations are presented by the so-called Okun's law and Phillips curve. Specifically, Okun's law describes a relation between real

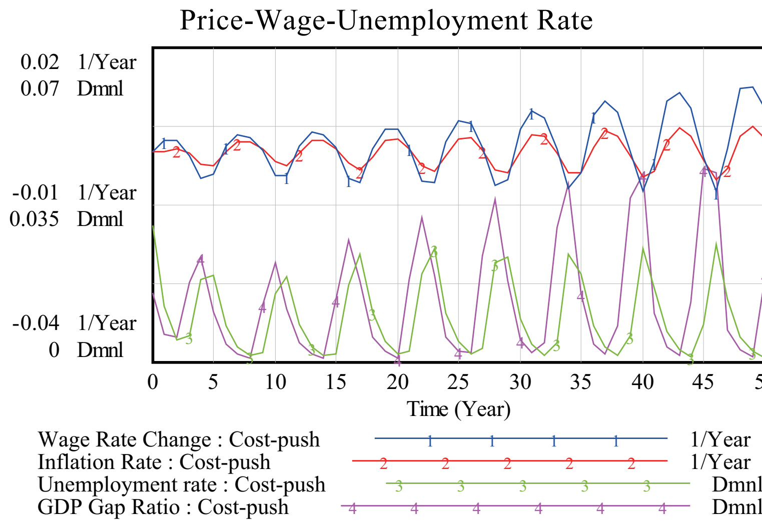

Figure 13.16: Wage, Inflation and Unemployment Rates and GDP Gap

growth rate and unemployment rate, while Phillips curve describes a relation between inflation rate and unemployment rate (Figure 13.17).

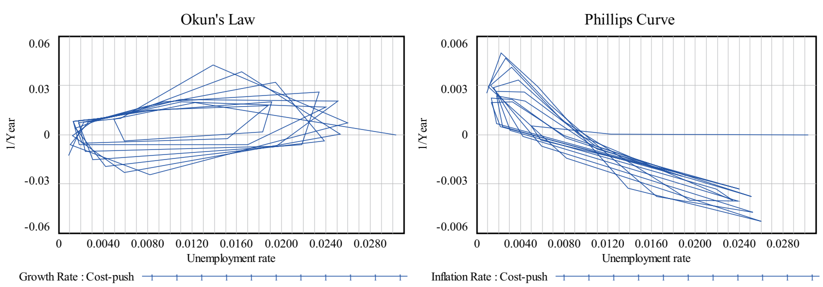

Figure 13.17: Okun's Law and Phillips Curve

In this way, two similar business cycles are triggered, out of the same almost equilibrium growth path, by two different causes; one by an increase in inventory coverage period, and the other by the price and wage changes. The ability to produce these different behaviors of business cycles and economic fluctuations indicates a richness of our macroeconomic generic model.

Recessions by Credit Crunch (Window Guidance)

With the introduction of discount credit loans to banks, the central bank seems to have acquired an almighty power to control credit. The power has been overlooked in standard textbooks. This hidden exerting power has been known in Japan as "window guidance".

To demonstrate how influential the power is, let us suppose that the central bank reduces the amount of discount credit loans by 30%; that is, window guidance value is reduced to 0.7 from 1. In other words, banks can borrow only 70% of the desired amount of borrowing from the central bank.

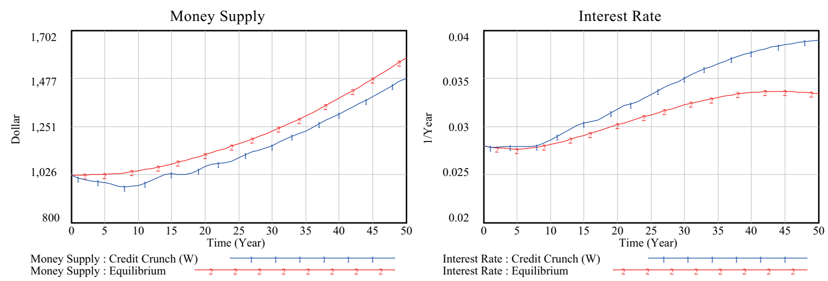

Figure 13.18: Supply of Money and Interest Rate by Credit Crunch

Figure 13.18 illustrates how supply of money shrinks and, accordingly, interest rate increases by the credit crunch caused by the central bank. Figure

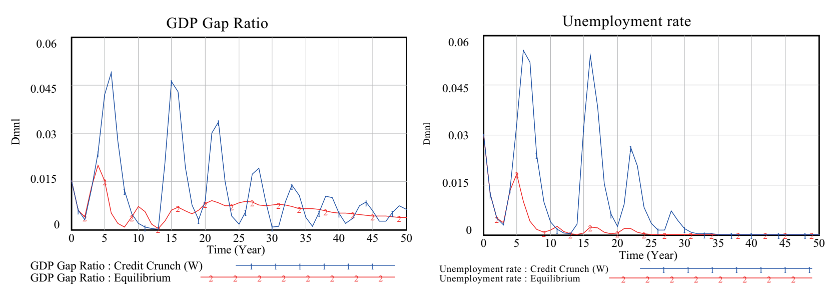

Figure 13.19: Economic Recessions caused by Credit Crunch

13.19 demonstrates that the economy is now deeply triggered into recession in the sense that GDP gaps under credit crunch appear as another business cycles, followed by similar unemployment rate cycles. It is a surprise to observe that economic recessions are provoked by the intentional credit crunch of the central bank in addition to the business cycles as shown above.

As discussed above, growing economy needs new currency to be incessantly put into circulation. If the central bank, instead of the government, is historically endowed with this important role, savvy control of credits by the central bank becomes crucial for the stability and growth of macroeconomy as demonstrated here.

Depressions by Credit Crunch (Window Guidance & Currency Ratio)

As already confirmed, credit crunch can be further worsened if the public rush to the banks to withdraw their deposits, a so-called *bank run*. To see this impact, let us consider the above economic recessions triggered by the above credit crunch of window guidance (=0.7), in which economic growth rate plunges to -2.6% at the year 15. Under such a recession, let us further assume that bank runs arise all over. In our model this can be simulated by increasing a currency ratio by 0.2 at the year 12 when economic growth starts to go down faster. Figure 13.20 illustrates how currency in circulation jumps (line 3) and deposits plummets (line 3), compared with equilibrium states (lines 2) and credit crunch (lines 1).

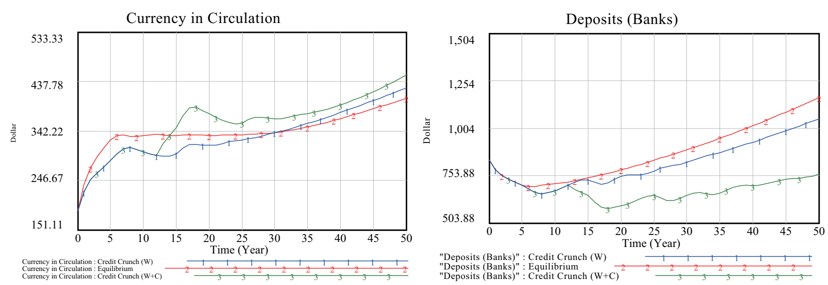

Figure 13.20: Currency in Circulation and Deposits by Bank Run

These changes affect overall behavior of money stock, specifically it is decreased as indicated by the left diagram of Figure 13.21 (line 3), which in turn worsens the GDP growth and causes depressions as shown by the right diagram of Figure 13.21 (line 3).

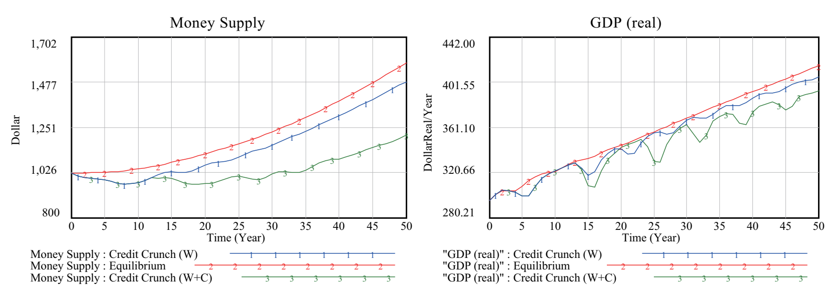

Figure 13.21: Supply of Money and Depression by Bank Run

GDP gap ratio jumps to 9.6% at the year 16 from 5.3% caused by the previous recession at the year 15 as illustrated in the left diagram of Figure 13.22 (line 3). Meanwhile, unemployment rate reaches to 9.2% at the year 16 from the previous recession of 4.9% at the same year as shown in the right diagram of Figure 13.22 (line 3). Indeed, these recessions are appropriately called *Depression*.

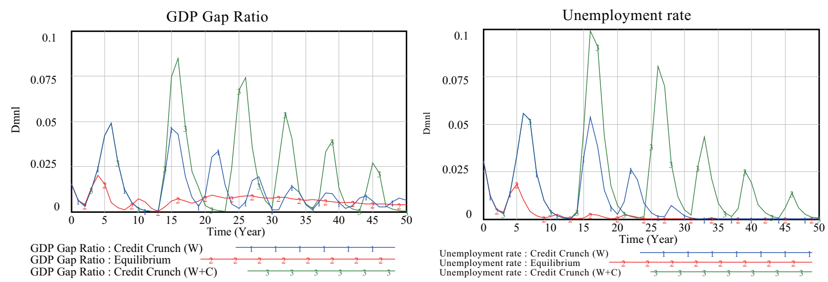

Figure 13.22: Depression by Bank Run

As already discussed in the previous chapter, during the Great Depression in 1930s, currency in circulation continued to increase from 4.52 $ billion in 1930 to 5.72 $ billion in 1933, while demand deposits continued to decline from 22.0 $ billion to 14.8 $ billion during the same period. As a result, money stock of M1 (about the sum of currency in circulation and demand deposits) also continued to decline from 25.8 $ billion to 19.9 $ billion.

Our simulation results may support these monetary behaviors of the Great Depression.

Monetary and Fiscal Policies for Equilibrium

So far, we have examined several states of disequilibria caused by fixprice and business cycles. Can we restore equilibrium, then ? According to the Keynesian theory, the answer is affirmative if fiscal and monetary policies are appropriately applied.

To answer the question, let us start with the case of fixprice disequilibria and consider monetary policy, first, for the restoration of equilibria. Suppose the central bank increases the purchase of government securities by 15% for 10 years starting at the year 6 (see the top left diagram of Figure 13.23). Then, money stock continues to grow gradually, and interest rate eventually starts to decrease (see top right diagram.). These changes in the monetary sector will eventually restore full capacity GDP at the year 22 through the year 39 for 18 years, and almost full employment equilibria from the year 20 through the year 39 for 20 years. (see the bottom two diagrams).

Second scenario of restoring the equilibrium is to apply fiscal policy. In our model quite a few tools are available for fiscal policy such as changes in income tax rate, lump-sum taxes, excise rate, corporate tax rates and government expenditures. We employ here income tax rate. The reader can try other policy tools by running the model.

Facing the fixprice disequilibria, the government now decides to introduce an increase in income tax rate by 5%; that is, from the original 10% to 15 %,

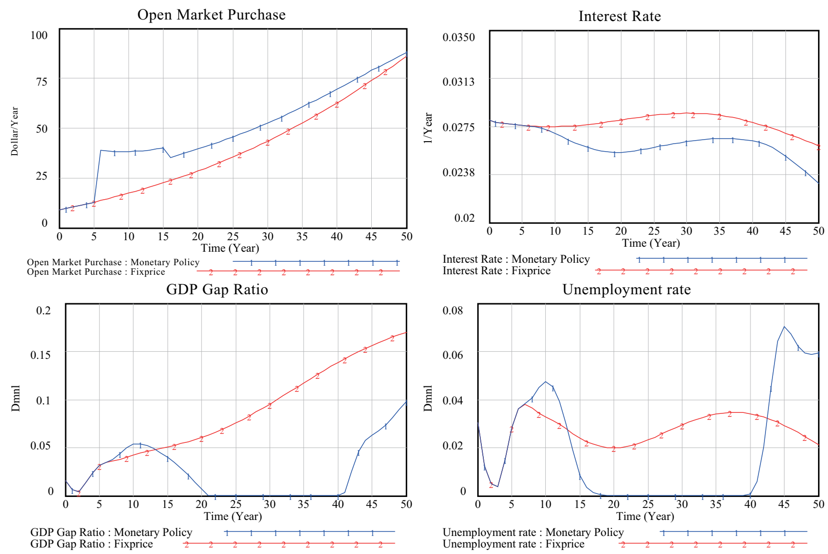

Figure 13.23: Monetary Policy of Open Market Purchase and GDP

at the year 15. Under the assumption of balanced budget, or a unitary primary balanced ratio, an increase in income tax also becomes the same amount of increase in government expenditure (see top left hand diagram in Figure 13.24).

This causes the increase in interest rate, which crowds out investment. Even so, aggregate demand is spontaneously stimulated to restore the full capacity GDP at the year 18 through the year 27 for 10 years, and almost full employment equilibrium at the year 19 through 28 for 10 years (see the bottom diagrams). Compared with the monetary policy, the effect of fiscal policy appears quickly in a couple of year.

In this way, our complete macroeconomic model can provide effective scenarios of sustaining full capacity and full employment equilibrium growth path through monetary and fiscal policies so long as they are timely applied.

Government Debt

So long as the equilibrium path in the real sector is attained by fiscal policy, no macroeconomic problem seems to exist. Yet behind the full capacity aggregate demand growth path attained in Figure 13.24, government debt continues to accumulate as the left diagram of Figure 13.25 illustrates. Primary balance ratio is initially set to one and balanced budget is assumed in our model; that is, government expenditure is set to be equal to tax revenues, as lines 1 and 2 overlap in the diagram. Why, then, does the government continue to suffer from the current deficit?

In the model government deficit is defined as

$$\text{Deficit} = \text{Tax Revenues - Expenditure - Debt Redemption - Interest} \quad (13.35)$$

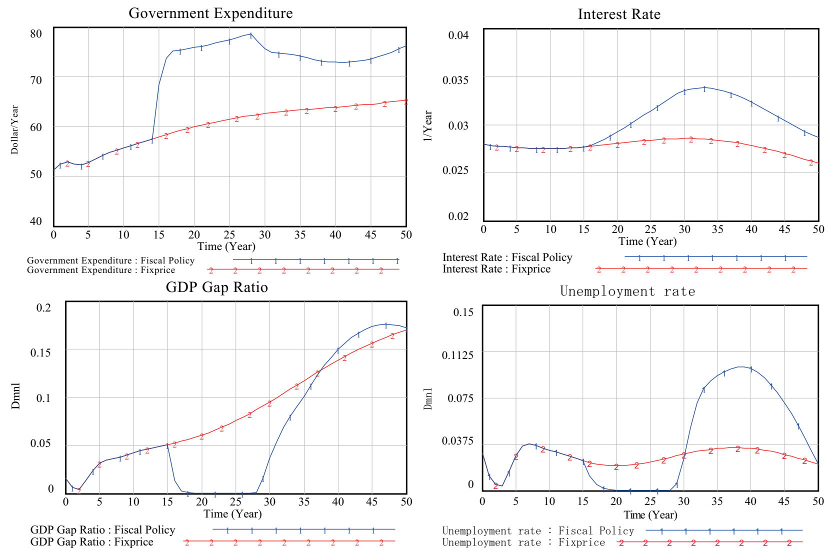

Figure 13.24: Fiscal Policy of a Change in Income Tax Rate and GDP

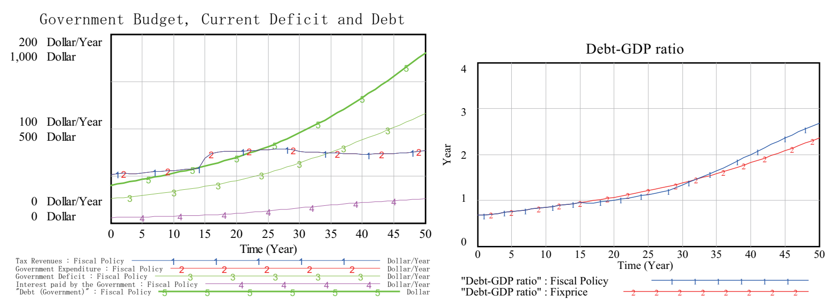

Figure 13.25: Accumulation of Government Debt

Therefore, even if balanced budget is maintained, the government still has to keep paying its debt redemption and interest. This is why it has to keep borrowing and accumulating its debt, a negative side of exponential growth in the current financial system. Initial GDP in the model is obtained to be 295, while government debt is initially set to be 200. Hence, the initial debt-GDP ratio is around 0.68 year (a little bit higher than the current ratios among EU countries). The ratio continues to increase to 2.7 years at the year 50 in the model as illustrated in the right diagram of Figure 13.25. This implies the government debt becomes 2.7 times as high as the annual level of GDP.

Can such a high debt be sustained? Absolutely no. Eventually this runaway accumulation of government debt may cause nominal interest rate to increase, because the government may be forced to pay higher and higher interest rate in order to keep borrowing, which may in turn launch a hyper inflation[4].

On the other hand, a higher interest rate may trigger a sudden drop of government security price, deteriorating the value of financial assets of banks, producers and consumers. The devaluation of financial assets may force some banks and producers to go bankrupt eventually. In this way, under such a hyper inflationary circumstance, financial crisis becomes inevitable and government is destined to collapse. This is one of the hotly debated scenarios about the consequences of the abnormally accumulated debt in Japan, whose debt-GDP ratio in 2010 is about 1.97 years; the highest among OECD countries!

Let us now consider how to avoid such a financial crisis and collapse. At the year 15 when fiscal policy is introduced to restore a full capacity aggregate demand equilibrium in the model, the economy seems to have gotten back to a right track of sustained growth path. And most macroeconomic textbooks emphasize this positive side of fiscal policy. A negative side of fiscal policy is the accumulation of debt for financing the government expenditure. Yet most macroeconomic textbooks neglect or less emphasize this negative side, partly because their macroeconomic framework cannot handle this negative side effect properly as our complete macroeconomic model does here. In our example the debt-GDP ratio is 0.68 years at the introduction year of fiscal policy.

At the face of financial crisis as discussed above, suppose that the government is forced to reduce its debt-GDP ratio to around one by the year 50, To attain this goal, a primary balance ratio has to be reduced to 0.87 in our economy. In other words, the government has to make a strong commitment to repay its debts annually by the amount of 13 percent of its tax revenues. Let us assume that this reduction is put into action around the same time when fiscal policy is introduced; that is, the year 15. Under such a radical financial reform, as illustrated in Figure 13.26, debt-GDP ratio will be reduced to around one (right diagram) and the accumulation of debt will be eventually curved (left diagram).

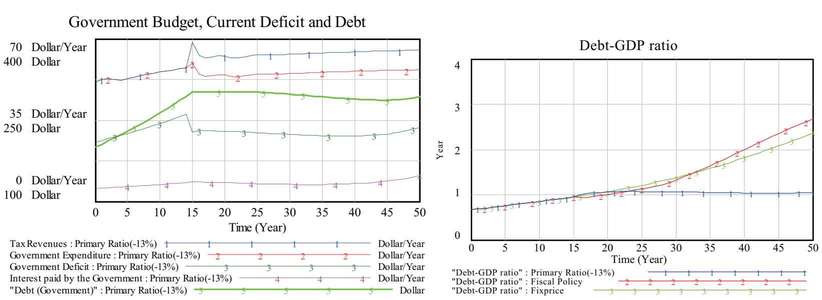

Figure 13.26: Government Debt Deduction

Even so, this radical financial reform becomes very costly to the government and its people as well. At the year of the implementation of 13 % reduction of a primary balance ratio, growth rate is forced to drop to minus 4.86%, and

[4]This feedback loop from the accumulating debt to the higher interest rate is not yet fully incorporated in the model.

the economy fails to sustain a full capacity and full employment equilibrium as illustrated by line 1 in Figure 13.27. In fact, GDP gap ratio continues to rise to 30% and unemployment rate peaks to 15.5% at the year 22. In other words, the reduction of the primary balance ratio by 13% totally nullifies the attained full capacity and full employment equilibrium by fiscal policy. The same diagrams compare three states of GDP; line 3 is when price is fixed, line 2 is when fiscal policy is applied, and line 1 is when primary balance ratio is reduced by 13%.

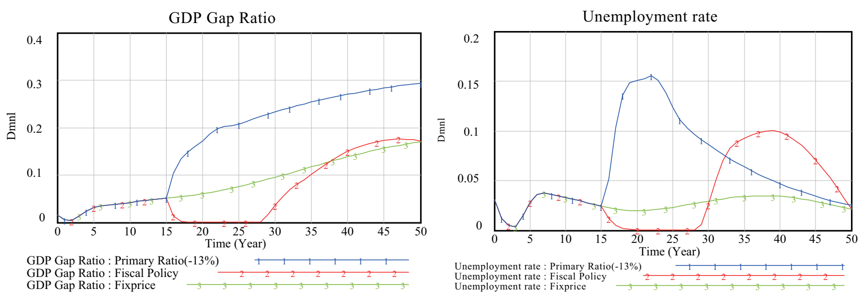

Figure 13.27: Effect of Government Debt Deduction

Price Flexibility

Is there a way to reduce government debt without sacrificing equilibrium? The monetary and fiscal policies introduced above are applied to the disequilibria caused by fixprice. Let us make price flexible again by setting price elasticity to be 1. Left diagram (line 1) of Figure 13.28 shows that GDP gap ratio is again reduced to be below 0.1, while right diagram (line 1) shows that unemployment rate gradually gets reduced to zero.

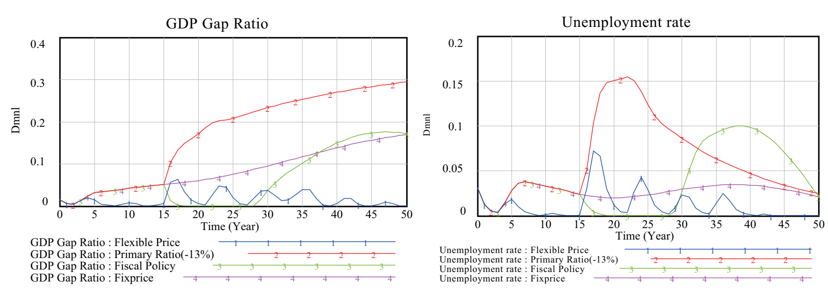

Figure 13.28: GDP Gap and Unemployment Rate under Price Flexibility

In this way, the reduction of the government debt by diminishing a primary balance ratio is shown to be possible without causing a sustained recession by introducing flexible price. A financial reform of this radical type seems to allude to a soft-landing solution path for a country with a serious debt problem such as Japan, so long as our SD simulation suggests, if a sudden collapse of the government and macroeconomy is absolutely to be avoided. Its success depends on how people can endure getting *worse before better*.

Figure 13.29 compares growth paths of the economy under several different situations among almost equilibrium (line 1), fixprice (line 2), fiscal policy (line 3), primary rate reduction (line 4) and flexible price (line 5). Compared with the almost equilibrium path (line 1), debt-reducing path (line 5) causes a business cycle. Yet, compared with another debt-deduction path (line 4), this seems a better path.

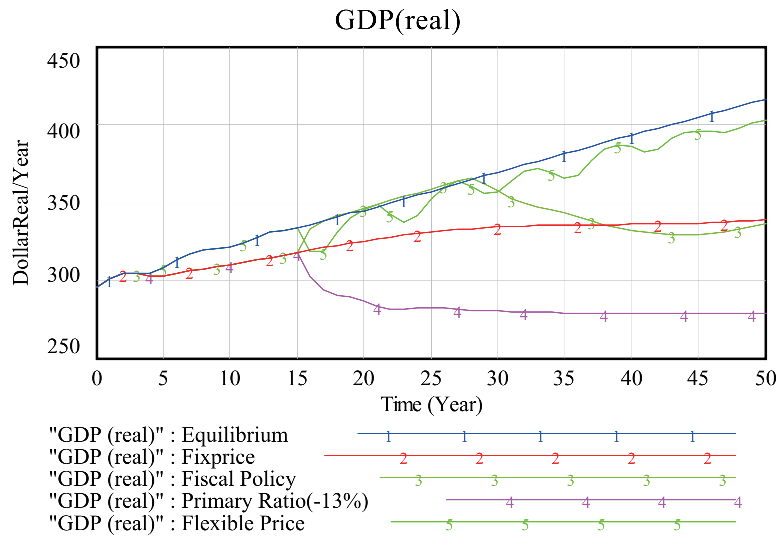

Figure 13.29: Comparison of GDP paths

13.6 Conclusion

Labor market is newly brought to the integrated model of the real and monetary sectors that is analyzed in the previous chapter. Accordingly, several changes are made in this chapter to make the model a complete macroeconomic model. First, production function is revised as Cobb-Douglas production function. Second, population dynamics is added and labor market is newly introduced. This also enables the price adjustment process by cost-push forces.

Under such a complete macroeconomic model, five macroeconomic sectors are brought to the model such as producers, consumers, government, banks and the central bank. The model becomes generic in the sense that diverse macroeconomic behaviors will be produced within the same model structure.

To show such a capability, some macroeconomic behaviors are discussed in this chapter. First, the existence of mostly equilibria is shown. Second, disequilibria are triggered by fixprice and business cycles caused by two different characteristics; inventory coverage period, and flexible and cost-push prices.

Then, economic recession is also shown to be triggered by the credit crunch intentionally caused by the central bank.

Finally, it is demonstrated how these business cycles and economic recessions could be overcome by monetary and fiscal policies. Specifically, Keynesian monetary and fiscal policies are applied to the disequilibria caused by fixprice. In addition, accumulating government debt issue is explored.

As demonstrated by these analyses, we believe the complete macroeconomic model presented here will provide a foundation for the analysis of diverse macroeconomic behaviors.

Part V

Open Macroeconomic Systems of Debt Money

Chapter 14

Balance of Payments and Foreign Exchange

This chapter[1] explores a dynamic determination process of foreign exchange rate in an open macroeconomy in which goods and services are freely traded and financial capital flows efficiently for higher returns. For this purpose it becomes necessary to employ a new method contrary to a standard method of dealing with a foreign sector as adjunct to macroeconomy; that is, an introduction of another macroeconomy as a foreign sector. Within this new framework of open macroeconomy, transactions among domestic and foreign sectors are handled according to the principle of accounting system dynamics, and their balance of payments is attained. For the sake of simplicity of analyzing foreign exchange dynamics, macro variables such as GDP, its price level and interest rate are treated as outside parameters. Then, eight scenarios are produced and examined to see how exchange rate, trade balance and financial investment, etc. respond to such outside parameters. To our surprise, expectations of foreign exchange rate turn out to play a crucial role for destabilizing trade balance and financial investment. The impact of official intervention on foreign exchange and a path to default is also discussed.

14.1 Open Macroeconomy as a Mirror Image

As a natural step of the research, we are now in a position to open our macroeconomy to a foreign sector so that goods and services are freely traded and financial assets are efficiently invested for higher returns. The analytical method employed here is the same as the previous chapters; that is, the one based on the principle of accounting system dynamics.

[1] It is based on the paper: Balance of Payments and Foreign Exchange Dynamics – SD Macroeconomic Modeling (4) – in "Proceedings of the 24th International Conference of the System Dynamics Society", Boston, USA, July 29 - August 2, 2007. (ISBN 978-0-9745329-8-1)

The method requires to manipulate all transactions among macroeconomic sectors, and when applied to a foreign sector, it turns out to be necessary to introduce another macroeconomy as a reflective image of domestic macroeconomy. Contrary to a method employed in standard international economics textbooks such as Krugman and Obstfeld (2006) and Mankiw (2016), a foreign sector is no longer treated as an additional macroeconomic sector adjunct to a domestic macroeconomy [Companion Model: ForeignExchange.vpmx].

To understand this, for instance, consider a transaction of importing goods. They add to the inventory of importers (a red disk numbered 1 in Figure 14.2 below), while the same amount is reduced from the inventory of foreign exporters (a red disk numbered 4 in Figure 14.3 below). To pay for the imported goods, importers withdraw their deposits from their bank and purchase foreign exchange, (red disks numbered 2 and 3 in Figures 14.2 and 14.5 below), which is then sent to the deposit account of foreign exporters' bank that will notify the receipts of export payments to exporters (red disks numbered 3 and 4 in Figures 14.6 and 14.3 below). In this way, a mirror image of domestic macroeconomy is needed for a foreign country as well to describe even domestic transaction processes of goods and services. Similar manipulations are also needed for the transactions of foreign direct and financial investment. Figure 14.1 expresses our image of modeling open macroeconomy by the principle of accounting system dynamics.

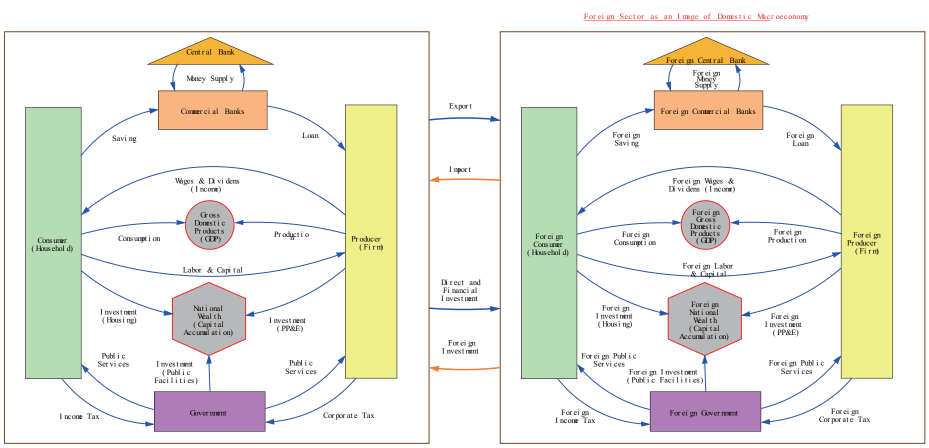

Figure 14.1: Foreign Sector as a Mirror Image of Domestic Macroeconomy

14.2 Open Macroeconomic Transactions

Modeling open macroeconomy was hitherto considered to be easily completed by merely adding a foreign sector. The introduction of a foreign country as a mirror image of domestic macroeconomy makes our analysis rather complicated. To overcome the complexity, we are forced, in this chapter, to focus only on a mechanism of the transactions of trade and foreign investment in terms of the balance of payments and dynamics of foreign exchange rate. For this purpose, transactions among five domestic sectors and their counterparts in a foreign country are simplified as follows.

Producers

Major transactions of producers are, as illustrated in Figure 14.2, summarized as follows.

- GDP (Gross Domestic Product) is assumed to be determined outside the economy, and grows at a growth rate of 2% annually.

- Producers are allowed to make direct investment abroad as well as financial investment out of their financial assets consisting of stocks, bonds and cash[2], and receive investment income from these investment abroad. Meanwhile, they are also required to pay foreign investment income (returns) to foreign investors according to their foreign financial liabilities and equity.

- Producers now add net investment income (investment income received less paid) to their GDP revenues (the added amount is called GNP (Gross National Product)), and deduct capital depreciation (the remaining amount is called NNP (Net National Product)).

- NNP thus obtained is completely paid out to consumers, consisting of workers and shareholders, as wages to workers and dividend to shareholders.

- Producers are thus constantly in a state of cash flow deficits. To make new investment, therefore, they have to borrow money from banks, but for simplicity no interest is assumed to be paid to the banks.

- Producers imports goods and services according to their economic activities, the amount of which is assumed to be 10% of GDP in this chapter.

- Similarly, their exports are determined by the economic activities of a foreign country, the amount of which is also assumed to be 10% of foreign GDP.

- Foreign producers are assumed to behave similarly as a mirror image of domestic producers as illustrated in Figure 14.3.

[2]In this chapter, financial assets are not broken down in detail and simply treated as financial assets. Hence, returns from financial investment are uniformly evaluated in terms of deposit returns.

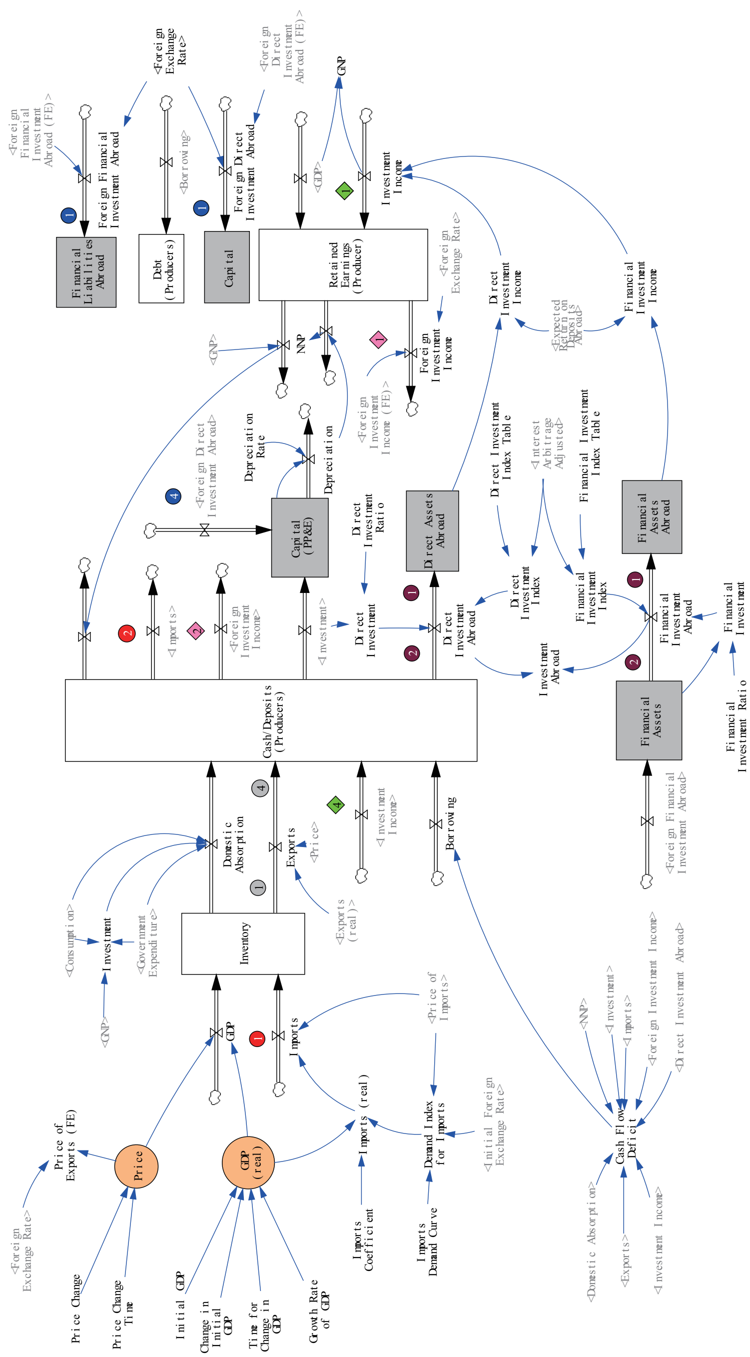

Figure 14.2: Transactions of Producers

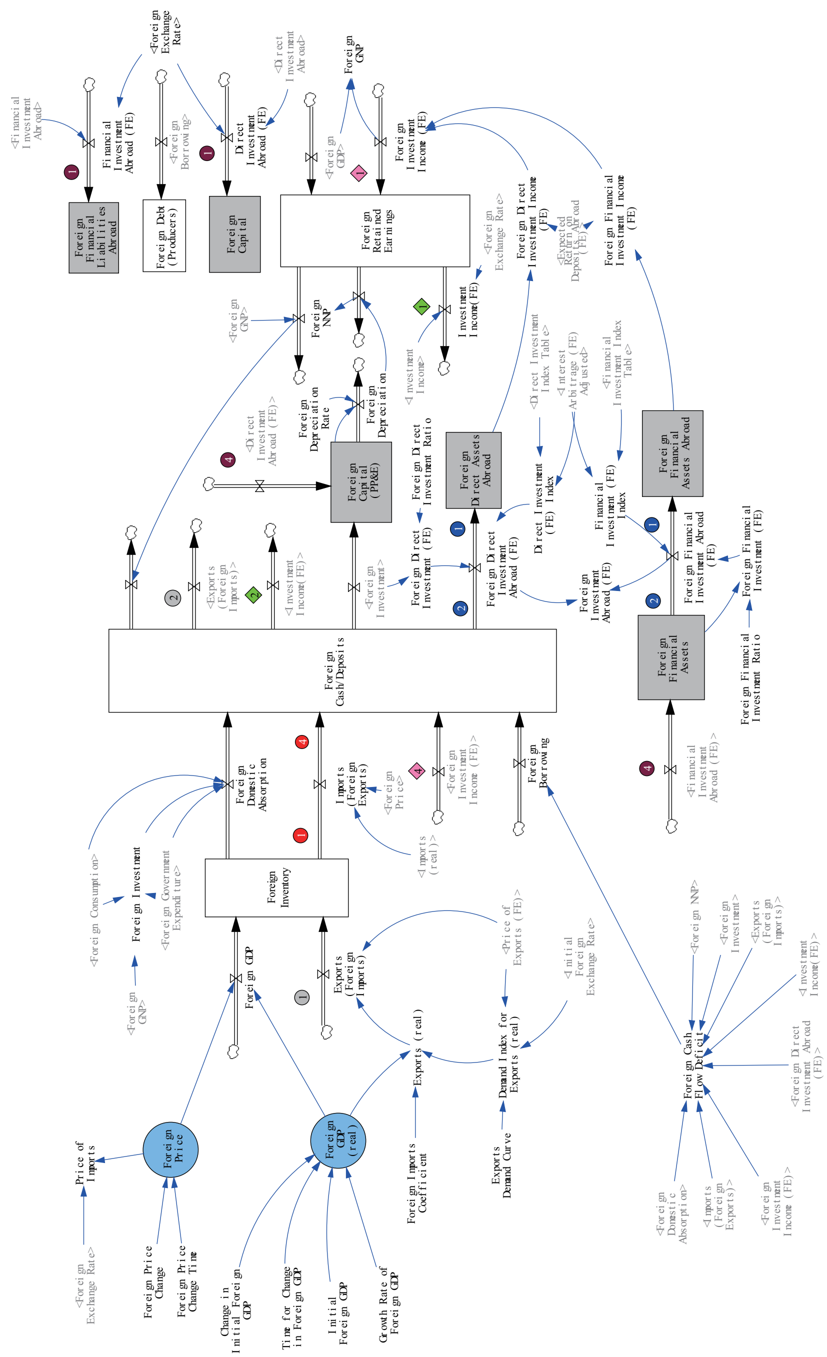

Figure 14.3: Transactions of Foreign Producers

Consumers and Government

Transactions of consumers and government are illustrated in Figure 14.4, some of which are summarized as follows.

- Consumers receive the amount of NNP as income, out of which 20% is levied by the government as income tax. The remaining amount becomes their disposable income.
- Consumers spend 60% of their disposable income and save the remaining as deposits with banks.
- Government only spends the amount it receives as income tax, and its budget is assumed to be in balance.

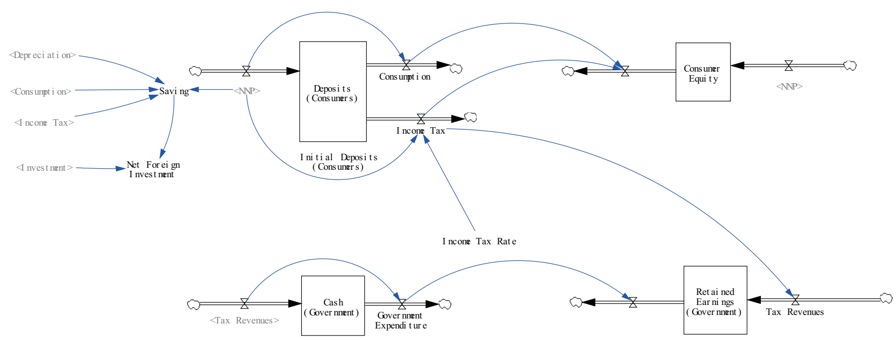

Figure 14.4: Transactions of Consumers and Government

Banks

Transactions of banks are illustrated in Figure 14.5, some of which are summarized as follows.

- Banks receive deposits from consumers and make loans to producers.
- Banks are obliged to deposit a portion of the deposits as required reserves with the central bank, but such activities are not considered in this chapter.
- Banks buy and sell foreign exchange at the request of producers and the central bank.
- Their foreign exchange are held as bank reserves and evaluated in terms of book value. In other words, foreign exchange reserves are not deposited with foreign banks. Thus net gains realized by the changes in foreign exchange rate become part of their retained earnings (or losses).

- Foreign currency is assumed to play a role of *key* currency or *vehicle* currency. Accordingly foreign banks need not set up foreign exchange account. This is a point where a mirror image of open macroeconomic symmetry breaks down, as illustrated in Figure 14.6.

Central Bank

In the integrated model of the previous chapter, the central bank played an important role of providing a means of transactions and store of value; that is, currency, and its sources of assets against which currency is issued were assumed to be gold, loan and government securities. Transactions of the central bank here are exceptionally simplified, as illustrated in Figure 14.7, so long as necessary for the analytical purpose in this chapter.

- The central bank can control the amount of money stock through monetary policies such as the manipulation of required reserve ratio and open market operations. However, such a role of money stock by the central bank is not considered here.

- The central bank is allowed to intervene foreign exchange market; that is, it can buy and sell foreign exchange to keep a foreign exchange ratio stable. These transactions are manipulated with commercial banks, which inescapably change the amount of currency outstanding and, hence, money stock. In this chapter, however, such an effect of money stock on interest rate is assumed to be out of consideration.

- Foreign exchange reserves held by the central bank is assumed to be deposited with foreign banks so that it receives interest payments.

- The central bank of foreign country is excluded simply because foreign currency is assumed to be a *vehicle* currency, and it needs not to hold foreign reserves (that is, its own currency) to stabilize its own exchange rate in this simplified open macroeconomy.

14.3 The Balance of Payments

All transactions with a foreign country such as foreign trade and foreign investment (that is, payments and receipts of foreign exchange) are booked according to a double entry bookkeeping rule, and such a bookkeeping record is called the balance of payments. According to Krugman and Obstfeld (2006) in page 295, all payments are recorded in the debit side with a minus sign, while all receipts are recorded in the credit side with plus sign. Hence, by definition, the balance of payments are kept in balance all the time. It consists of current account, capital and financial account, and net official reserve assets.

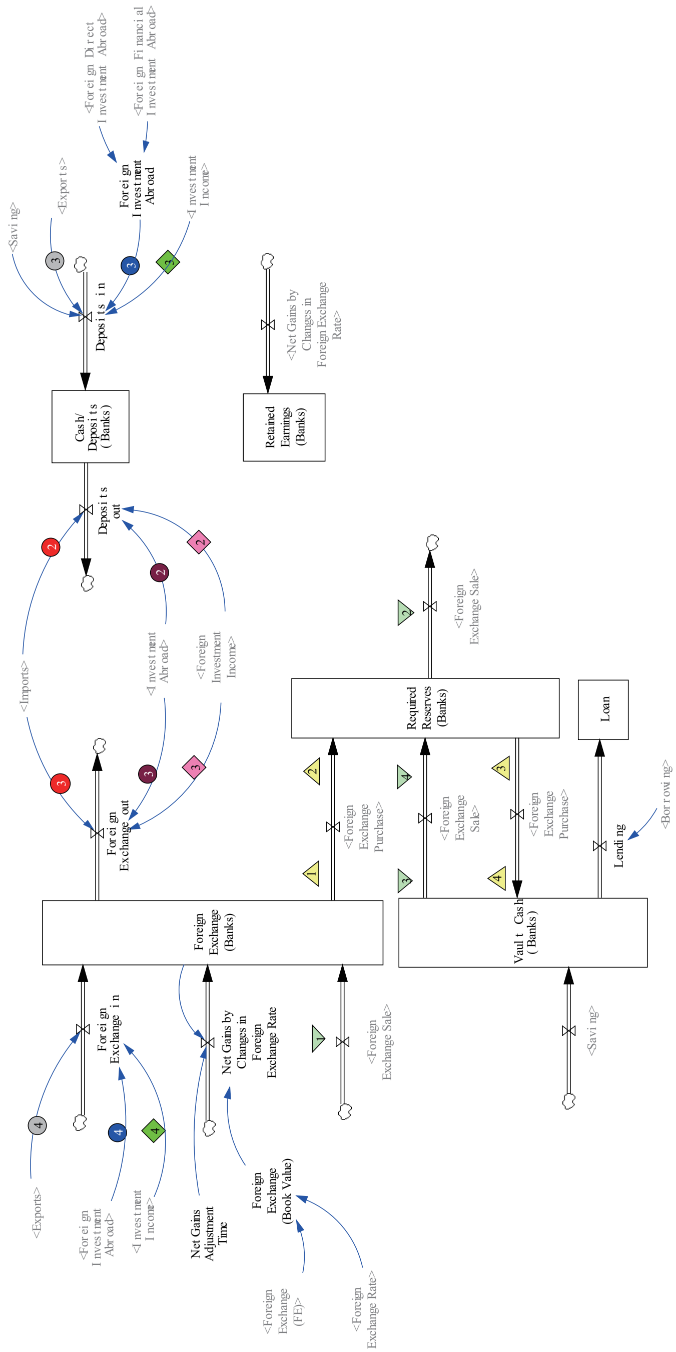

Figure 14.5: Transactions of Banks

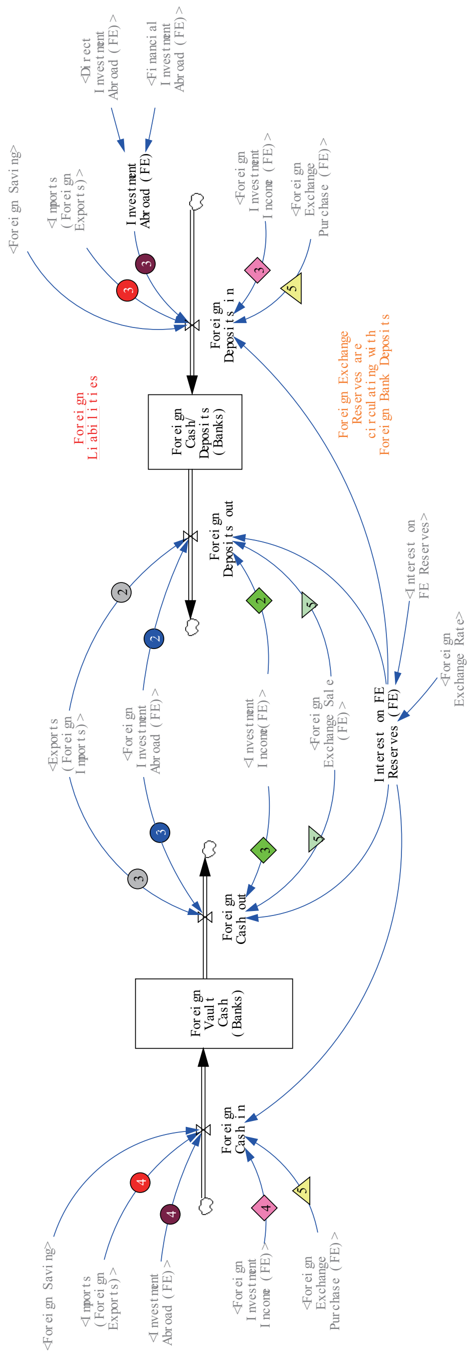

Figure 14.6: Transactions of Foreign Banks

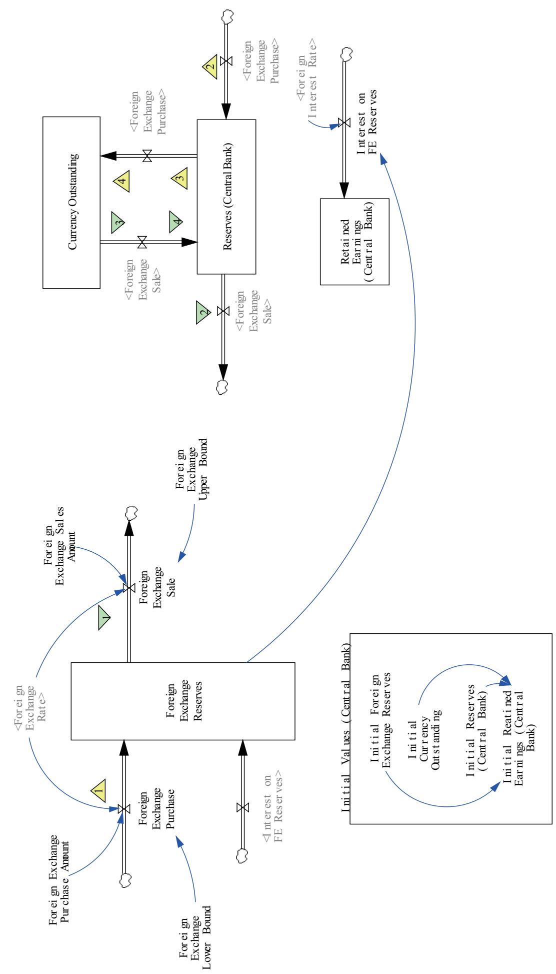

Figure 14.7: Transactions of the Central Bank

Current account consists of trade balance of goods and services and net investment income. Capital account is an one-way transfer of fund by the government that is excluded from our analysis here. Financial account consists of direct and financial foreign investment. Figure 14.8 illustrates all transactions which enter into the balance of payments account.

Figure 14.9, obtained from one of our simulation runs, displays relative positions of current account, capital and financial account, and net official reserve assets (or changes in reserve assets). A numerical value of the balance of payments is shown in the figure as being in balance all the time; that is a zero value.

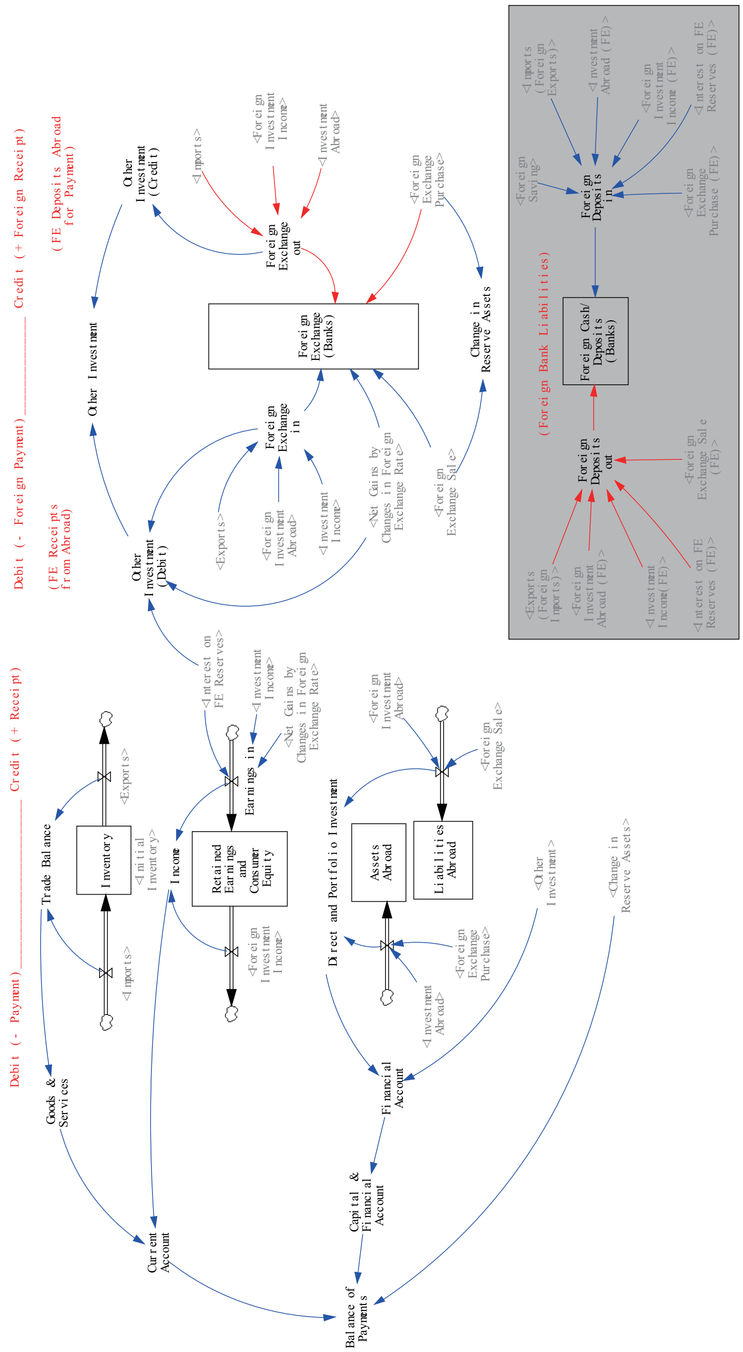

Figure 14.8: The Balance of Payments

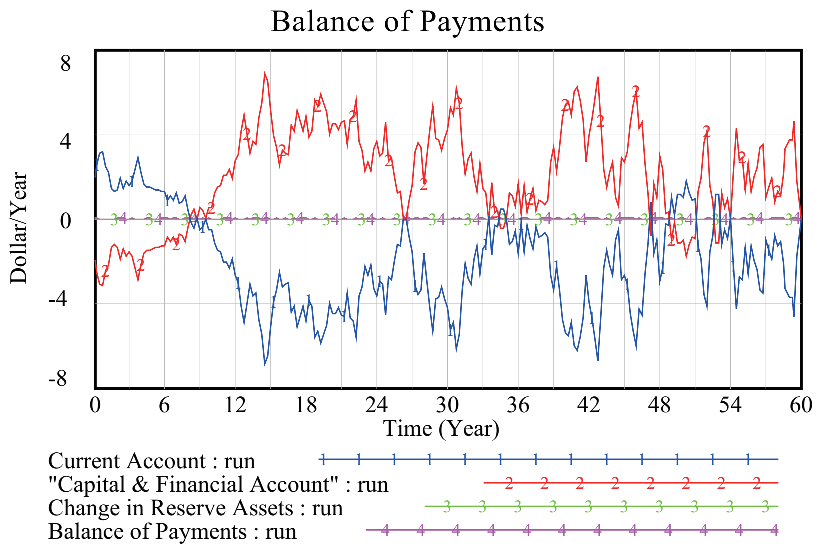

Figure 14.9: A Simulation of Balance of Payments

14.4 Determinants of Trade

Let M and X be real imports and exports, and Y and P be real GDP and its price level, respectively. Counterpart variables for a foreign country is denoted with a subscript f. A foreign exchange rate E is defined as a price of foreign currency (which has a unit of FE here) in terms of domestic dollar currency; for instance, 1.2 dollars per FE. Then, a price of imports is calculated as $P_M = P_f E$.

Imports are here simply assumed to be a function of real GDP and price of imports such that

$$M = M(Y, P_M), \text{ where } \frac{\partial M}{\partial Y} > 0 \text{ and } \frac{\partial M}{\partial P_M} < 0. \tag{14.1}$$

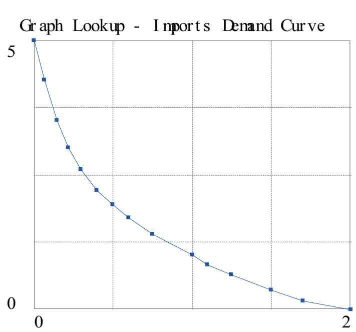

Figure 14.10: Normalized Demand Curve

This implies that imports increases as domestic economic activities, hence GDP expand, and decreases as price of imports rises as a standard downward-sloping demand curve conjectures. Figure 14.10 illustrates one of such demand curves employed in this chapter in which demand is normalized between a scale of zero and five on a vertical axis against a price level of between zero and two on a horizontal axis.

From these simple assumptions, we can

derive the following relations:

$$M = M(Y, P_M) = M(Y, P_f E), \qquad (14.2)$$

$$\frac{\partial M}{\partial P_f} = \frac{\partial M}{\partial P_M}\frac{\partial P_M}{\partial P_f} = \frac{\partial M}{\partial P_M}E < 0 \qquad (14.3)$$

$$\frac{\partial M}{\partial E} = \frac{\partial M}{\partial P_M}\frac{\partial P_M}{\partial E} = \frac{\partial M}{\partial P_M}P_f < 0 \qquad (14.4)$$

These relations imply that imports decrease as foreign price of imports increases and/or foreign exchange rate appreciates.

In our model, imports function is further simplified as a product of imports determined by the size of GDP and a normalized demand curve such that

$$M = M(Y, P_M) = M(Y)D(P_M) = mYD(P_f E) \qquad (14.5)$$

where m is a constant coefficient of imports on GDP.

Exports are nothing but imports of a foreign country, and similarly determined as a mirror image of domestic imports function such that

$$X = X(Y_f, P_{M,f}), \text{ where } \frac{\partial X}{\partial Y_f} > 0 \text{ and } \frac{\partial X}{\partial P_{M,f}} < 0. \qquad (14.6)$$

This implies that exports increase as foreign economic activities, hence foreign GDP, expand, and decreases as price of imports in a foreign country rises as a standard downward-sloping demand curve conjectures.

Price of imports in a foreign country is calculated by a domestic price and foreign exchange rate such that $P_{M,f} = P/E$. Hence, we obtain the following relations:

$$X = X(Y_f, P_{M,f}) = X(Y_f, P/E), \qquad (14.7)$$

$$\frac{\partial X}{\partial P} = \frac{\partial X}{\partial P_{M,f}}\frac{\partial P_{M,f}}{\partial P} = \frac{\partial X}{\partial P_{M,f}}\frac{1}{E} < 0 \qquad (14.8)$$

$$\frac{\partial X}{\partial E} = \frac{\partial X}{\partial P_{M,f}}\frac{\partial P_{M,f}}{\partial E} = \frac{\partial X}{\partial P_{M,f}}(-\frac{P}{E^2}) > 0. \qquad (14.9)$$

Thus, exports decrease as a domestic price rises. Meanwhile, whenever foreign exchange appreciates, our products become cheaper in a foreign country and exports increase.

Exports are similarly broken down as a product of foreign imports and normalized demand curve of foreign country, which is assumed to be exactly the same as domestic demand curve for imports.

$$X = X(Y_f, P_{M,f}) = X(Y_f)D(P_{M,f}) = m_f Y_f D(P/E) \qquad (14.10)$$

where m_f is a constant import coefficient of a foreign country.

Let us define trade balance as

$$TB(E; Y, Y_f, P, P_f) = X(E; Y_f, P) - M(E; Y, P_f) \tag{14.11}$$

Then we have

$$\frac{\partial TB}{\partial Y} = -\frac{\partial M}{\partial Y} < 0, \ \frac{\partial TB}{\partial Y_f} = \frac{\partial X}{\partial Y_f} > 0, \tag{14.12}$$

$$\frac{\partial TB}{\partial P} = \frac{\partial X}{\partial P} < 0, \ \frac{\partial TB}{\partial P_f} = -\frac{\partial M}{\partial P_f} > 0. \tag{14.13}$$

$$\frac{\partial TB}{\partial E} = \frac{\partial X}{\partial E} - \frac{\partial M}{\partial E} > 0. \tag{14.14}$$

The last relation indicates that a trade balance is an increasing function of foreign exchange rate. The relation is also confirmed in our model as illustrated in the two diagrams of Figure 14.11 in which upward-sloping blue curves are obtained from our simulation runs. As an mirror image, foreign trade balance is shown to be a decreasing function of foreign exchange rate, as indicated by downward-sloping red curves.

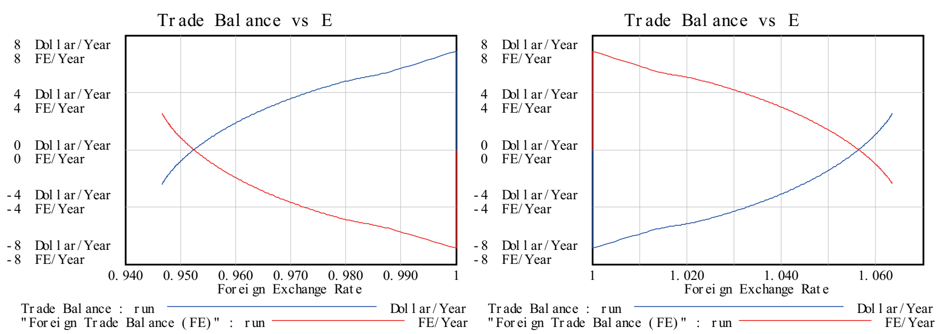

Figure 14.11: Trade Balance vs Foreign Exchange Rate

National Income Identity

Let us now briefly summarize our model in terms of national income account as follows:

$$Y = C(Y - T) + I + G + TB(E) \tag{14.15}$$

That is to say, GDP is the sum of consumption spending, investment, government expenditure and trade balance. In our model of foreign trade, investment is calculated to make this equation an identity all the time.

Private saving is defined as $S_p = Y - T - C$. Government saving is defined as $S_g = T - G$. Then national saving is obtained as a sum of these savings such that

$$S = S_p + S_g = Y - C - G, \tag{14.16}$$

which reduces to

$$S - I = TB(E). \tag{14.17}$$

Saving less investment is called net foreign investment, which is equal to trade balance. This becomes another way of describing the above national income identity in terms of net foreign investment and trade balance.

14.5 Determinants of Foreign Investment

Foreign investment consists of direct investment and financial investment such as stocks, bonds and cash, which constitute financial assets. In this chapter financial assets are not specified without losing generality as already mentioned in the footnote above. Foreign investments are here assumed to be determined on a principle of foreign exchange market efficiency under the uncovered interest rate parity (UIP) condition as explained in standard textbooks such as Krugman and Obstfeld (2006) and Sarno and Taylor (2002).

Let i and R be interest rate and a rate of return from financial investment, and E^e be an expected foreign exchange rate. A rate of return from a bank deposit is the same as the interest rate:

$$R = i \tag{14.18}$$

An expected return from a deposit with a foreign bank is calculated as

$$R_f = (1 + i_f)\frac{E^e}{E} - 1 \tag{14.19}$$

Thus we obtain

$$\frac{\partial R_f}{\partial E} = -\frac{(1 + i_f)E^e}{E^2} < 0 \tag{14.20}$$

$$\frac{\partial R_f}{\partial E^e} = \frac{(1 + i_f)}{E} > 0 \tag{14.21}$$

This implies that a rate of return from foreign financial investment decreases if foreign exchange rate appreciates, but it increases when foreign exchange rate is expected to appreciate.

Let us define an expected return arbitrage as

$$A(E, E^e; i, i_f) = R_f(E, E^e; i_f) - R(i) \tag{14.22}$$

and net capital flow(NCF) as

$$NCF = \text{Foreign Investment Abroad} - \text{Investment Abroad} \tag{14.23}$$

This is the amount of capital we receive from foreign country's investment less the amount we invest abroad. Under the assumption of an efficient financial market, if expected returns are greater in a foreign country and an expected return arbitrage becomes positive, then financial capital continues to outflow until the arbitrage ceases to exist. In a similar fashion, if expected returns are greater in a domestic market and an expected return arbitrage becomes negative, then financial capital continues to inflow until the arbitrage disappears. Hence, so long as a foreign exchange market is efficient, the relation between net capital flow and an expected return arbitrage become as follows:

$$\begin{cases} NCF < 0 & \text{if } A > 0 \\ NCF > 0 & \text{if } A < 0 \end{cases} \tag{14.24}$$

It is unrealistic, however, to assume an indefinite outflow of capital even if $A > 0$, or an indefinite inflow of capital even if $A < 0$. So it is assumed here that the maximum amount of direct and financial investment made available per year is a finite portion of domestic investment and financial assets. Yet, actual amount of financial investment is further assumed to be dependent on a level of an expected return arbitrage by its factor. Figure 14.12 illustrates table functions of investment levels that are assumed in our model in terms of expected return arbitrate.

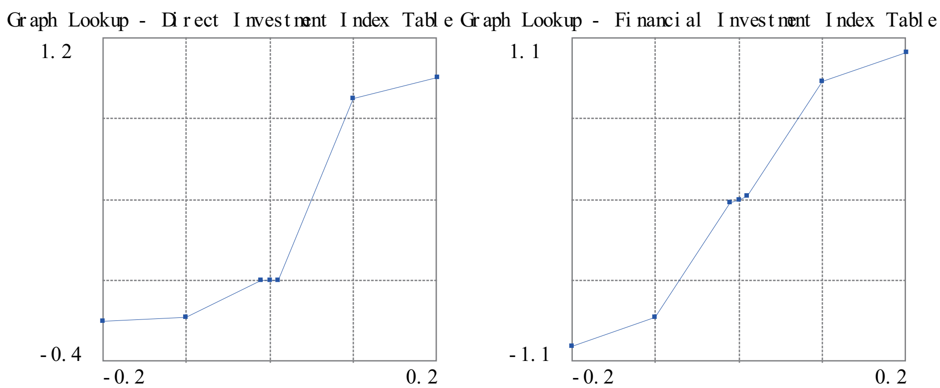

Figure 14.12: Direct and Financial Investment Indices

Specifically, left-hand diagram shows a table function of direct investment, which assumes that between the arbitrage range of -0.01 and 0.01 direct investment is not made. Right-hand diagram shows a table function of financial investment, which assumes that between the arbitrage range of -0.01 and 0.01 financial capital flows slowly between a portion of -0.02 and 0.02. These assumptions are made to reflects a realistic situation in which direct investment is not so sensitive to the arbitrage values compared with financial investment.

In this way net capital flow could be described as a function of an expected return arbitrage such that

$$NCF = NCF(A(E, E^e)), \text{ where } \frac{\partial NCF}{\partial A} < 0 \tag{14.25}$$

It is important to note, however, that this functional relation holds only in the neighborhood of equilibrium, so do the following relations as well.

$$\frac{\partial NCF}{\partial E} = \frac{\partial NCF}{\partial A}\frac{\partial A}{\partial E} = \frac{\partial NCF}{\partial A}\frac{\partial R_f}{\partial E} > 0 \tag{14.26}$$

$$\frac{\partial NCF}{\partial E^e} = \frac{\partial NCF}{\partial A}\frac{\partial A}{\partial E^e} = \frac{\partial NCF}{\partial A}\frac{\partial R_f}{\partial E^e} < 0 \tag{14.27}$$

Whenever a foreign exchange rate begins to appreciate, an expected return arbitrage declines, and capital begins to inflow, causing a positive net capital flow. When foreign exchange rate is expected to appreciate, an expected return arbitrage increases and capital begins to outflow, causing a negative net capital flow. In this way, changes in a foreign exchange rate and its expectations play a crucial role for financial investment.

It is examined in our model that these relations only hold in the neighborhood of equilibrium. In Figure 14.13, net capital flow is shown to be an

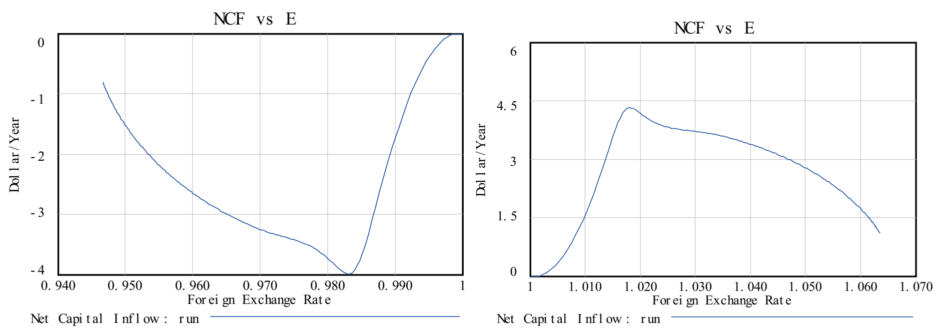

Figure 14.13: Net Capital Inflow vs Foreign Exchange Rate

increasing function only when a foreign exchange rate is around the equilibrium; that is, between 0.983 and 1.018. This may indicate a limitation of the above mathematical method of economic analysis which has been dominantly used in many textbooks. In other words, mutually interdependent economic behaviors cannot be fully captured unless they are simulated in a system dynamics model such as the one in this chapter.

14.6 Dynamics of Foreign Exchange Rates

How are the foreign exchange rate and its expectations determined, then? Foreign exchange rate is here simply assumed to be determined by the excess demand for foreign exchange; that is, a standard logic of price mechanism in economic theory. From the left-hand diagram of Figure 14.8, demand for foreign exchange is shown to stem from the need for payments due to imports, direct and financial investment abroad, and foreign investment income, as well as foreign exchange purchase by the central bank. Supply of foreign exchange results from the receipts from foreign country due to exports, foreign direct and financial investment abroad, and investment income from abroad, as well as foreign exchange sale by the central bank.

Hence, excess demand for foreign exchange is calculated as follows:

$$\begin{aligned}
& \text{Excess Demand for Foreign Exchange} \\
= \; & \text{Imports - Exports} \\
& + \text{Investment Abroad - Foreign Investment Abroad} \\
& + \text{Foreign Investment Income - Investment Income} \\
& + \text{Foreign Exchange Purchase - Foreign Exchange Sale} \\
= \; & - \text{Trade Balance } (TB) \\
& - \text{Net Capital Flow } (NCF) \\
& - \text{Net Investment Income } (NII) \\
& + \text{Net Exchange Reserves } (NER)
\end{aligned} \tag{14.28}$$

Net investment income is derived from the financial assets invested abroad and here assumed to be dependent only on domestic and foreign interest rates. Net exchange reserves depend on the official foreign exchange intervention. Therefore, NII and NER are not dependent on foreign exchange rate and its expectations.

With these relations taken into consideration, dynamics of foreign exchange rate is mathematically expressed as a function of excess demand for foreign exchange, which in turn becomes a function of E and E^e as follows:

$$\frac{dE}{dt} = \Psi(-TB(E) - NCF(E, E^e) - NII + NER) = \Psi(E, E^e) \tag{14.29}$$

On the other hand, a formation of expected foreign exchange rates is difficult to formalize. Here it is simply assumed that actual expectations of foreign exchange rate fluctuates randomly around the current exchange rate by the factor of random normal distribution of $N_{random}(m, sd)$ where (m, sd) denotes mean and standard deviation, and accordingly an expected foreign exchange rate is obtained as an adaptive expectation against the actual expectation of random normal distribution.

Mathematically, dynamics of the expected foreign exchange rate thus defined is described as

$$\frac{dE^e}{dt} = \Phi(N_{random}(m, sd)E - E^e) = \Phi(E, E^e) \tag{14.30}$$

Thus, expected foreign exchange rate can be easily adjusted to the actual trends and volatilities of various economic situations by refining values in mean and standard deviation. Figure 14.14 illustrates how foreign exchange rate and its expectation are modeled in our economy.

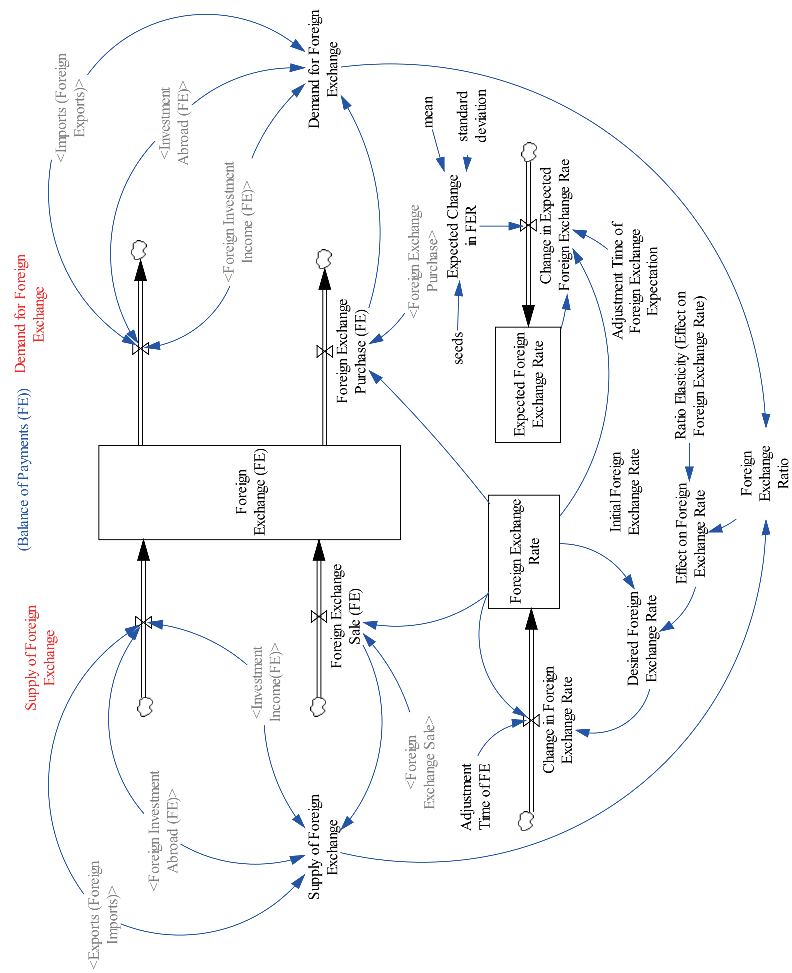

Figure 14.14: Determination of Foreign Exchange

Now dynamic modeling of foreign exchange rate in our open macroeconomy is complete. It consists of three equations: (14.15), (14.29), and (14.30), out of which three variables E, E^e and TB are determined, given parameters outside such as GDP, its price level and interest rate, as well as random normal distribution of expected foreign exchange rate. Schematically, it is written as

$$(Y, Y_f, P, P_f, i, i_f, N_{random}) \Longrightarrow (E, E^e, TB) \tag{14.31}$$

Figure 14.15 draws a theoretical gist of our open macroeconomic framework as a simplified causal loop diagram of the dynamics of foreign exchange rate in our open macroeconomy.

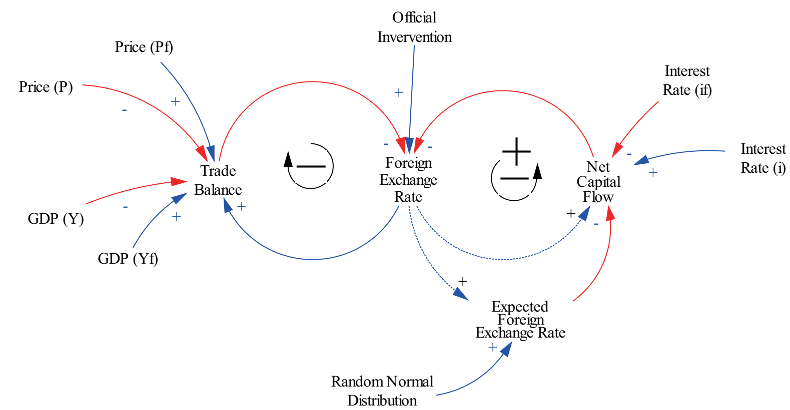

Figure 14.15: Causal Loop Diagram of the Foreign Exchange Dynamics

14.7 Behaviors of Current Account

An Equilibrium State (S)

We are now in a position to examine how our open macroeconomy behaves. Let us start with an equilibrium state of trade and foreign exchange. Domestic and foreign GDPs are assumed to grow at an annual rate of 2%. Random normal distribution for the expected foreign exchange rate is assumed to have a zero mean value and 0.1 value of standard deviation. Figure 14.16 illustrates the equilibrium state under such circumstances. Macroeconomic figures such as consumption spending, investment, government expenditures, exports and imports are shown to be growing, while trade balance is in equilibrium at a zero value in the left-hand diagram. On the other hand, a constant foreign exchange rate at one dollar per FE and its fluctuating expected rates are shown in the right-hand diagram.

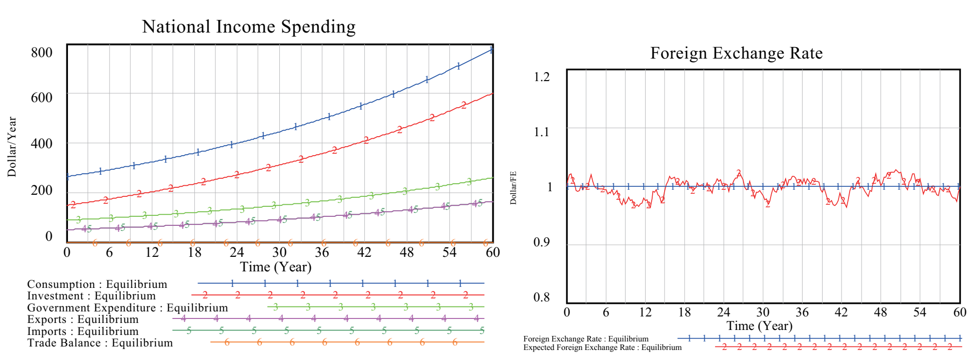

Figure 14.16: Equilibrium State of Trade and Foreign Exchange Rate (S)

In this state of equilibrium, financial investment is not yet considered. Hence, in spite of non-zero expected return arbitrate, caused by the fluctuations of estimated foreign exchange rates, capital flows are not provoked, and accordingly trade balance stays undisturbed.

Change in real GDP (S1)

Several scenarios can be considered that lead economic behaviors out of the above equilibrium state. Let us start with two simple cases in which no capital flows are allowed; that is, our dynamic system of foreign exchange rate is now simply described as

$$\frac{dE}{dt} = \Psi(-TB(E)) \tag{14.32}$$

As a first scenario, suppose a foreign real GDP decreases by 60 (billion) dollars at the year 7 due to a recession in a foreign country. The effect of this recession appears first of all as a sudden drop in our exports which are wholy dependent on foreign economic activities. This sudden plunge in exports causes a trade deficit. This will begin to increase demand for foreign exchange, because imports become relatively larger than exports, which in turn will cause foreign exchange rate to appreciate. The appreciation of foreign exchange rate makes imported goods more expensive, and eventually curbs the imports and trade balance will be gradually restored. In due course a new equilibrium state of foreign exchange rate will be attained at 1.056 dollars per FE (an appreciation rate of 5.6%)

In this way a flexible foreign exchange rate plays a decisive role of restoring trade imbalance as illustrated in Figure 14.17. Trade balance in a foreign country moves exactly into the opposite direction, so that a perfect mirror image of trade balance is created as reflected in the right-hand diagram.

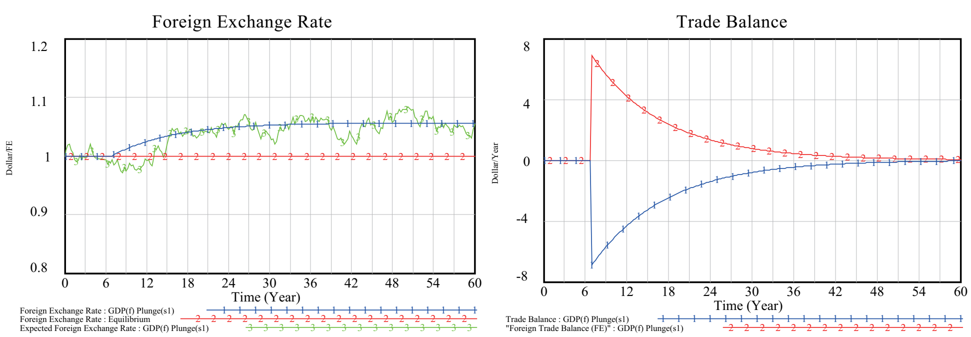

Figure 14.17: Foreign GDP Plunge and Restoring Trade Balance (S1)

Change in Price (S2)

As a second scenario, let us consider an opposite situation in which a foreign price rises by 10% due to an economic boom in a foreign country. The inflation makes imported goods more expensive and imports are suddenly suppressed, causing a surplus trade balance. Trade surplus will bring in more foreign exchange, causing a foreign exchange rate to depreciate. The depreciated foreign exchange rate now makes imported goods relatively cheaper and stimulates imports again. In this way trade balance will be restored and a new level of exchange rate is attained in due course at 0.97 dollars per FE (a depreciation rate of 3 %) as illustrated in Figure 14.18.

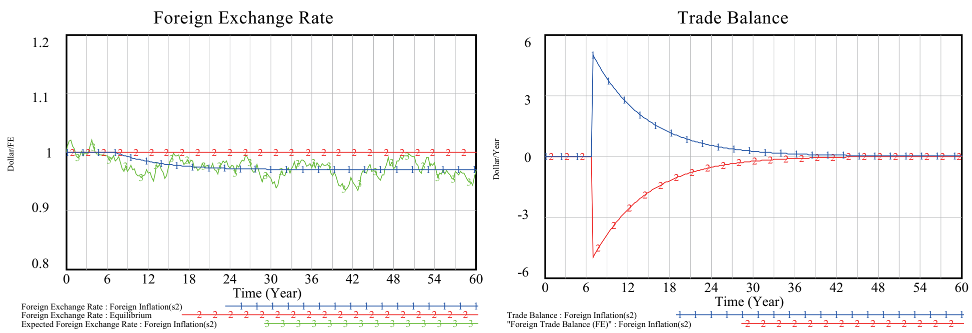

Figure 14.18: Foreign Inflation and Restoring Trade Balance (S2)

14.8 Behaviors of Financial Account

Expectations and Foreign Investment (S3)

In the above equilibrium state, standard deviation of random normal distribution is assumed to be 0.1, and expected foreign exchange rates are allowed to move randomly. Accordingly, non-zero return arbitrage caused by such fluctuations of foreign exchange rate could have triggered capital inflows and outflows under the assumption of efficient financial market. Yet, in order to see the effect of economic activities and price levels on trade balance and exchange rate, financial investment is excluded from the analysis. In this sense, the equilibrium state discussed above is not a real equilibrium state under free capital flows.

From now on let us consider three cases in which free capital flows are allowed for higher returns. In other words, behaviors of three variables E, E^e and TB are fully analyzed under the three equations: (14.15), (14.29), and (14.30).

As a scenario 3, let us consider the original equilibrium state again and see what will happen if free capital flows are additionally allowed for higher returns. As a source of financial investment, 20 % of domestic investment is assigned to direct investment abroad, and 30 % of financial assets are allowed for financial investment for both economies. The actual financial investment, however, depends on the scale of investment indices illustrated in Figure 14.12 above.

Figure 14.19 illustrates a revised equilibrium state under free flows of capital. Top-right figure shows the existence of the expected return arbitrage under the fluctuations of expected foreign exchange rates. The emergence of the arbitrage undoubtedly trigger capital flows of financial investment for higher returns, breaking down the original equilibrium state of trade balance, as shown in the bottom two diagrams. In this way, the original equilibrium state of trade is easily thrown out of balance by merely introducing random expectations of foreign exchange rate under an efficient capital market. In other words, random expectations among financial investors are shown to be a cause of trade turbulence, and hence economic fluctuations of boom and bust in international trade. A flexible foreign exchange rate can no longer restore a trade balance. This is an unexpected and surprising simulation result in this chapter.

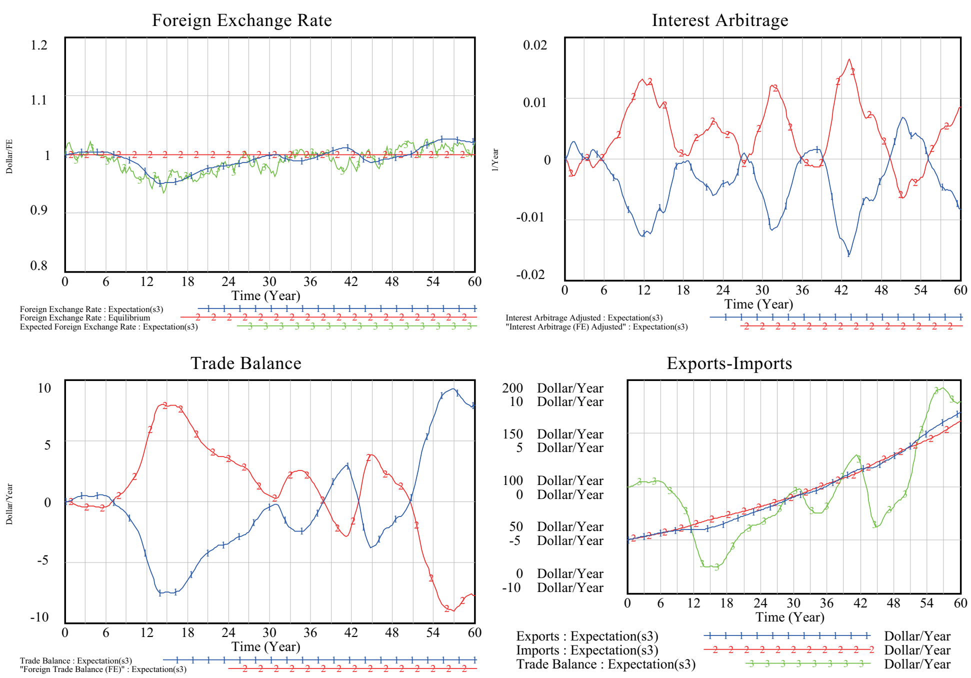

Figure 14.19: Random Expectations and Foreign Investment (S3)

Change in Interest Rate (S4)

Under the situation of the above scenario 3, let us additionally suppose, as scenario 4, that a domestic interest rate suddenly plummets by 2% and becomes

1% from the original 3% at the year 7. This drop may be caused by an increase in money stock. The lowered interest rate surely drives capital outflows abroad. This in turn will increase the demand for foreign exchange, and a foreign exchange rate will begin to appreciate. The appreciation of foreign exchange rate makes exports price relatively cheaper, and trade balance turns out to become surplus. Figure 14.20 illustrates how a plummet of interest rate appreciates foreign exchange rate and improve a trade balance.

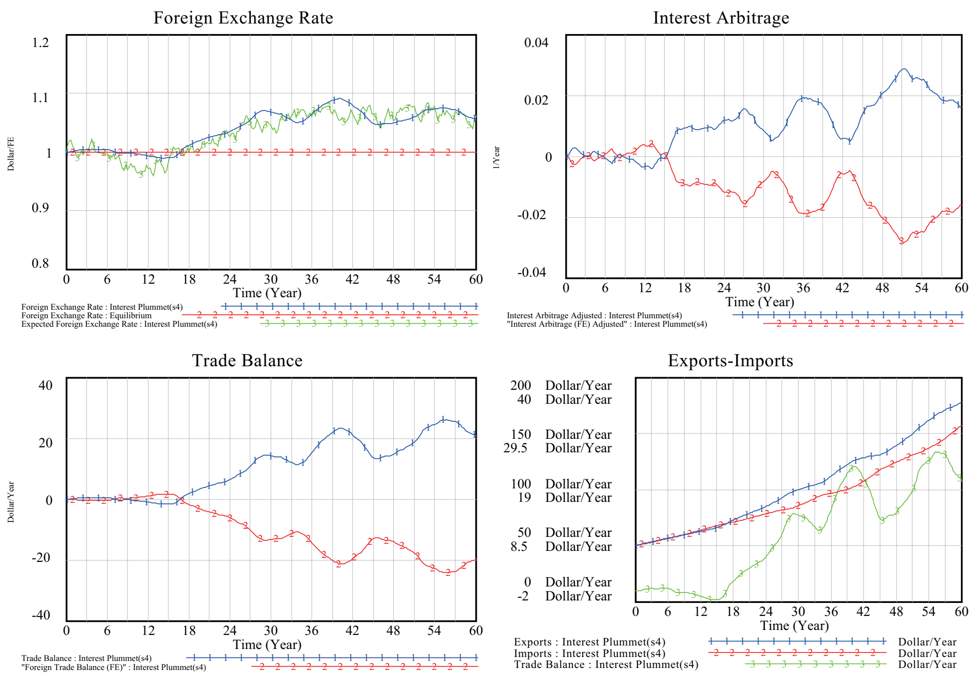

Figure 14.20: Interest Plummet under Random Expectations (S4)

Left-hand diagram of Figure 14.21 illustrates the balance of payments under the original equilibrium state (scenario 3). Current account is shown to be in deficit all the time, and in order to finance it financial account has to be in surplus. Under the same situation, a domestic interest rate is additionally lowered (scenario 4). Right-hand diagram indicates how lowered interest rate stimulates the economy and improves a deficit state of the balance of payments.

Change in GDP and Free Capital Flow (S5)

Let us revisit the scenario 3. Then as a scenario 5, let us additionally assume a decrease in foreign GDP by 60 (billion) dollars at the year 7 due to a recession in a foreign country as in the scenario 1. Furthermore, the central bank is now assumed to hold foreign exchange reserves of 100 (billion) dollars that are deposited with foreign banks.

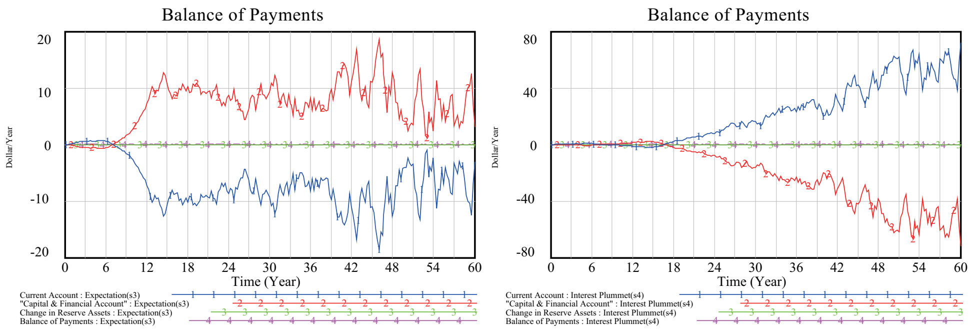

Figure 14.21: Comparison of the Balance of Payments between S3 and S4

As already discussed in the scenario 1, foreign exchange rate continues to appreciate, yet trade balance is no longer attained and trade deficits continues for a foreseeable future due to the disturbance caused by free capital flows as explored in the scenario 3. Top diagrams of Figure 14.22 illustrate these situations. Bottom-left diagram indicates current account deficits in the balance of payments, which has to be offset by the net inflow of capital.

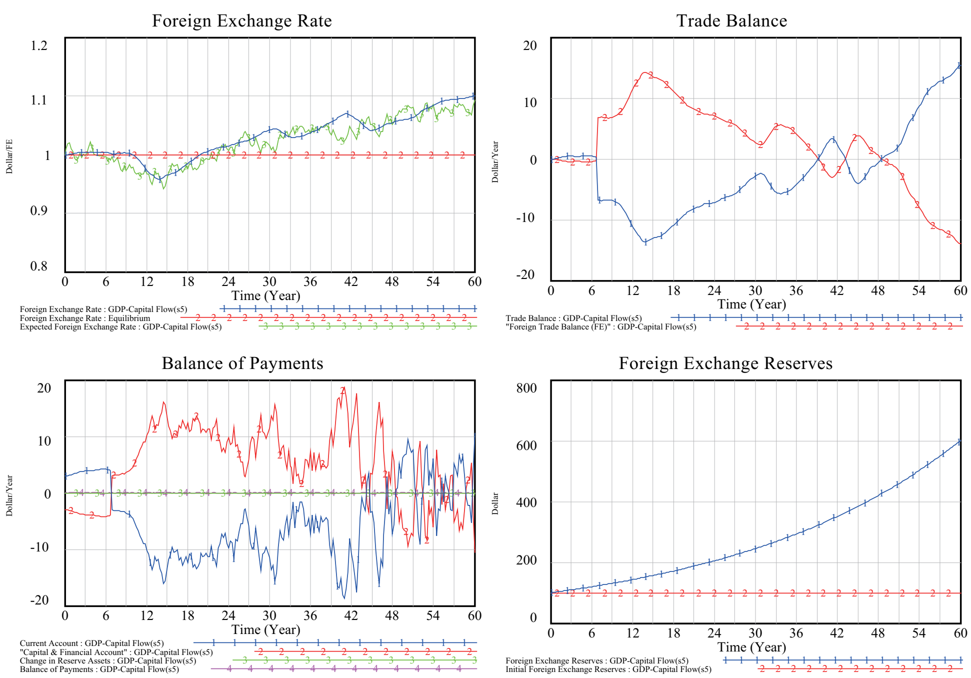

Figure 14.22: Foreign GDP Plunge and Foreign Investment (S5)

Bottom-right diagram shows that foreign exchange reserves by the central bank continues to grow at a rate of the foreign interest rate of 3 %. From a well-known principle of a doubling time of exponential growth, the reserves keep doubling approximately every 23 years.

14.9 Foreign Exchange Intervention

Official Intervention and Default (S6)

In the scenario 5 above, our macroeconomy continues to suffer from a continual depreciation of domestic currency (or an appreciation of foreign exchange rate), and deficits in trade and accordingly in current account. Surely, such a critical macroeconomic situation in a competitive international economic environment cannot be left uncontrolled. To prevent such an economic crisis let us introduce, as scenario 6, an official intervention to the foreign exchange market; specifically, the central bank (and government) begins to sell foreign exchange in order to reduce foreign exchange rate, say, to 1.02 dollars per FE; that is, by 2 % of the original equilibrium exchange rate.

As Figure 14.23 illustrates, even under such circumstances trade and current account deficits continue to persist. Gradually, the foreign exchange reserves begins to decline due to the official intervention, and becomes lower than the original reserve level of 100 (billion) dollars around the year 40 and completely gets depleted around the year 50, as indicated in the bottom right-hand diagram. This implies the government is forced to declare financial *default*, that is, an economic destruction, unless successfully eliciting an emergent loan from the international institutions such as the IMF.

Zero Interest Rate and Default (S7)

To avoid such financial default, now suppose, as scenario 7, money stock is increased to stimulate the economy and a domestic interest rate is lowered by 3%; that is, a zero interest rate is introduced from the original 3% at the year 3. This policy of zero interest rate surely improves trade balance and the balance of payments as Figure 14.24 indicates. Yet, under the official intervention of keeping a foreign exchange rate below 1.02 dollars per FE, the central bank (and the government) is forced to keep selling foreign exchange reserves[3]. The original 100 (billion) dollars of foreign exchange reserves will be completely depleted around the year 11 as the bottom right-hand diagram indicates. Therefore, this zero interest policy does not work unless the government can successfully borrow foreign exchange from the international institutions such as the IMF.

[3]To be precise, for maintaining the rate below this level, the central bank (and the government) has to keep selling 60 (billion) dollars of foreign exchange annually instead of 20 (billion) dollars in the previous scenario

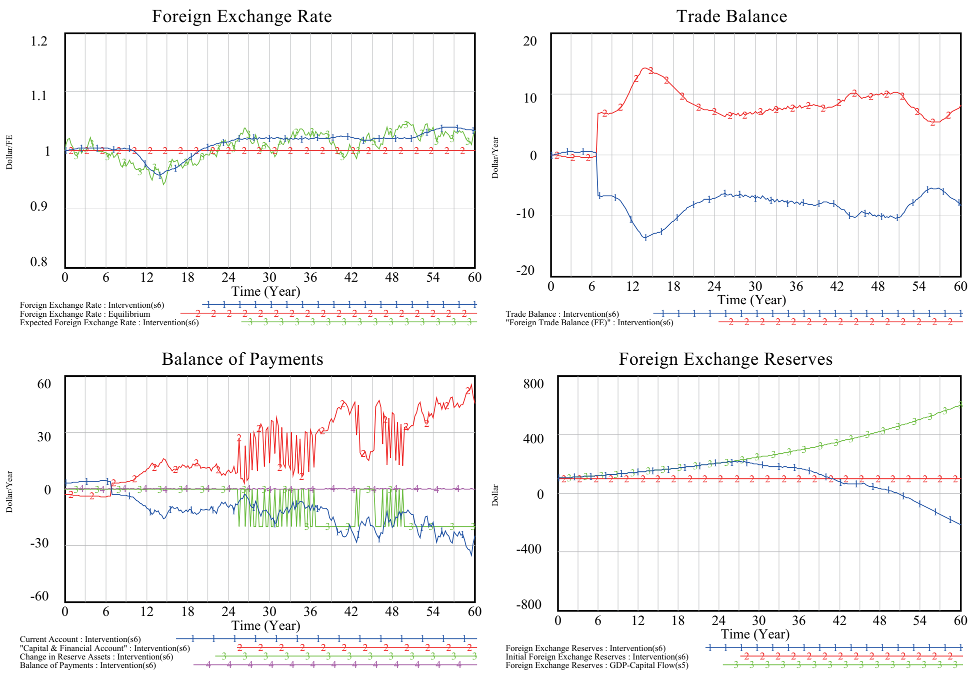

Figure 14.23: Official Intervention and Default (S6)

No Official Intervention (S8)

Let us further suppose that the central bank (and the government) gives up official intervention and stops selling foreign exchange to avoid a depletion of its foreign reserves. This scenario 8 surely brings about a further appreciation of foreign exchange rate. But to our surprise, after attaining a highest value of 1.225 dollars at the year 41, it begins to depreciate as the top left-hand diagram of Figure 14.25 illustrates. Moreover, trade balance and the balance of payments are getting improved, and foreign exchange reserves keeps growing according to the same figure. This is another counter-intuitive result in a sense that official intervention to foreign exchange market won't work to save the economic crisis.

In this way, so long as the working of our domestic macroeconomy is concerned, combined policies of zero interest rate and no official intervention seem to work. Yet, from a foreign country's point of view, the same policies worsen its economy as a mirror image of our economy. Hence, a so-called trade war becomes unavoidable in the international macroeconomic framework. Our simple open macroeconomic model has successfully exposed one of the fundamental causes of economic conflicts among nations.

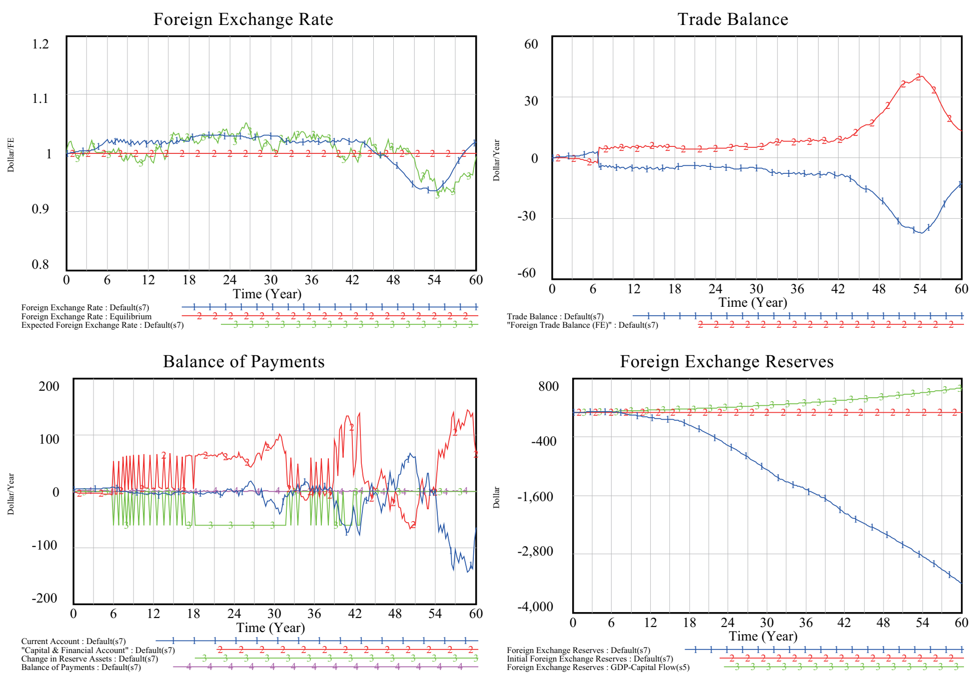

Figure 14.24: Zero Interest Rate and Default (S7)

14.10 Missing Feedback Loops

We have now presented eight different scenarios of international trade and financial investment, which indicates capability of our open macroeconomic modeling. Yet, our generic model is far from a complete open macroeconomy, because significant economic variables such as GDP, its price level and interest rate are treated as outside parameters, and no feedback loops exist in the sense that they are affected by the endogenous variables such as a foreign exchange rate and its expectations. Schematically, one-way direction of decision-making in the equation (14.31) has to be made two-way such that

$$(Y, Y_f, P, P_f, i, i_f, N_{random}) \Longleftrightarrow (E, E^e, TB) \tag{14.33}$$

Mundell-Fleming Model

Compared with our model, one of the repeatedly used open macroeconomic model in standard international economics textbooks is the Mundell-Fleming

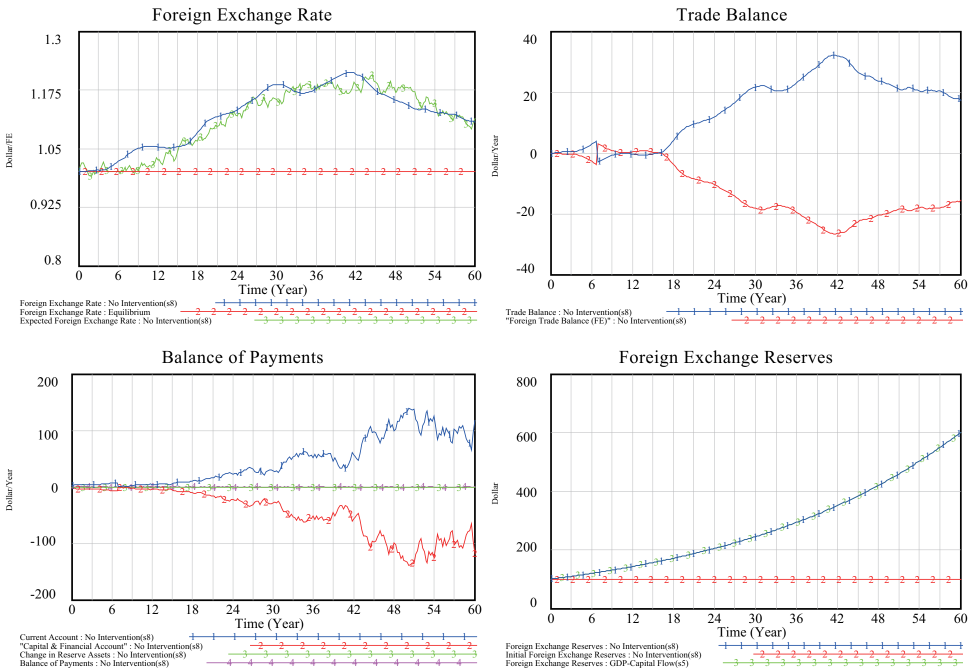

Figure 14.25: No Official Intervention (S8)

model that is described, according to Mankiw (2016), as

$$Y = C(Y-T) + I(i)) + G + TB(E) \tag{14.34}$$

$$\frac{M^s}{P} = L(i, Y) \tag{14.35}$$

$$i = i_f \tag{14.36}$$

This macroeconomic model indeed determines Y, E and i. In other words, significant economic variables such as GDP and interest rate are simultaneously determined in the model, though interest rate is restricted by a competitive world interest rate. In comparison, our model consisting of the three equations: (14.15), (14.29), and (14.30), determines only three variables E, E^e and TB, and fails to determine Y and i.

Hence, Mundel-Fleming model could be said to be a better presentation of open macroeconomy. Yet, it lacks a mechanism of determining money stock M^s and a price level P. In this sense, it is still far from a complete open macroeconomic model.

Missing Loops

It is now clear from the above arguments that for a complete open macroeconomic model some missing feedback loops have to be supplemented. They could constitute the following in our model:

- Imports and exports are assumed to be determined by the economic activities of GDPs, which are in turn affected by the size of trade balance. Yet, they are missing.
- Foreign exchange intervention by the central bank (and the government) such as the purchase or sale of foreign exchange surely changes the amount of currency outstanding and money stock, which in turn must affect an interest rate and a price level. Yet, they are being fixed.
- A change in interest rates affects investment, which in turn determines the level of GDP. Yet, investment is not playing such a role.
- A change in price level must also affect consumption spending and hence real GDP. Yet, these loops are missing.
- Official intervention must influence speculations and estimations on foreign exchange and investment returns among international financial investors. Yet, these fluctuations are only given by outside random normal distribution.

If we could add these missing feedback loops to the causal loop diagram of the foreign exchange dynamics in Figure 14.15, then we can obtain a complete feedback loop diagram as illustrated in Figure 14.26.

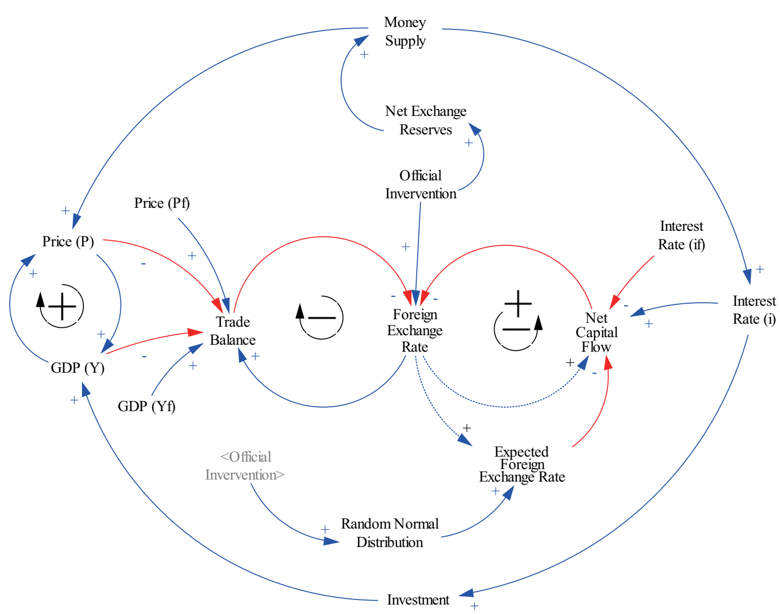

Figure 14.26: Missing Feedback Loops Added to the Foreign Exchange Dynamics

Obviously, our open macroeconomic model is not complete until these missing loops are incorporated in the model. Specifically, the previous chapter has presented a model of macroeconomic system which determines GDP, money stock, a price level, investment and interest rate, to name but a few. Therefore, our next challenge is to integrate the model with our present foreign exchange model by creating a whole image of domestic macroeconomy as its foreign sector macroeconomy.

14.11 Conclusion

Our open macroeconomic modeling turned out to need another model of the balance of payments and dynamics of foreign exchange rate. Consequently, the approach in this chapter led by the logic of accounting system dynamics became an entirely new one in the field of international economics.

Under the framework, a double-booking accounting of the balance of payments is modeled. Then determinants of trade and foreign direct and financial investment are analytically examined together with an introduction of differential equations of foreign exchange rate and its expected rate.

Upon a completion of the model, eight scenarios are produced and examined by running various simulations to obtain some behaviors observed in actual international trade and financial investment. It is a surprise to see how an equilibrium state of trade balance is easily disturbed by merely introducing random expectations among financial investors under the assumption of efficient financial market. To indicate the capability of our model furthermore, the impact of official intervention on foreign exchange and a path to default is discussed.

Finally, several missing feedback loops in our model are pointed out for making it a complete open macroeconomic model. This task of completion will inevitably lead to our next research in this system dynamics macroeconomic modeling series in the next chapter.

Chapter 15

An Open Macroeconomic System

This chapter[1] expands the comprehensive macroeconomic model in chapter 9 to the open macroeconomies on the basis of the framework developed in the previous chapter. It provides a complete generic model of open macroeconomies as a closed system, consisting of two economies such that a foreign economy becomes an image of a domestic economy. As a demonstration of its analytical capability, a case of credit crunch is examined to show how domestic macroeconomic behaviors influence foreign macroeconomy through trade and financial capital flows.

15.1 Open Macroeconomic System Overview

This chapter finalizes our series of macroeconomic modeling on the basis of the principle of accounting system dynamics. Chapters 5, 6 and 7 constructed models of money stock and its creation process, followed by the introduction of interest rate to the model. Chapter 8 modeled dynamic determination processes of GDP, interest rate and price level. For its analysis four sectors of macroeconomy were introduced such as producers, consumers, banks and government. Chapter 9 and 10 integrated real and monetary sectors that had been analyzed separately in chapter 8, by adding the central bank, then labor market. Chapter 11 built a model of a dynamic determination of foreign exchange rate in open macroeconomies in which goods and services are freely traded and financial capital flows efficiently for higher returns. For this purpose a new method is applied, contrary to the standard method of dealing with a foreign sector as being adjunct to the domestic macroeconomy; that is, an introduction of another whole macroeconomy as a foreign sector.

[1]It is based on the paper: Open Macroeconomies as A Closed Economic System – SD Macroeconomic Modeling Completed, which was presented at the 26th International Conference of the System Dynamics Society, Athens, Greece, July 20-24, 2008.

In this chapter, the integrated macroeconomy in chapter 10 is opened to foreign economy through trade and financial capital flows according to the framework developed in the previous chapter. In other words, a complete mirror economy is created as a foreign economy as illustrated in Figure 15.1.

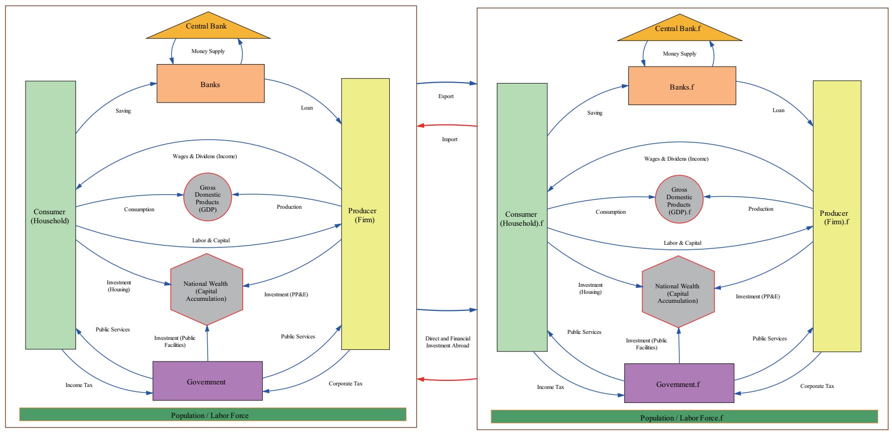

Figure 15.1: Open Macroeconomic System Overview

The only exception is the banking sectors such as commercial and central banks. Specifically, it is assumed that all foreign exchange transactions are done through domestic banks to meet the demand for foreign exchange services by consumers and producers.

15.2 Transactions in Open Macroeconomies

We are now in a position to open our integrated macroeconomy to foreign trade and direct and financial investment abroad [Companion Model: MacroDynamics2-5.vpmx]. According to our method in the previous chapter, this is nothing but a process of creating another macroeconomy as the image economy of the domestic macroeconomy. All variables of the foreign economy are thus renamed with a suffix of .f; for instance, the foreign GDP is written as GDP.f.

To avoid analytical complication, we have picked up the existing currency units of yen and dollar, among which dollar is assumed to plays a role of key currency. We have further assumed that a domestic economy has yen currency, and a foreign economy has dollar currency.

Nominal foreign exchange rate FE (merely called foreign exchange rate here) is now the amount of yen in exchange for one unit of foreign currency; that is, dollar as assumed above, and has a unit of *Yen/Dollar*. At this stage of building a generic open macroeconomies, the initial foreign exchange rate is assumed to be one; that is, one yen is exchanged for one dollar. Foreign exchange rate thus defined does not by all means reflect the ongoing current exchange rate in the real world economy.

Real foreign exchange rate (RFE) is the amount of real goods worth per unit of the equivalent foreign real goods such that

$$RFE = \frac{FE * P_f}{P} \tag{15.1}$$

which has a unit of *YenReal/DollarReal*.

Let us now describe main transactions of the open macroeconomies by producers, consumers, government, banks and the central bank.

Producers

Main transactions of producers are summarized as follows. They are also illustrated in Figure 15.6 in which stocks of gray color are newly added for open economies.

- Out of the GDP revenues producers pay excise tax, deduct the amount of depreciation, and pay wages to workers (consumers) and interests to the banks. The remaining revenues become profits before tax.
- They pay corporate tax to the government out of the profits before tax.
- The remaining profits after tax are paid to the owners (that is, consumers) as dividends, including dividends abroad. However, a small portion of profits is allowed to be held as retained earnings.
- Producers are thus constantly in a state of cash flow deficits. To make new investment, therefore, they have to borrow money from banks and pay interest to the banks.
- Producers imports goods and services according to their economic activities, the amount of which is assumed to be a portion of GDP in our model, though actual imports are also assumed to be affected by their demand curves.
- Similarly, their exports are determined by the economic activities of a foreign economy, the amount of which is also assumed to be a portion of foreign GDP.
- Produces are also allowed to make direct investment abroad as a portion of their investment. Investment income from these investment abroad are paid by foreign producers as dividends directly to consumers as owners of assets abroad. Meanwhile, producers are required to pay foreign investment income (returns) as dividends to foreign investors (consumers) according to their foreign financial liabilities.
- Foreign producers are assumed to behave in a similar fashion as a mirror image of domestic producers

Consumers

Main transactions of consumers are summarized as follows. They are also illustrated in Figure 15.7 in which stocks of gray color are newly added for open economies.

- Sources of consumers' income are their labor supply, financial assets they hold such as bank deposits, shares (including direct assets abroad), and deposits abroad. Hence, consumers receive wages and dividends from producers, interest from banks and government, and direct and financial investment income from abroad.

- Financial assets of consumers consist of bank deposits and government securities, against which they receive financial income of interests from banks and government.

- In addition to the income such as wages, interests, and dividends, consumers receive cash whenever previous securities are partly redeemed annually by the government.

- Out of these cash income as a whole, consumers pay income taxes, and the remaining income becomes their disposal income.

- Out of their disposable income, they spend on consumption. The remaining amount is either spent to purchase government securities or saved.

- Consumers are now allowed to make financial investment abroad out of their financial assets consisting of stocks, bonds and cash. For simplicity, however, their financial investment are assumed to be a portion out of their deposits . Hence, returns from financial investment are uniformly evaluated in terms of deposit returns.

- Consumers now receive direct and financial investment income. Similar investment income are paid to foreign investors by producers and banks. The difference between receipt and payment of those investment income is called income balance. When this amount is added to the GDP revenues, GNP (Gross National Product) is calculated. If capital depreciation is further deducted, the remaining amount is called NNP (Net National Product).

- NNP thus obtained is completely paid out to consumers, consisting of workers and shareholders, as wages to workers and dividends to shareholders, including foreign shareholders.

- Foreign consumers are assumed to behave in a similar fashion as a mirror image of domestic consumers.

Government

Transactions of the government are illustrated in Figure 15.8, some of which are summarized as follows.

- Government receives, as tax revenues, income taxes from consumers and corporate taxes from producers.
- Government spending consists of government expenditures and payments to the consumers for its partial debt redemption and interests against its securities.
- Government expenditures are assumed to be endogenously determined by either the growth-dependent expenditures or tax revenue-dependent expenditures.
- If spending exceeds tax revenues, government has to borrow cash from consumers and banks by newly issuing government securities.
- Foreign government is assumed to behave in a similar fashion as a mirror image of domestic government.

Banks

Main transactions of banks are summarized as follows. They are also illustrated in Figure 15.9 in which stocks of gray color are newly added for open economies.

- Banks receive deposits from consumers and consumers abroad as foreign investors, against which they pay interests.
- They are obliged to deposit a portion of the deposits as the required reserves with the central bank.
- Out of the remaining deposits, loans are made to producers and banks receive interests to which a prime rate is applied.
- If loanable fund is not enough, banks can borrow from the central bank to which discount rate is applied.
- Their retained earnings thus become interest receipts from producers less interest payment to consumers and to the central bank. Positive earnings will be distributed among bank workers as consumers.
- Banks buy and sell foreign exchange at the request of producers, consumers and the central bank.
- Their foreign exchange are held as bank reserves and evaluated in terms of book value. In other words, foreign exchange reserves are not deposited with foreign banks. Thus net gains realized by the changes in foreign exchange rate become part of their retained earnings (or losses).

- Foreign currency (dollars in our model) is assumed to play a role of *key* currency or *vehicle* currency. Accordingly foreign banks need not set up foreign exchange account. This is a point where a mirror image of open macroeconomic symmetry breaks down.

Central Bank

Main transactions of the central bank are summarized as follows. They are also illustrated in Figure 15.10 in which stocks of gray color are newly added for open economies.

- The central bank issues currencies against the gold deposited by the public.
- It can also issue currency by accepting government securities through open market operation, specifically by purchasing government securities from the public (consumers) and banks. Moreover, it can issue currency by making credit loans to commercial banks. (These activities are sometimes called *money out of nothing*.)
- It can similarly withdraw currencies by selling government securities to the public (consumers) and banks, and through debt redemption by banks.
- Banks are required by law to reserve a certain amount of deposits with the central bank. By controlling this required reserve ratio, the central bank can control the monetary base directly.
- The central bank can additionally control the amount of money stock through monetary policies such as open market operations and discount rate.
- Another powerful but hidden control method is through its direct influence over the amount of credit loans to banks (known as *window guidance* in Japan.)
- The central bank is allowed to intervene foreign exchange market; that is, it can buy and sell foreign exchange to keep a foreign exchange ratio stable (though this intervention is actually exerted by the Ministry of Finance in Japan, it is regarded as a part of policy by the central bank in our model).
- Foreign exchange reserves held by the central bank is usually reinvested with foreign deposits and foreign government securities, which are, however, not assumed here as inessential.

Missing Loops Fixed

In the previous chapter five loops below are pointed out as missing. To repeat,

- Imports and exports are assumed to be determined by the economic activities of GDPs, which are in turn affected by the size of trade balance. Yet, they are missing.

- Foreign exchange intervention by the central bank (and the government) such as the purchase or sale of foreign exchange surely changes the amount of currency outstanding and money stock, which in turn must affect an interest rate and a price level. Yet, they are being fixed.

- A change in interest rates affects investment, which in turn determines the level of GDP. Yet, investment is not playing such a role.

- A change in price level must also affect consumption spending and hence real GDP. Yet, these loops are missing.

- Official intervention must influence speculations and estimations on foreign exchange and investment returns among international financial investors. Yet, these fluctuations are only given by outside random normal distribution.

Our open macroeconomies have now successfully augmented these missing feedback loops except the last loop of speculation. Figure 15.2 illustrates newly fixed feedback loops.

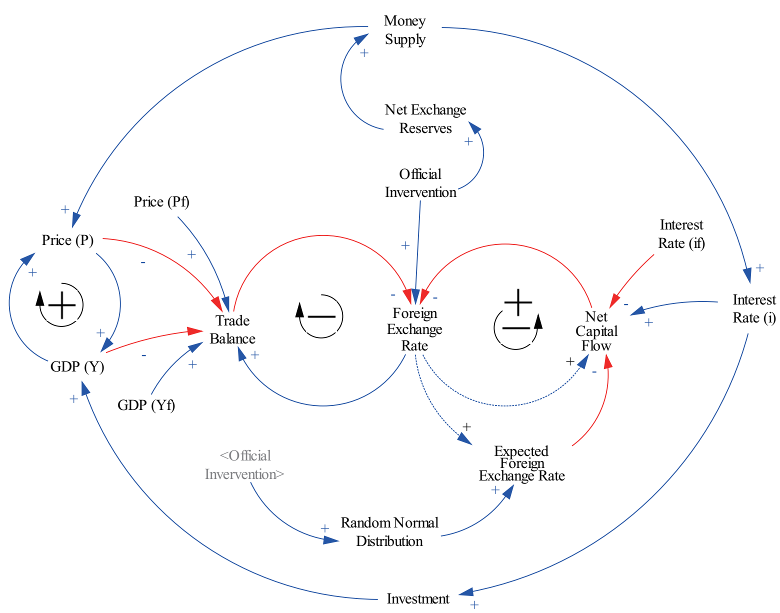

Figure 15.2: Fixed Missing Loops in the Foreign Exchange Dynamics Model

We are now in a position to present our complete open macroeconomic model. Due to the limited spaces, only domestic economic sectors are shown below.

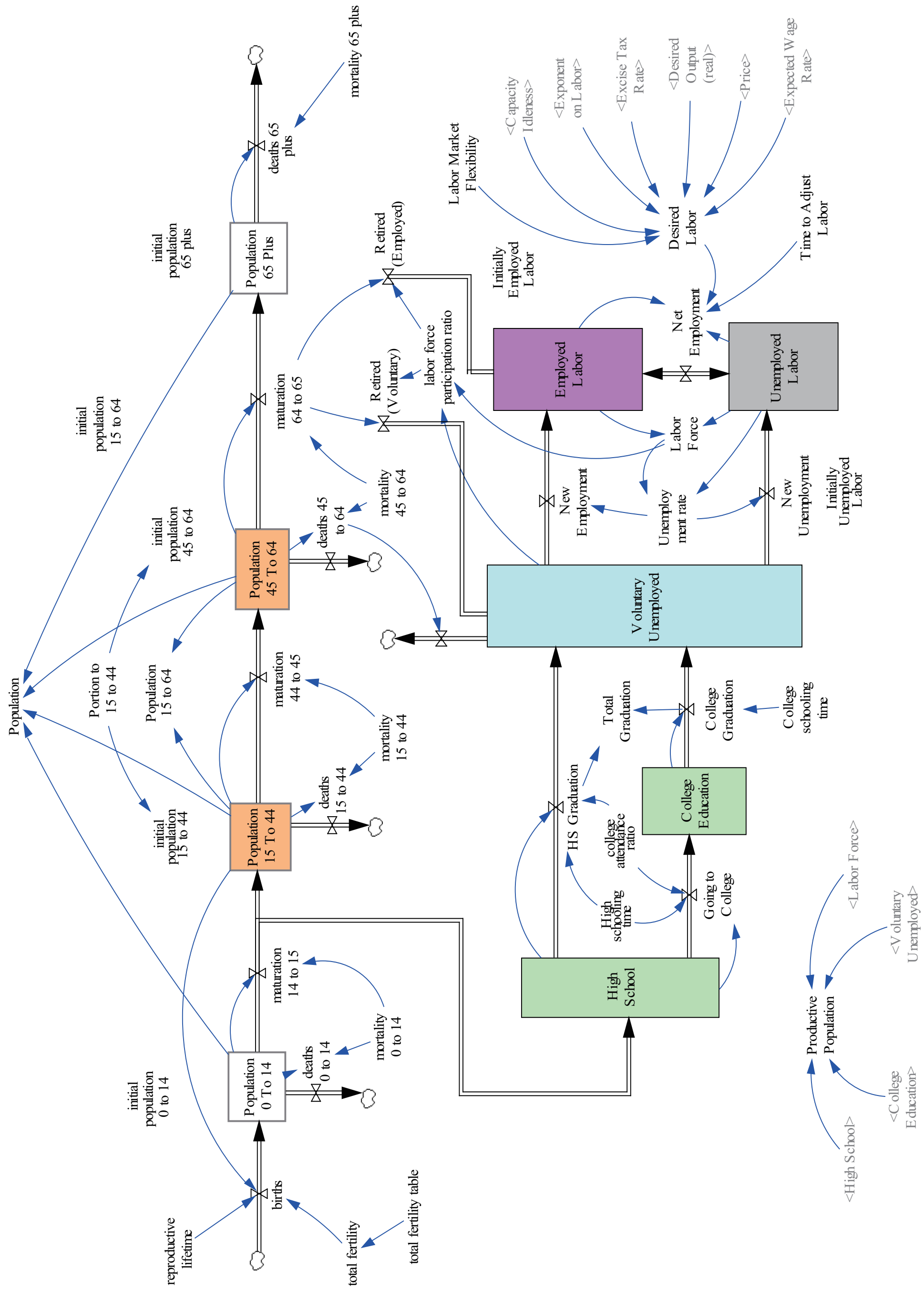

Figure 15.3: Population and Labor Force

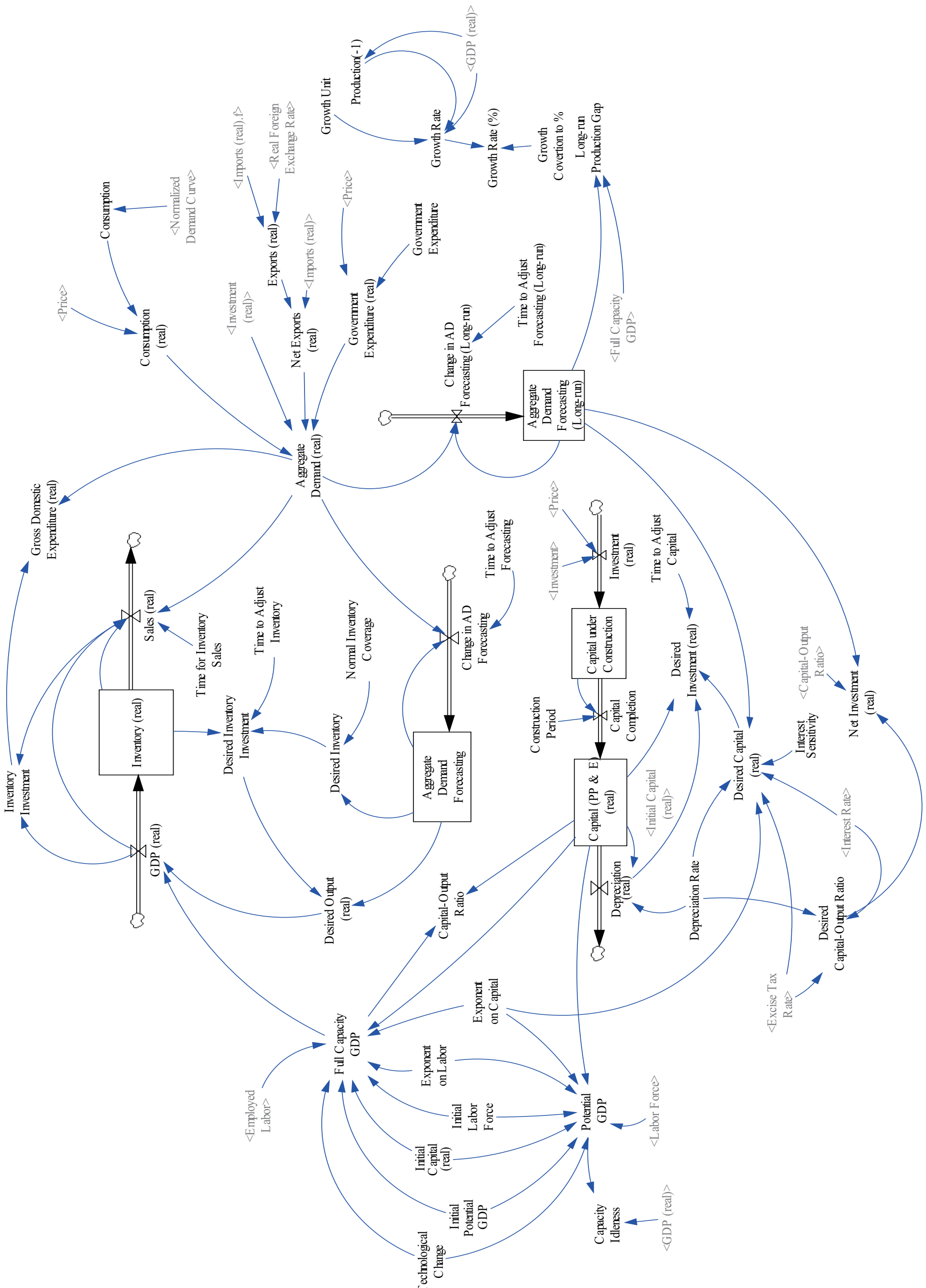

Figure 15.4: GDP Determination

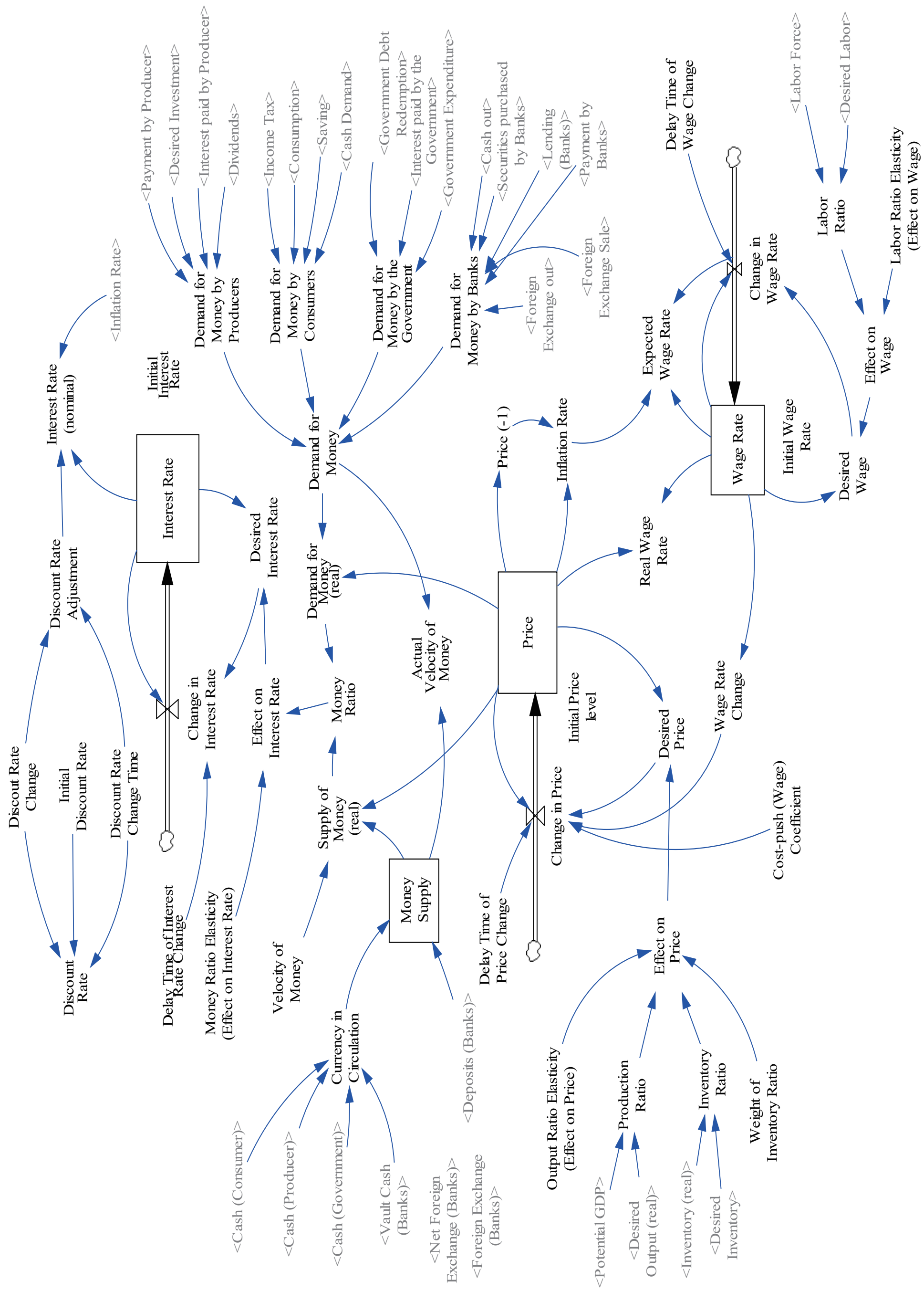

Figure 15.5: Interest Rate, Price and Wage Rate

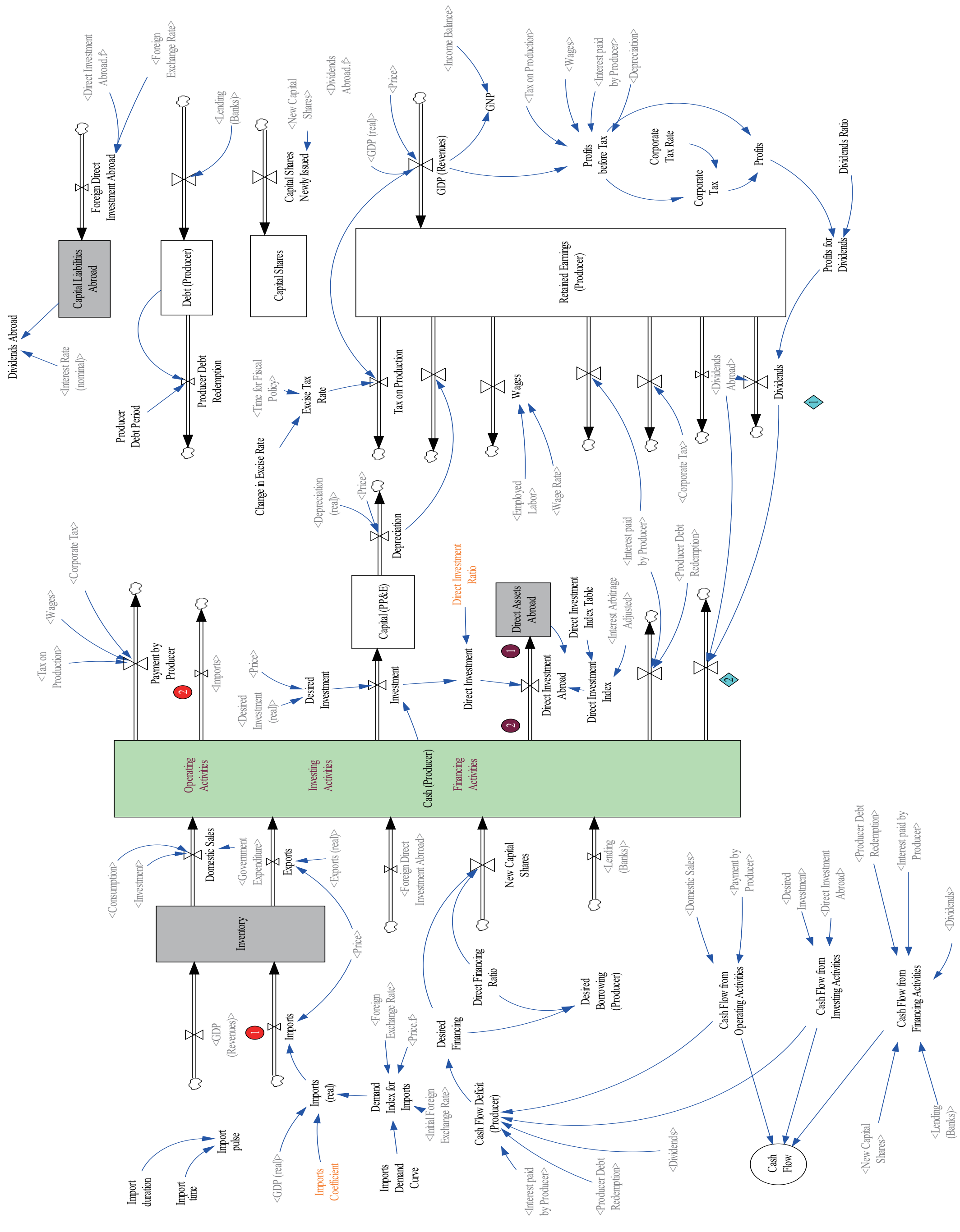

Figure 15.6: Transactions of Producers

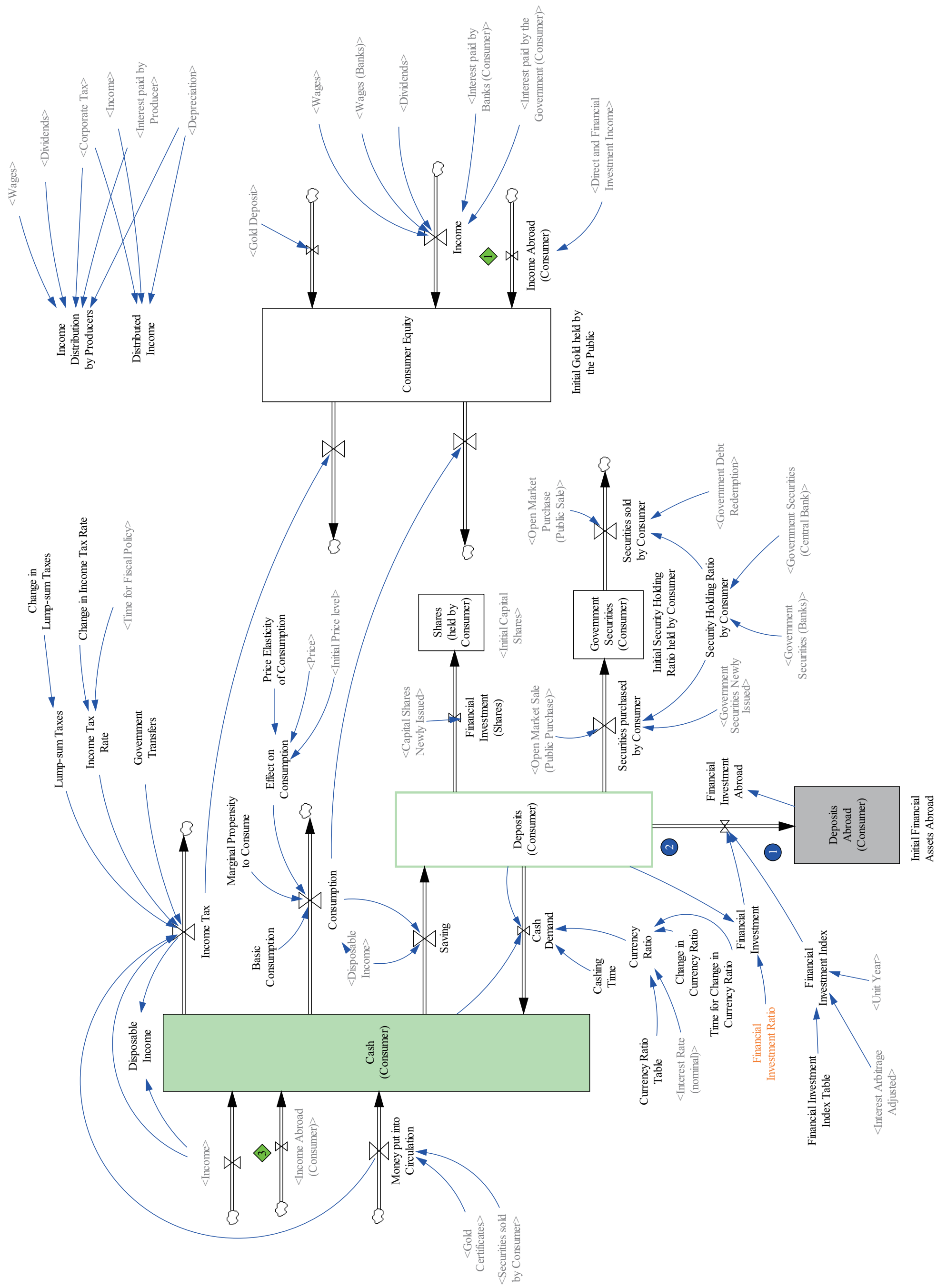

Figure 15.7: Transactions of Consumers

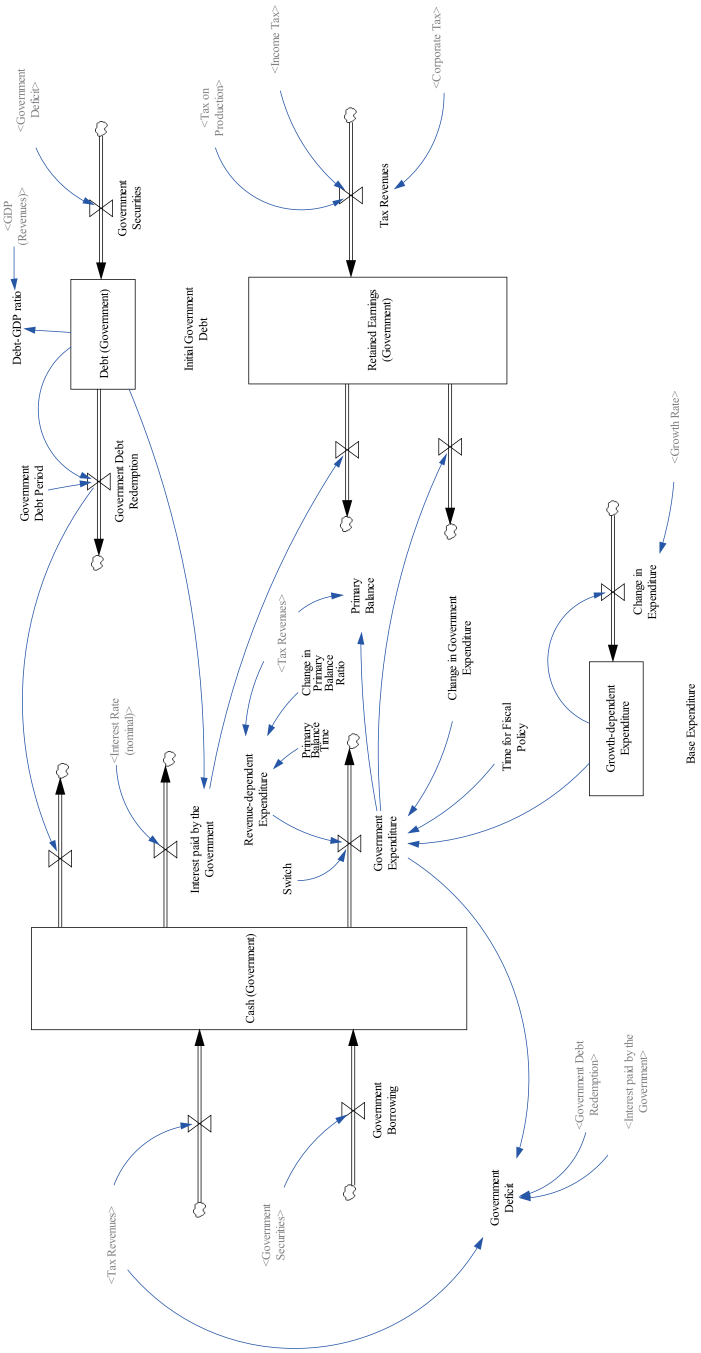

Figure 15.8: Transactions of Government

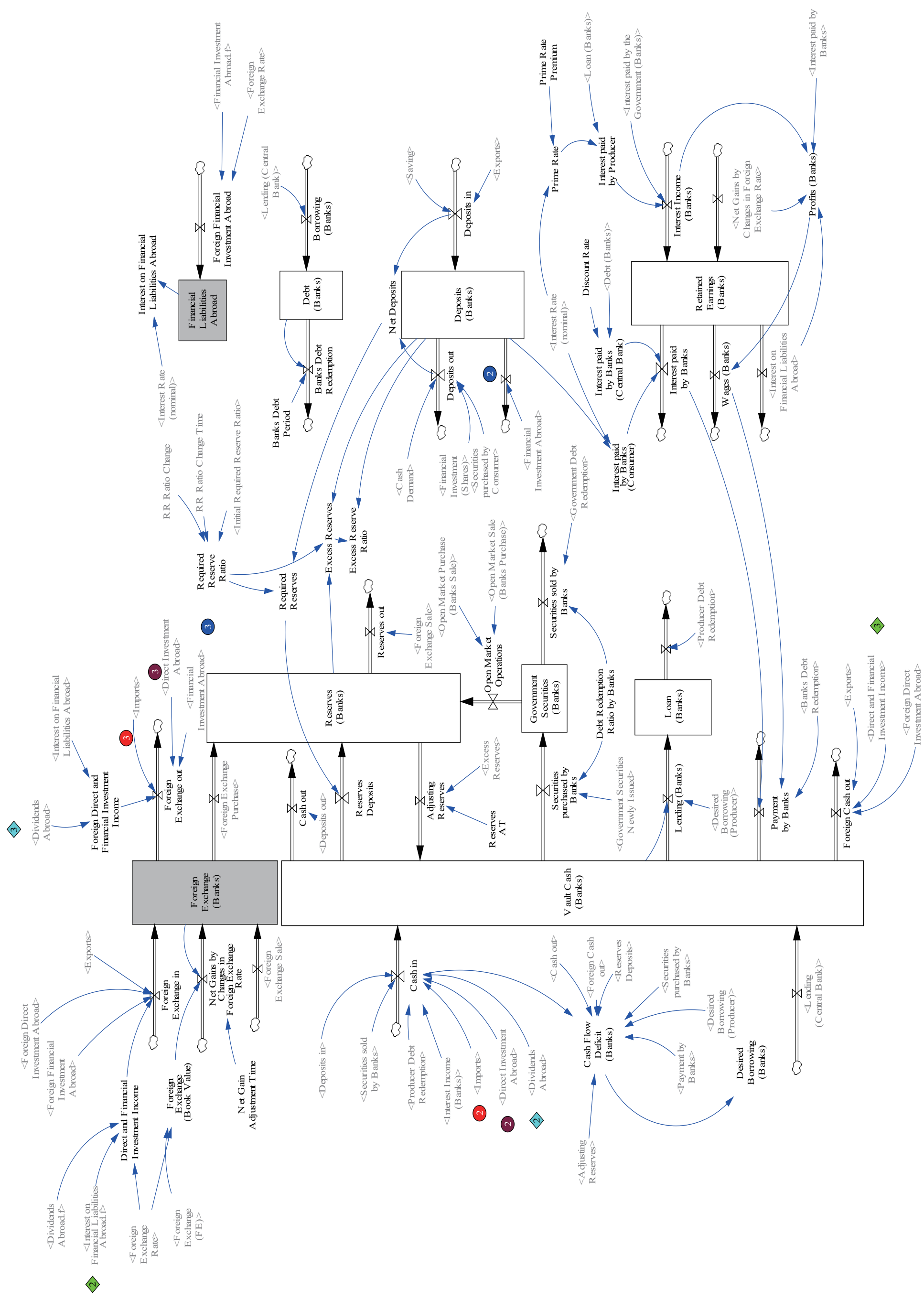

Figure 15.9: Transactions of Banks

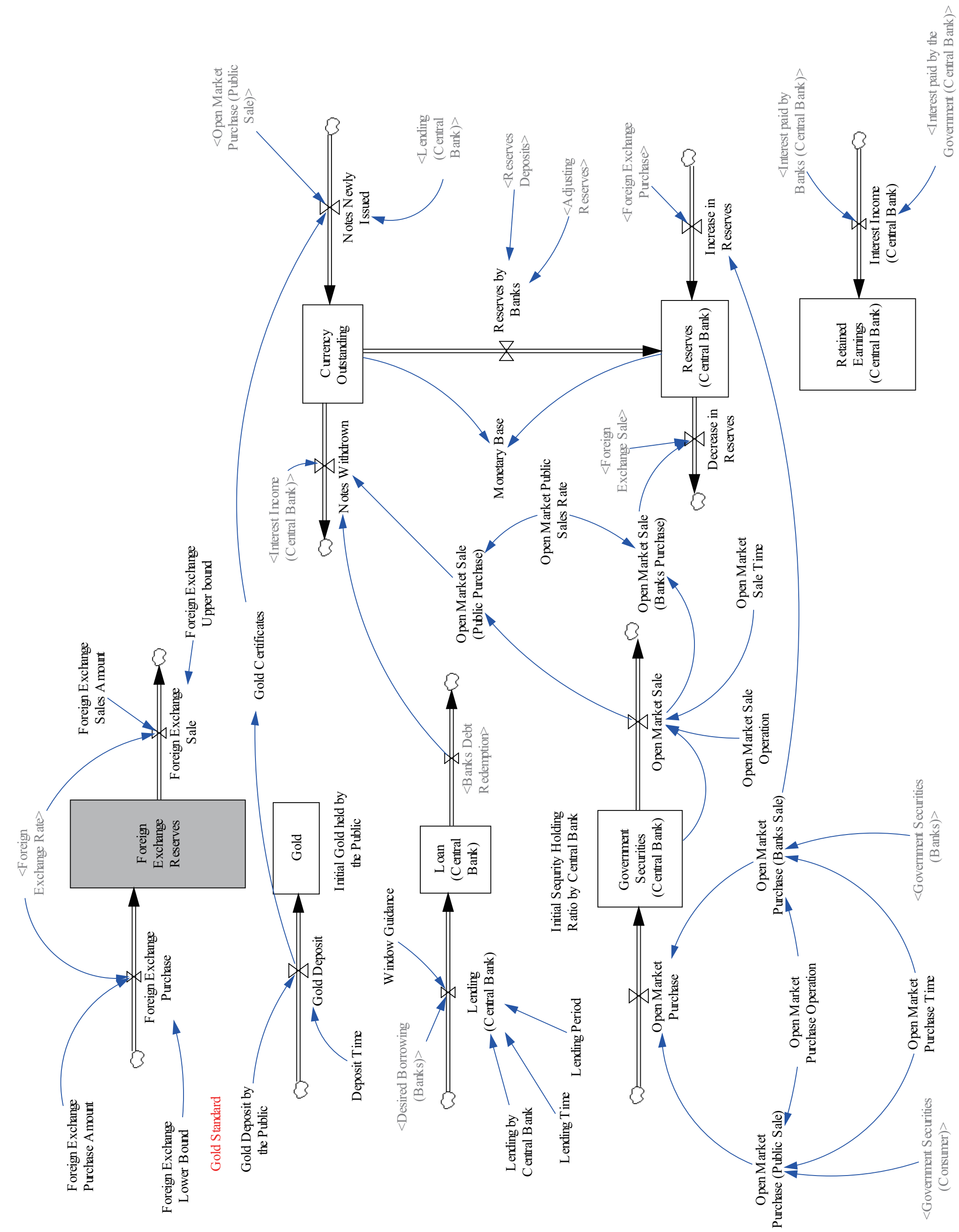

Figure 15.10: Transactions of Central Bank

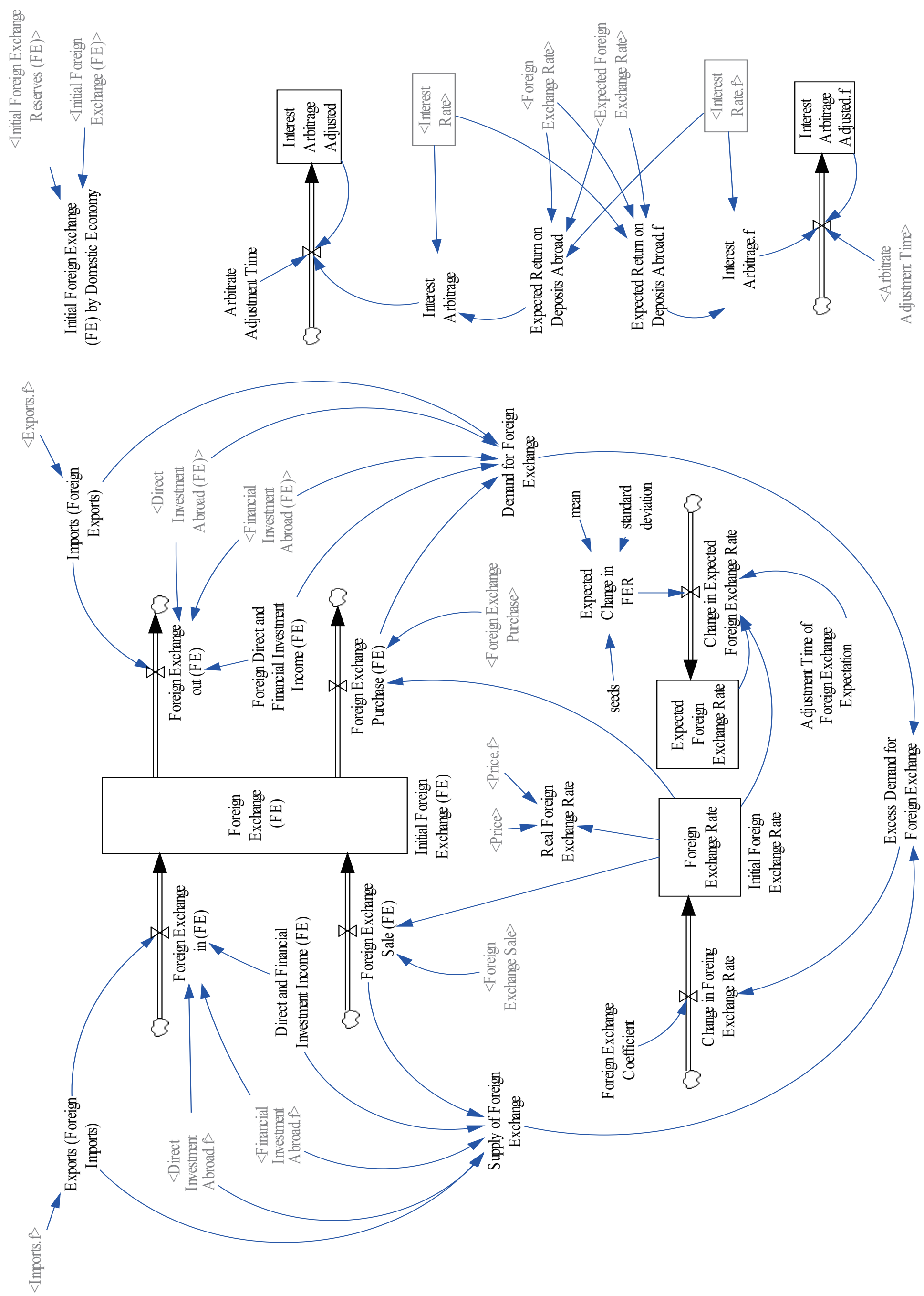

Figure 15.11: Foreign Exchange Market

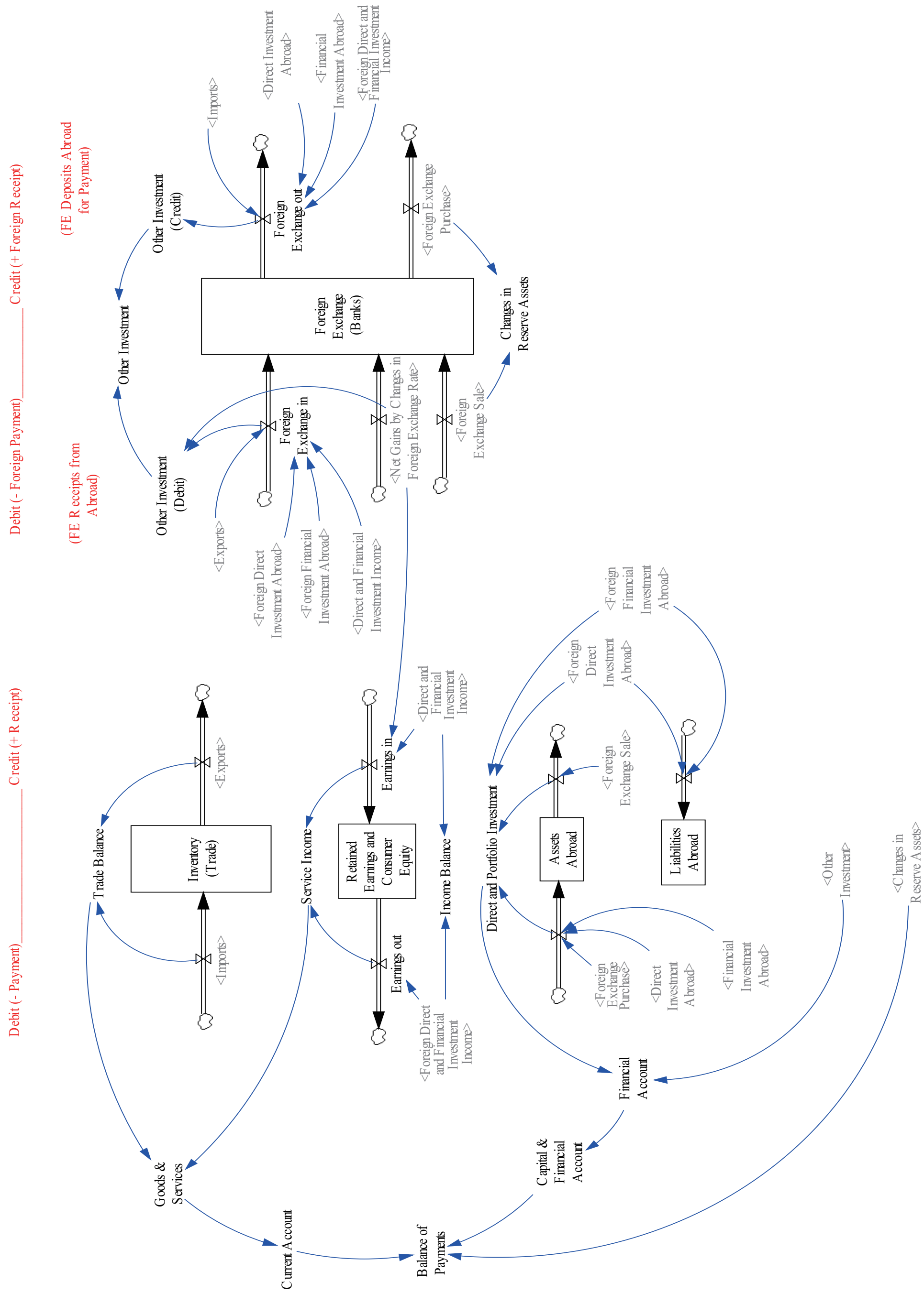

Figure 15.12: Balance of Payment

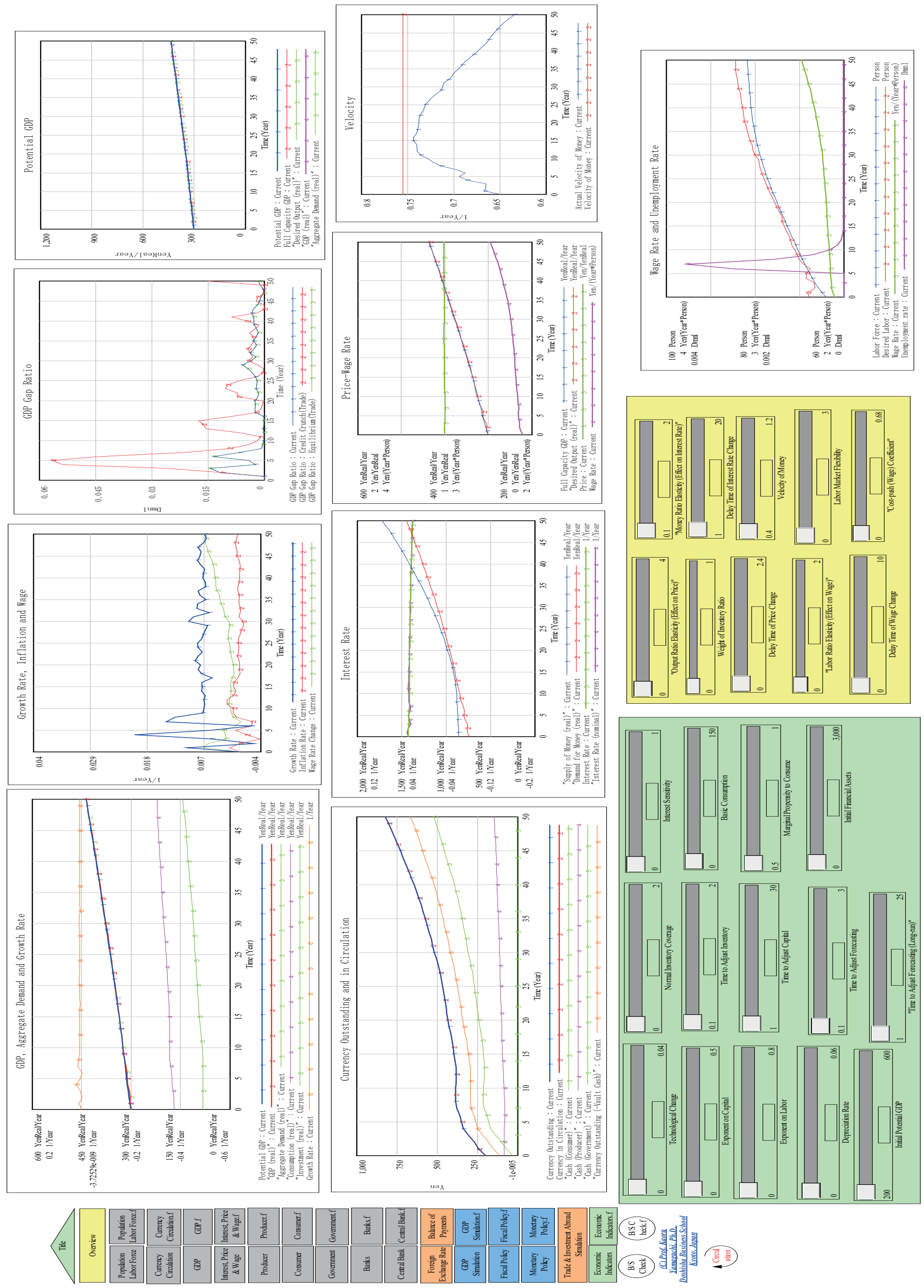

Figure 15.13: Simulation Panel of GDP

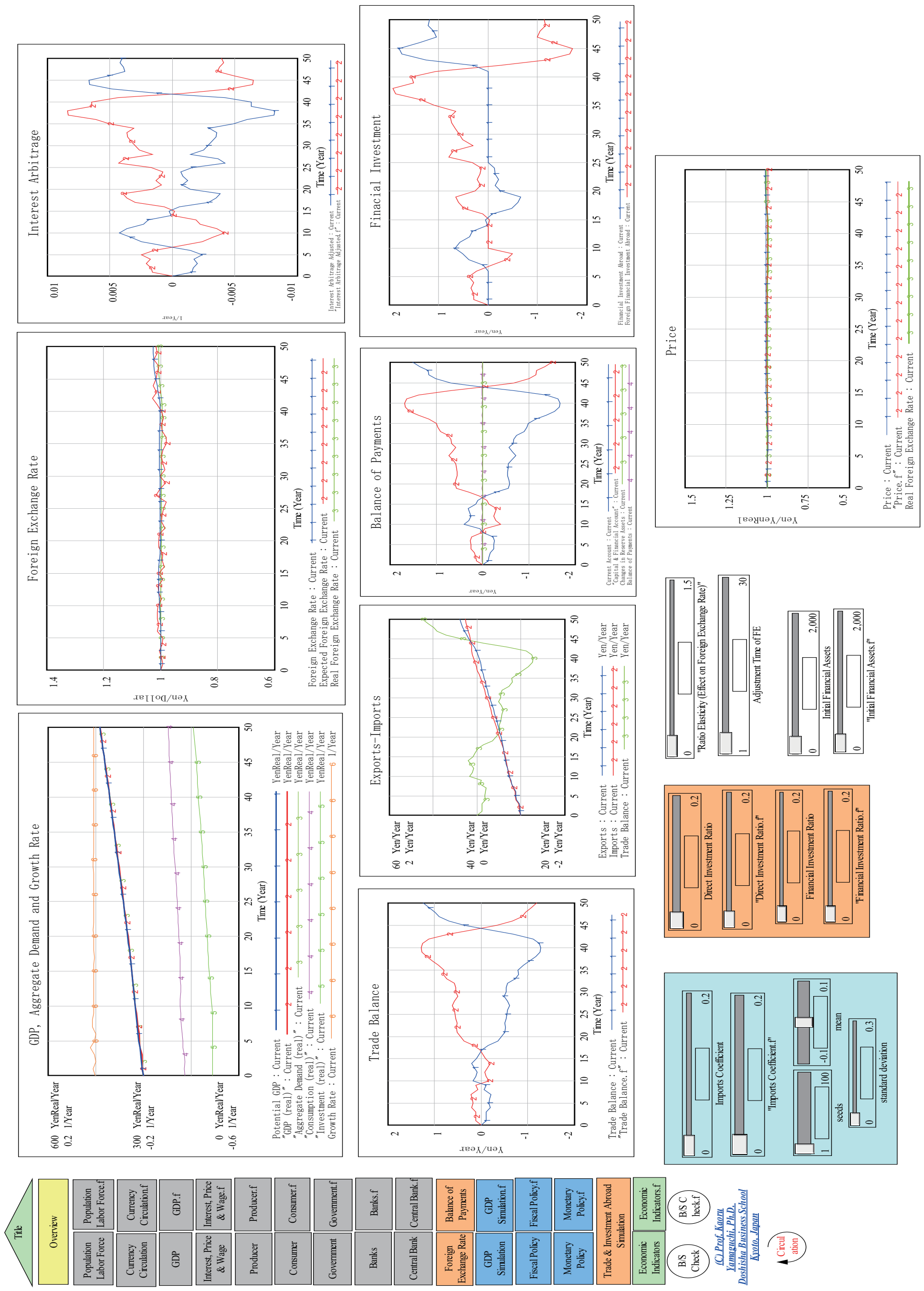

Figure 15.14: Simulation Panel of Trade and Investment Abroad

15.3 Behaviors of Open Macroeconomies

Mostly Equilibria under Trade and Capital Flows

The construction of open macroeconomies is now completed. There are three channels to open a domestic economy to a foreign economy. Trade channel is opened by allowing producers to import a portion of its GDP for domestic production and distribution. Capital flows have two channels. First, producers are allowed to make direct investment abroad as a portion of their domestic investment. Secondly, consumers are allowed to make deposits abroad out of their domestic deposits as a financial portfolio investment. (For simplicity, portfolios among deposits, shares and securities are not considered here.) These capital flows by direct and financial investment are determined by the interest arbitrage as analyzed in the previous chapter.

Let us now open all three channels by setting the values of import coefficient, direct investment ratio, and financial investment ratio to be the same 10%, respectively. Under the international activities of such trade and capital flows, Figure 15.15 demonstrates that our open macroeconomies can attain mostly equilibrium states.

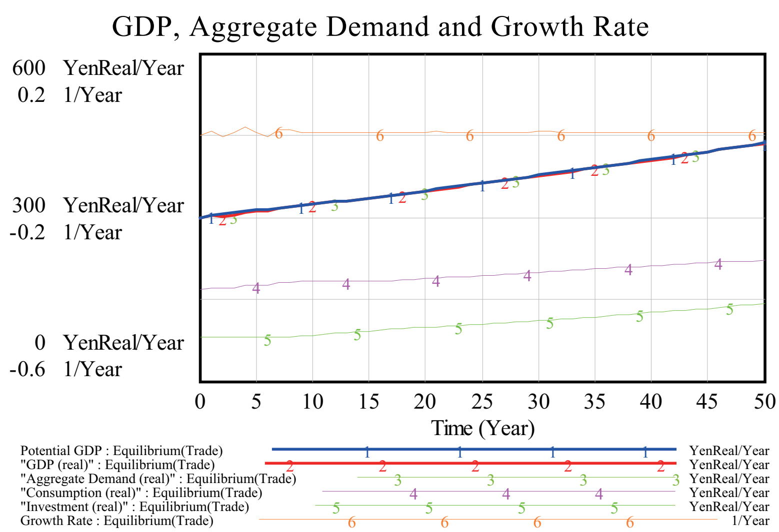

Figure 15.15: Mostly Equilibria under Trade and Capital Flows

Mostly equilibria thus obtained, however, do not imply balances of trade and capital flows. In fact, very small amount of trade imbalance is still observed as illustrated in Figure 15.16. Moreover, alternating interest arbitrages generate very small amounts of capital inflows and outflows as illustrated in Figure 15.17 due to the different interest rates prevailing over two economies, and random normal distribution that is exerted on the expected foreign exchange rate. Compared with the size of GDP, however, variances of trade and capital flows are

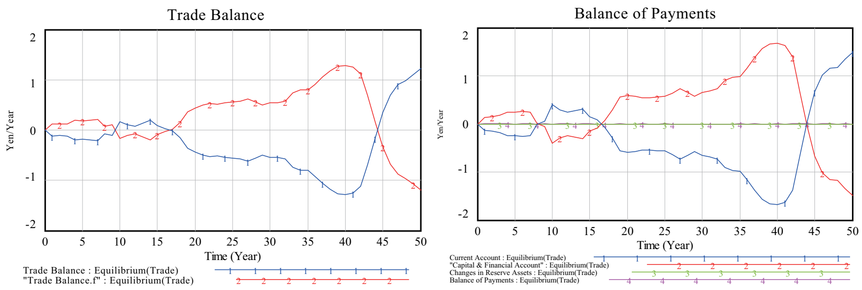

Figure 15.16: Trade Balance and Balance of Payments

within the range of less than 0.5% of GDP.

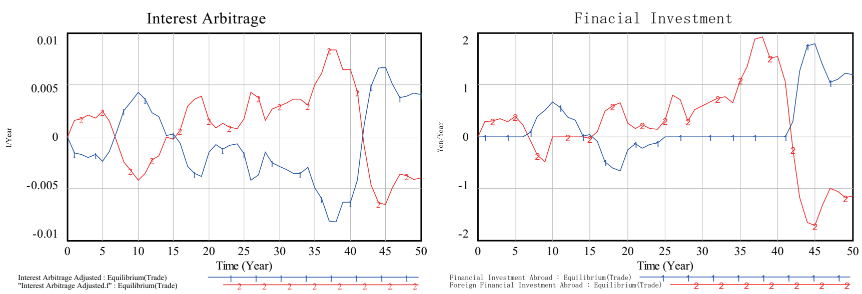

Figure 15.17: Interest Arbitrage and Financial Investment

Inventory Business Cycles under Trade and Capital Flows

Our generic model of open macroeconomies could be applied in many different ways to the economic analyses of specific issues. In chapter 9, two types of business cycles are triggered out of the mostly equilibrium states such as the ones by inventory coverage, price fluctuation and cost-push wages, as well as an economic recession by credit crunch. It would be interesting, as a continuation of our discussions, to examine how these domestic business cycles and recession affect foreign macroeconomies through trade and capital flows.

Let us first consider a business cycle caused by inventory coverage. Suppose a normal inventory coverage is set to be 0.7 or 8.4 months instead of the initial value of 0.1 or 1.2 month as done in chapter 9. As expected again a similar business cycle is being generated in the domestic economy as illustrated in Figure 15.18.

Does this business cycle affect a foreign economy? Figure 15.19 illustrates the foreign country's GDP and its growth rate. It clearly displays that business cycles are being exported to the foreign economy through trade and capital flows. This means vice versa that our domestic economy cannot be also free from the influence of foreign economic behaviors. In this sense, open macroeconomies can

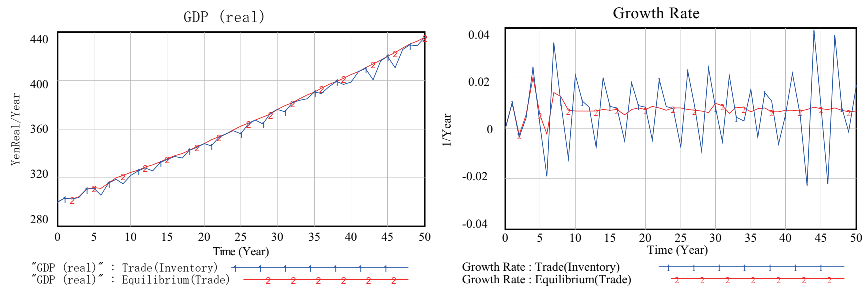

Figure 15.18: Inventory Business Cycles under Trade and Capital Flow

be said to be mutually interdependent and constitute indeed a closed economic system as a whole.

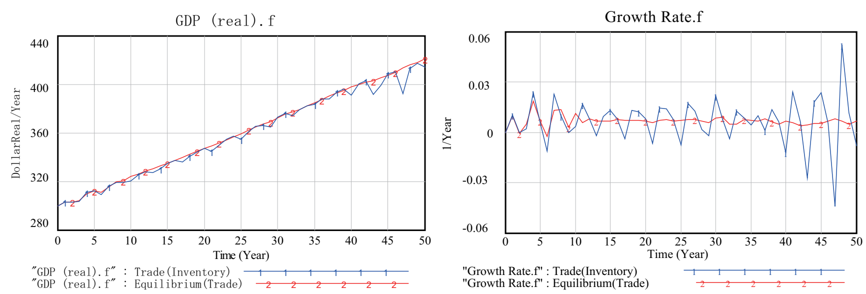

Figure 15.19: Inventory Business Cycles Affecting Foreign Macroeconomy

Credit Crunch under Trade and Capital Flows

Now let us examine an economic recession triggered by the credit crunch. For this purpose, let us now assume that the central bank reduces the amount of credit loans by 40%. An economic recession is similarly generated again in the domestic economy as illustrated in Figure 15.20.

Does this domestic recession affect the foreign economy? Figure 15.21 illustrates the foreign country's GDP and its growth rate. It clearly displays that economic recession is being exported to the foreign economy through trade and capital flows. This means vice versa that our domestic economy cannot be also free from the influence of foreign economic behaviors. In this sense, open macroeconomies can be said to be mutually interdependent and constitute indeed a closed economic system as a whole.

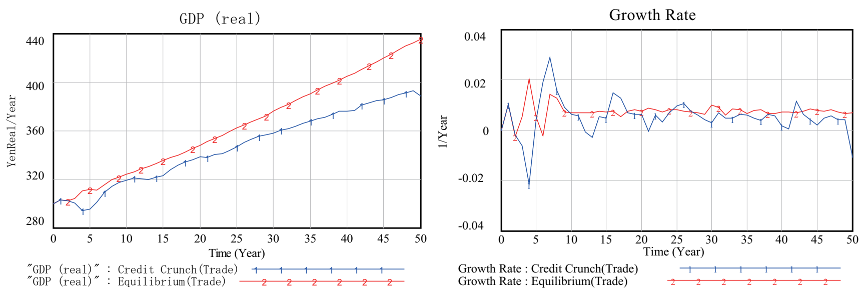

Figure 15.20: Credit Crunch under Trade and Capital Flow

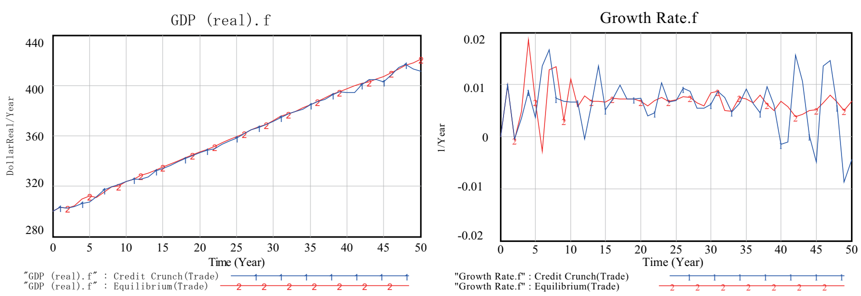

Figure 15.21: Credit Crunch Affecting Foreign Macroeconomy

15.4 Where to Go from Here?

Robust Foundation of the Model

Our macroeconomic model building is based on the following two well-established scientific methods;

- Double-entry accounting system: a foundation of social science
- Theory of differential equations: a foundation of natural science

Accounting system has been said to be the most rigorous methodology in social science, and widely used since ancient times to keep orderly records of chaotic market transactions. Differential equations have been, since Newton, widely applied to describe dynamic movements in natural science as the most fundamental tool for dynamical analysis. System dynamics is in a sense a computer-based tool for the numerical computation of differential equations.

These two well-established scientific methods are consolidated as the principle of accounting system dynamics in Yamaguchi (2003) and Chapter 3, and have been applied in our model building of macroeconomic system. Hence, our open macroeconomic model can be said to have been built on the robust foundation, and in this sense provides a sturdy and versatile framework for further behavioral analyses in macroeconomic theory. Where should we go, then, from here more specifically? At least the following four trails seem to lie ahead of us.

Trail 1: Unified Macroeconomic Systems View

By its nature as a generic model, our model could be refined to clarify the fundamental causes of disputes among different schools of economic thoughts; for instance, in the line of unification among Neoclassical, Keynesian and Marxian schools in Yamaguchi (1988). It is our belief that their differences are those of the assumptions made in the model, not the framework of the model itself. If this is right, the model could provide a common framework for further theoretical discussions among economists. Accordingly, depending on the economic issues for clarification the model could be fine-tuned for sharing various economic views.

Following are some of these fine-tuning directions for further analysis of the economic issues if they are the focus of macroeconomic controversies.

1. Portfolio decisions for financial assets and wealth among cash, shares and securities are not yet incorporated.

2. Housing investment and real estate transactions by consumers are not treated. This could be an interesting extension to analyze the subprime housing investment bubbles, followed by the housing crisis in 2007, and financial crisis in 2008.

3. Consumption is a function of basic consumption C_0, income Y and Price P, but interest i and wealth effect W_e are still not considered such that

$$C = C(C_0, Y, P, i, W_e) \tag{15.2}$$

4. An interdependent relation between money stock and inflation is weak, and only the following causal route is covered;
   Money(↑) ⟶ Investment(↑) ⟶ Desired Output(↑) ⟶ Price(↑).
   Moreover, inflation in financial assets and real estate is not treated.

5. Proportionate movement of price and wages is weak.

6. Comparative advantage theory of international trade is not handled.

Trail 2: Japanese and US Macroeconomic Modeling

The series of macroeconomic modeling was originally intended to construct a Japanese macroeconomic model for strategic applications among business executives and policy makers. Accordingly, it seems natural to follow this trail as a next step, and simultaneously analyze the world two largest[2] economies; that

[2]Chinese GDP surpassed Japanese GDP in 2010, and Japan is now the third largest economy.

is, Japanese macroeconomy as a domestic economy and US macroeconomy as a foreign economy along the framework of our open macroeconomies.

For this purpose, actual macroeconomic data have to be incorporated into the model. It would be very interesting to observe, out of many possible behaviors the model can produce like chaos being produced out of a simple deterministic equation, which behavior is to be chosen historically by the real economy.

Trail 3: Systems of National Account

Our modeling method turns out to be along the United Nations *System of National Accounts 1993*, known as 'the SNA93', though in a more wholistic way. Accordingly, it could be extended closer to the complete SNA93 in a systemic way.

Three trails discussed above can be followed under the current macroeconomic systems of debt money. Readers who are interested in further analyses of debt money system are encouraged to follow these off-road journeys.

Trail 4: Public Money and Sustainability

Financial crises following the bankruptcy of Leman Brothers in 2008 have awakened my mind further into the exploration of the root cause of monetary and financial instabilities and national debt crises that our current economies have begun facing more seriously since then.

Before this awakening, my interest was partially in a sustainability modeling such as the one in chapter 3 of "Handbook of Sustainable Development Planning" Yamaguchi (2004a), which was based on my step-by-step definition of sustainability in terms of physical, social and ecological reproducibilities Yamaguchi (1997), with a belief that macroeconomic activities cannot be sustained without a support by ecological environment. More specifically, I believed that the current macroeconomic activities are destroying our living environment, which is in turn threatening our sustainable futures that our macroeconomic activities are supposed to provide.

This irony convinced me that our sustainable futures are threatened by our aggressive macroeconomic activities for endless pursuit of economic and financial growth, which in turn are driven by the current macroeconomic system of debt money as briefly discussed in Chapter 6. In other words, the root cause of both economic instability, debt crises and unsustainable futures is the current debt money system!

What is the alternative to the debt money system, then? From our analysis for the nature of money in Chapter 5, it has to be the public money system. Understanding in this way, our next off-road journey has to be the one in which we explore an alternative macroeconomic system of public money to find out if it works better than the current debt money system in the sense of monetary and financial stability, liquidation of national debt and sustainable futures. Our final off-road journey is now set toward the public money and sustainability.

15.5 Conclusion

This is the final chapter that completes our series of building macroeconomic system of debt money. The integrated model in chapter 9 is extended to the open macroeconomies on the basis of the balance of payment in the previous chapter. Its main feature is that two similar macroeconomies are needed to analyze international trade and capital flows through direct and financial investment.

With a completion of building the open macroeconomies this way, many possibilities are made available for the analysis of economic issues. Our analyses are confined to the issues of inventory business cycles and credit crunch. Then, it is shown that a business cycle and an economic recession triggered in the domestic economy causes similar recessions in a foreign economy through the transactions of trade and capital flows. In this sense, open macroeconomies are indeed demonstrated to be a closed system in which economic behaviors are reciprocally interrelated.

Since our open macroeconomic model is still far from being complete, these three trails are suggested to follow if the reader is interested in the investigation of the current debt money system. We've decided to take the forth off-road journey that explores the alternative macroeconomic system of public money for the monetary and financial stability, liquidation of national debt and our sustainable futures.

Part VI

Public Money System

Chapter 16

Designing A Public Money System

This chapter [1] first discusses government debt crisis as a systemic failure, and examines that it is structurally built in the current macroeconomic *system of debt money* which is founded on the Keynesian macroeconomic framework. Then it argues that it becomes very costly to reduce it, within the current scheme, by raising tax or cutting expenditure. On the other hand, it demonstrates how the government debt could be liquidated without cost under an alternative macroeconomic *system of public money* that is proposed by the American Monetary Act. Finally, it is posed that public money system of macroeconomy is far superior to the debt-burden current macroeconomic system in the sense that it can liquidate government debt without inflation.

16.1 Search for An Alternative System

While my macroeconomic modeling series in Part II and III was advancing, world-wide financial crises, called *the Great Recession* in Stiglitz (2010), were triggered by the bankruptcy of Lehman Brothers in September, 2008, and the US government has been forced to bail out the troubled financial institutions with $800 billion out of taxpayers' pockets, which in turn caused furious angers among American people.

These financial turmoils gave me, as a system dynamics researcher, a chance to re-think about the effectiveness of current macroeconomic system as a system

[1] This chapter is based on the paper: On the Liquidation of Government Debt under A Debt-Free Money System – Modeling the American Monetary Act – in "Proceedings of the 28th International Conference of the System Dynamics Society", Seoul, Korea, July 25 - 29, 2010. With a modest revision, the paper was presented at the 6th Annual Monetary Reform Conf. in Chicago, organized by the American Monetary Institute, on Oct. 1, 2010, for which the following award was given; "Advancement of Monetary Science and Reform Award to Prof. Kaoru Yamaguchi, Kyoto, Japan, For his advanced work in modeling the effects on national debt of the American Monetary Act".

design, since system dynamics is a methodology to help design a better system as Jay Forrester, founder of system dynamics, emphasized in 1961:

> Labor turmoil, bankruptcy, inflation, economic collapse, political unrest, revolution, and war testify that we are not yet expert enough in the design and management of social systems (Forrester, 1961, p.1).

Being enlightened by the books such as Griffin (2006) and Zarlenga (2002), my search for an alternative macroeconomic system design took place immediately in place of the currently dominant macroeconomic system. What's wrong with the current system, I posed. Without exception almost all of macroeconomic textbooks such as Mankiw (2016), McConnell and Bruce (2008), Mishkin (2006), Hall and Taylor (1997), which have been referred to my modeling works, justify the current macroeconomic system without mentioning an alternative system, if any.

Indeed, nothing may be wrong if the current system provides economic stability, full employment, fair income distribution and environmental sustainability. On the contrary, the current system behaves oppositely, as theoretically analyzed in the model in chapter 11, and historically evidenced by the Great Depression in 1929 and the recent financial crises, to pick up some major ones. It is because the current macroeconomic system has been structurally fabricated by the Keynesian macroeconomics, in which it is proposed that monetary and fiscal policies can rescue the troubled economy from recession, as discussed in previous chapters.

Yet, it fails to analyze why such policies, specifically a fiscal policy, are destined to accumulate government debt as already analyzed in Part III. Pick up an example. Japanese economy has been suffering from serious recessions for the last two decades, which is mockingly called *lost two decades*, and its GDP gap remained very huge. Yet due to the fear of runaway accumulation of debt, the government is very reluctant to stimulate the economy and, in this sense, it seems to have totally lost the discretion of public policies for the welfare of people even though production capacities and workers have been sitting idle and ready to be called in service. In addition, in face of the zero interest rate, Keynesian monetary policy has already lost its discretion as well. In other words, Keynesian policies can no longer be applied to the troubled Keynesian macroeconomy. Isn't this an irony of the Keynesian theory? Macroeconomic system of debt money seems to have fallen into the dead-end trap.

16.2 Debt Crises As A Systemic Failure

Debt Crises Looming Ahead

Let us now examine how the current macroeconomic system faces its systemic failure in terms of government debt. Being intensified by the recent financial crisis following the collapse of Lehman Brothers in 2008, severe crisis of sovereign or government debts seems to be looming ahead. Let us explore how serious our accumulating debts are. Table 16.1 shows that, among 33 OECD countries, 18 countries are suffering from higher debt-to-GDP ratios of more than 50% in 2010. Average ratio of these 33 countries is 66.7%, while world average ratio of 131 countries is 58.3%[2]. This implies that developed countries are facing debt crises more seriously than many developing countries.

Country	Ratio(%)	Country	Ratio(%)
Japan	196.4	Israel	77.3
Greece	144.0	Germany	74.8
Iceland	123.8	Hungary	72.1
Italy	118.1	Austria	68.6
Belgium	102.5	United Kingdom	68.1
Ireland	98.5	Netherlands	64.6
United States	96.4	Spain	63.4
France	83.5	Poland	50.5
Portugal	83.2	OECD	66.7
Canada	82.9	World	58.3

Table 16.1: Public Debt-GDP Ratio(%) of OECD Countries in 2010

Let us now take a look at the US national debt. Following the Lehman shock in 2008, US government is forced to bail out troubled banks and corporations with taxpayers's money, and the Fed continued printing money to purchase poisoned subprime and related securities. In fact, according to the Federal Reserve Statistical Release H.4.1 the Fed assets jumped more than doubles in a year from $905 billion, Sept. 3, 2008, to $2,086 billion on Sept. 2, 2009. This unusual increase was mainly caused by the abnormal purchase of federal agency debt securities ($119 billion) and mortgage-backed securities ($625 billion). In addition, US government is obliged to spend more budget on war in Middle East. These factors contributed to accumulate US national debt beyond 14 trillion dollars as of Feb. 2011, more than 4 trillion dollars' increase since Lehman shock in Sept. 2008. Figure 16.1 (line 2) illustrates how fast US national debt has been accumulating almost exponentially[3]. From a simple calibration of data between 1970 through 2011 , the best fit of their exponential growth rate is calculated to be 9% !, which in turn implies that a doubling time of accumulating debt is 7.7 years. If the current US national debt continues to grow at this rate, this means that the doubling year of the 14 trillion dollars' debt in 2011 will be 2019. In fact, our debt forecast of that year becomes 29 trillion dollars. Moreover, in 2020, the US national debt will become higher than 31 trillion dollars, while US

[2]Data of 131 countries for 2010 are taken from CIA Factbook at https://www.cia.gov/library/publications/the-world-factbook/rankorder/2186rank.html except USA Data, which is taken from US National Debt Clock Real Time on Feb. 12, 2011 at http://www.usdebtclock.org/

[3]Data illustrated in the Figure are obtained from TreasuryDirect Web page, http://www.treasurydirect.gov/govt/reports/pd/histdebt/histdebt.htm

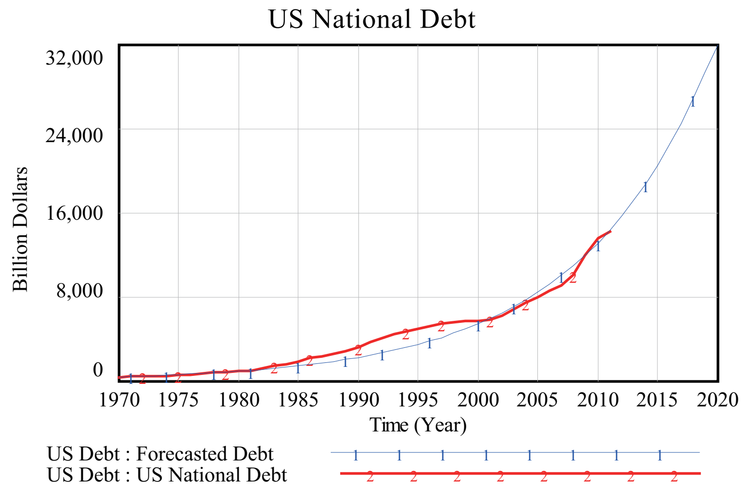

Figure 16.1: U.S. National Debt and its Forecast: 1970 - 2020

GDP in 2020 is estimated to be 24 trillion dollars according to the Budget of the U.S. Government, Fiscal Year 2011; that is, the debt-to-GDP ratio in the US will be 129%!.

Can such an exponentially increasing debt be sustained? From system dynamics point of view, it is absolutely impossible. In fact, following the financial crisis of 2008, sovereign debt crisis hit Greece in 2009, then Ireland, and now Portugal is said to be facing her debt crisis. Debt crises are indeed looming ahead among OECD countries.

A Systemic Failure of Debt Money

From the quantity theory of money $MV = PT$, where M is money stock, V is its velocity, P is a price level and T is the amount of annual transactions, it can be easily foreseen that transactions of a constantly growing economy PT demand for more money M being incessantly put into circulation. Under a debt money system this increasing demand for money has been met by the following monetary standards.

Gold Standard Failed (1930s) Historically speaking gold standard originated from the transactions of goldsmith certificates, which eventually developed into convertible bank notes with gold. Due to the limitation of the supply of gold, this gold standard system of providing money stock was abandoned in 1930s, following the Great Depression.

Gold-Dollar Standard Failed (1971) Gold standard system was replaced with the Bretton Woods system of monetary management in 1944. Under the system, convertibility with gold is maintained indirectly through US dollar as a key currency, and accordingly called the *gold-dollar standard*.

Due to the increasing demand for gold from European countries, US president Richard Nixon was forced to suspend gold-dollar convertibility in 1971, and the so-called *Nixon Shock* hit the world economy.

Dollar Standard Collapsing (2010s?) Following the Nixon shock, flexible foreign exchange rates were introduced, and US dollar began to be used as a world-wide key currency without being supported by gold. As a result, central banks acquired a free hand of printing money without being constrained by the amount of gold. Due to the exponentially accumulating debt of the US government as observed above, US dollar is now under a pressure of devaluation, and the dollar standard system of the last 40 years is destined to collapse sooner or later.

As briefly assessed above, we are now facing the third major systemic failures of debt money, following the failures of gold standard and gold-dollar standard systems. Specifically, our current debt money system seems to be heading toward three impasses: defaults, financial meltdown and hyper-inflation. By using causal loop diagram of Figure 16.2, let us now explore a conceivable systemic failure of the current debt money system.

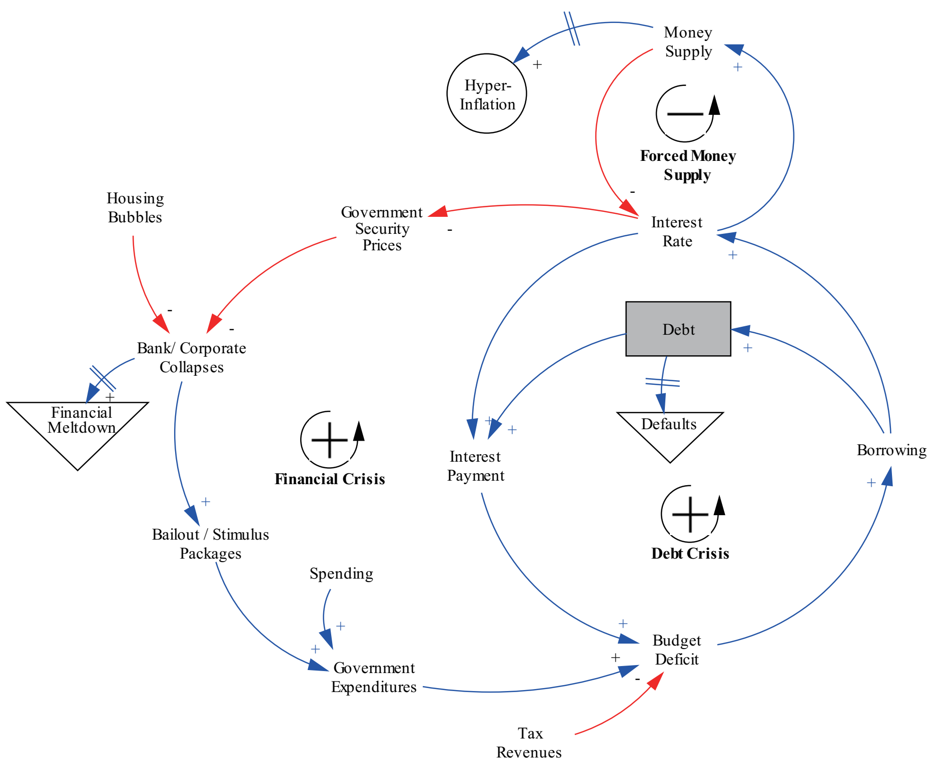

Figure 16.2: Impasses of Defaults, Financial Meltdown and Hyper-Inflation

Defaults

A core loop of the systemic failure is the debt crisis loop. This is a typical reinforcing loop in which debts increase exponentially, which in turn increases interest payment, which contributes to accumulate government deficit into debt. In fact, interest payment is approximately as high as one third of tax revenues in the US and one fourth in Japan. Eventually, governments may get confronted with more difficulties to continue borrowing for debt reimbursements, and eventually be forced to declare defaults.

Financial Meltdown

Exponential growth of debt eventually leads to the second loop of financial crisis. To be specific, a runaway accumulation of government debt may cause nominal interest rate to increase eventually, because government would be forced to keep borrowing by paying higher interests[4]. Higher interest rates in turn will surely trigger a drop of government security prices, deteriorating values of financial assets among banks, producers and consumers. Devaluation of financial assets thus set off may force some banks and producers to go bankrupt in due course.

Under such circumstances, government would be forced to bail out or introduce another stimulus packages, increasing deficit as flow and piling up debt as stock. This financial crisis loop will sooner or later lead our economy toward a second impasse which is in this paper called *financial meltdown*, following Woods (2009). Recent financial crisis following the burst of housing bubbles, however, is nothing but a side attack in this financial crisis loop, though reinforcing the debts crisis. Tougher financial regulations being considered in the aftermath of financial crisis might reduce this side attack. Yet they do not vanquish the financial crisis loop originating from the debts crisis loop in Figure 16.2.

Hyper-Inflation

To avoid higher interest rate caused by two reinforcing crisis loops, central banks would be forced to increase money stock (balancing loop), which inevitably leads to a third impasse of hyper-inflation. Incidentally, this possibility of hyper-inflation in the US may be augmented by the aftermath behaviors of the Fed following the Lehman Shock of 2008. In fact, monetary base or high-powered money doubled from \$905 billion, Sept. 3, 2008, to \$1,801 billion, Sept. 2, 2009, within a year (FRB: H.3 Release). Thanks to the drastic credit crunch, however, this doubling increase in monetary base didn't trigger inflation so far. In other words, M1 consisting of currency in circulation, traveler's checks, demand deposits, and other checkable deposits, only increased from \$1,461 billion in Sept. 2008 to \$1,665 billion in Sept. 2009 (FRB: H.6 Release), which implies that money multiplier dropped from 1.61 to 0.92. As of Feb. 2011, it is 0.91. In short, traditional monetary expansion policy by the Fed didn't work to restore

[4]This feedback loop from the accumulating debt to the higher interest rate is not yet fully incorporated in our model below.

the US economy so far. Yet, these tremendous increase in monetary base will, as a monetary bomb, force the US dollars to be devalued sooner or later. Once it gets burst, hyper-inflation will attack world economy in the foreseeable future. One of the main subject of G20 meetings last year in Seoul, Korea was how to avoid currency wars being led by the devaluation of dollar.

As discussed above in this way, current economies built on a debt money system seems to be getting trapped into one of three impasses, and government may be eventually destined to collapse due to a heavy burden of debts. These are hotly debated scenarios about the consequences of the rapidly accumulating debt in Japan, whose debt-GDP ratio in 2009 was 196.4% as observed above; the highest among OECD countries! Greece has almost experienced this impasse in 2009.

With the above analysis of system failure of the current economic system in mind, we are now in a position to search for an alternative system of macroeconomy in place of the current debt money system.

16.3 A Public Money System

Two Lessons from the Great Depression in 1930s

The Great Depression in 1929 was a severe challenge from the real economy to the dominant classical economic theory that poses that market economies have self-restoring forces to recover equilibrium, and money is neutral to such economic activities. Economists in those days tried to derive lessons from the event theoretically to avoid further disasters of economic recessions and unemployment in the future. The lessons they learned resulted in the publication of two books symbolically in the same year of 1935[5]; John M. Keynes's book: *The General Theory of Employment, Interest, and Money* Keynes (1936), and Irving Fisher's book: *100% Money* Fisher (1945).

Keynes proposed that the Great Depression was caused by the deficiency in the effective demand of macro economy by presenting the innovative framework of macroeconomy, which eventually revolutionized the economic analyses, up to the present days, under the so-called *Keynesian Revolution*. Our macroeconomic analyses in Parts II and III are essentially based on his macroeconomic framework. Yet, he paid little attention on the role of money as debt, and overlooked possible debt crises, as discussed above, that are being built in our debt money system.

On the other hand, Fisher, a great monetary economist in those days, argued that the Great Depression was caused by the debt money system itself; specifically, money that is created by the privately owned central bank, and credit(as money) that is created by commercial banks out of nothing through the fractional reserve banking system. He has regarded the debt money system

[5] Strictly speaking, Keynes' Preface to the book was written on December 13, 1935, and Fisher's Preface to the first edition of the book was written in March, 1935.

as a root cause of the Great Depression by refuting the classical theory of the neutrality of money. The lesson he learned is known as "100% Money Plan"

> I have come to believe that the plan, "properly worked out and applied, is incomparably the best proposal ever offered for speedily and permanently solving the problem of depressions; for it would remove the chief cause of both booms and depressions, namely the instability of demand deposits, tied as they are now, to bank loans." (Fisher, 1945, p. 9)

His proposal, however, had been preceded by the plan that was privately prepared and handed over to the Hon. Henry A. Wallace, Secretary of Agriculture, Washington, D.C. and "the forty odd who get this who will not think we are quite loony". It was written in the face of collapsing banking system of the early 1930s under the title of *The Chicago Plan for Banking Reform* by eight economists at the University of Chicago such as G.V. Cox, Aaron Director, Paul Douglas, A.G. Hart, F.H. Knight, L.W. Mints, Henry Schultz, and H.C. Simons (Phillips, 1995, pp. 191-199). Irrespective of the support of these economists, the Chicago Plan failed to be implemented.

Being disappointed by this failure, in July 1939, Irving Fisher had written his own version of a mimeograph called *A Program for Monetary Reform*(Fisher, 1945, pp. 157-183), co-signed this time by five professional colleagues: Paul H. Douglas (University of Chicago), Frank D. Graham and Charles R. Whittlesey (Princeton University), Earl J. Hamilton (Duke University), and Willford I. King (New York University). It was then sent to "the completest available list of academic economists... Up to the date of writing (July 1939) 235 economists from 157 universities and colleges have expressed their general approval of this Program; 40 more have approved it with reservations; 43 have expressed disapproval. The remainder have not yet replied (Fisher, 1945, p. 158)."

In this way, the second lesson from the Great Depression resulted in the movement of banking/monetary reform, which has been sometimes called the Chicago Plan as its representative name collectively to honor the original efforts of the economists at the University of Chicago. Among those proponents of the monetary reform, Irving Fisher stayed very active all his life in establishing his monetary reform to stabilize the economy out of recessions such as the Great Depression. In spite of his devotion, being supported by many academic economists, his monetary reform also failed to be implemented. This vividly contrasts with the Keynes's influences on the economic policies later on.

The implementation of the Chicago Plan was taken over by the more moderate banking reform that tried to save the collapsing banking system by avoiding political oppositions from the Wall Street bankers and financiers. It was established as the Banking Act of 1933, known as the Glass-Steagall Act later, followed by its revised Banking Act of 1935. The Glass-Steagall Act was intended to separate banking activities between Wall Street investment banks and depository banks.

These two novel lessons obtained from the Great Depression, however, have been gradually denuded. First, Keynesian revolution lost its influential power in the face of stagflation in the 1970s, and has been gradually replaced with the neoclassical market fundamentalism. This counter-revolution, this time, began to take over the financial markets as well with the introduction of the Efficient Markets Hypothesis, which claims that financial markets have a tendency to attain market efficiency only when they are deregulated. Under such circumstances, the Glass-Steagall Act, though more moderate than the Chicago Plan, was repealed in 1999 by the Gramm-Leach-Bliley Act.

As early as 2000, these two lessons from the Great Depression have been entirely denuded, and the economic situations became very similar to those of the 1920s before the Great Depression. History has repeated! This time the repeal of the Glass-Steagall has triggered the financial crisis of subprime mortgage loans, followed by the collapse of Lehman Brothers in 2008, which may be more appropriately called the "Second Great Depression".

The American Monetary Act: A New Lesson

What lessons can we learn from the Second Great Depression, then? On-going movement of financial reforms in the US may be an attempt to bring back a little bit stricter banking regulations in the spirit of the Glass-Steagall Act. Yet, this cannot be our lesson, because we are facing a systemic failure of debt crises as discussed in the above section. Keynes' lesson of the General Theory cannot be our lesson either, because it turned out to be a root cause of debt crises.

Our new lesson in face of the looming debt crises has to be the modern version of the Chicago Plan of monetary reform which has failed to be implemented so far. The Chicago Plan has indeed fully predicted the fixing power of national debts "as a by-product of the 100% reserve system", as the following section 17 demonstrates:

> (17a) Under the present fractional reserve system, the only way to provide the nation with circulating medium for its growing needs is to add continually to our Government's huge bonded debt. Under the 100% reserve system the needed increase in the circulation medium can be accomplished without increasing the interest bearing debt of the Government (Fisher, 1945, p. 181).
>
> (17b) As already noted, a by-product of the 100% reserve system would be that it would enable the Government gradually to reduce its debt, through purchases of Government bonds by the Monetary Authority as new money was needed to take care of expanding business (Fisher, 1945, p. 182).

In the United State, the American Monetary Act[6] has been endeavoring to restore the proposal of the Chicago Plan and monetary reform by replacing the

[6] Its full text is available at http://www.monetary.org/wp-content/uploads/2011/09/32-page-brochure.pdf. On Dec. 17, 2010, a bill based on the American Monetary Act was introduced to the US House Committee on Financial Services as H.R. 6550 by the congressman Dennis Kucinich. This bill is called "The National Emergency Employment Defense Act of 2010 (NEED Act)". The bill was re-submitted on Sept. 21,

Federal Reserve Act of 1913. Accordingly, it has become our new lesson after the Second Great Depression; the lesson and the only remaining one that once failed to be implemented.

In our terminology in this book, it is nothing but the restoration of a *public money* system from a *debt money* system. Specifically, the American Monetary Act tries to incorporate the following three features based on the Chicago Plan. For details see (Zarlenga, 2002, Chap. 24) and Zarlenga (2009).

- Governmental control over the issue of money
- Abolishment of credit creation with full reserve ratio of 100%
- Constant inflow of money to sustain economic growth and welfare

As a system dynamics researcher, I have become interested in the system design of macroeconomics proposed by the American Monetary Act, and posed a question whether this public money system of macroeconomy can solve the most imminent problem our economy is facing; that it, accumulation of government debt. Accordingly, next objective of this chapter is to construct a macroeconomic model which incorporates the above three features and examine if this alternative system could help liquidate government debt or not. Before moving on, let us take a closer look at these features in detail.

Governmental control over the issue of money

In macroeconomics, the amount of money to be issued by the central bank is called *monetary base* or *high-powered money*. In order for the government to control the issue of money and monetary base, the American Monetary Act suggests as follows:

> First, the Federal Reserve system becomes incorporated into the U.S. Treasury. This nationalizes the money system, not the banking system. Banking is *not a proper function of government*, but control and oversight of the money system *must be done by government* (Zarlenga, 2009, p.12).

In Japan, the government owns 55% of the shares of the Bank of Japan. Accordingly, its incorporation to the government could be rather smoothly done, though the government, its major shareholder, is currently prohibited from the bank's decision-making process by law. In Europe, two incorporation processes could be possible. First, EU member countries are politically integrated into, say, the United States of Europe, which in turn establishes its own federal European government and incorporate the current European Central Bank into its branch. Or the ECB is once again disintegrated and incorporated into the governments of member countries, respectively.

2011 as H.R. 2990 by the congressman Dennis Kucinich. Its full text is available at http://www.govtrack.us/congress/billtext.xpd?bill=h112-2990 .

On July 26, 2011, about two months before its submission, I was invited to the US Congressional Briefing by the congressman to present the findings of my macroeconomic simulation results based on this chapter and next chapter.

Abolishment of credit creation

Credit can be created by the lending of commercial banks, and becomes a part of money stock, because it plays a role of means of exchange. The credit creation has been called *money out of nothing* or *money out of thin air* by Keynes. It is made possible because banks are required to hold only a fraction of deposits (with the central bank) and can lend the remaining larger portion. This system is called *a fractional reserve banking system.* Heavily-criticized practice of leveraged investment that led to the recent financial crises is made possible by the credit creation. Under a public money system, this fractional reserve banking system is abolished; that is, a fractional reserve ratio has to be 100%. The American Monetary Act suggests as follows:

> Second, the accounting privilege banks now have of creating money through fractional reserve lending of their credit is stopped entirely, once and for all. Banks remain private companies and are encouraged to act as intermediaries between their clients who want a return on their savings and those clients willing to pay for borrowing those savings, but they may no longer create any part of the nation's money stock (Zarlenga, 2009, p.12).

When full reserve system is implemented by the Act, bank reserves become equal to deposits so that we have

$$\begin{aligned}\text{Money Stock} &= \text{Currency in Circulation} + \text{Deposits} \\ &= \text{Currency in Circulation} + \text{Reserves} \\ &= \text{High-Powered Money}\end{aligned} \tag{16.1}$$

Accordingly, under the public money system, money is created only by the government, and money stock becomes public money[7].

It will be worthwhile to clarify a position of money in an economy. Suppose there exists N commodities in an economy. Under gold standard or commodity money standard, one of the commodities becomes money against which the remaining N-1 commodities are exchanged. Hence, quantity of money is limited by the production of gold or commodity money. Under a fractional reserve banking system, credit is created and used as *low-powered* money in addition to monetary base or high-powered money. In other words, 2 types of money are being used for the exchange of N commodities; that is, currency in circulation and deposits. Finally, under a system of public money, only the government-issued fiat money is used to exchange for N commodities. Schematically, positions of money under different monetary system is summarized as follows:

[7]Money stock is also defined in terms of high-powered money as

$$\text{Money Stock} = m * \text{High-Powered Money} \tag{16.2}$$

where m is a money multiplier. Under a full reserve system, money multiplier becomes unitary, $m = 1$, so that money can no longer be created by commercial banks.

Gold or Commodity Money Standard
(N - 1) + Gold

Debt Money
N + Currency in Circulation + Credits(Deposits)

Public Money
N + Money

Constant inflow of money

Growing economy demands for a growing amount of money as a means of exchange if monetary value is to be sustained. This can be easily verified from the following quantity theory of money:

$$MV = PT = kPY \tag{16.3}$$

where M is money stock, V is a velocity of money, P is a price level, T is the amount of transaction, Y is real GDP, and k is a so-called Marshall's k.

Assuming that V and k are constant, we have

$$\frac{\dot{M}}{M} = \frac{\dot{P}}{P} + \frac{\dot{Y}}{Y} \tag{16.4}$$

Thus, to sustain a monetary value by avoiding inflation or deflation, we have to attain $\dot{P}/P = 0$. This implies that $\dot{M}/M = \dot{Y}/Y$; that is, money has to be issued and put into circulation in accordance with the economic growth.

Under a system of debt money, the injection of new money into circulation has only been carried out by the privately-controlled central bank at its discretion and for its interest. Under a public money system, two channels for money injection becomes available. First, the government can directly distribute newly issued money into circulation as an additional expenditure according to its public policies supported by voters in the field of infrastructures, education, medical care, green technologies and environment. Second, the central bank, now as a part of government, can make loans to commercial banks, free of interest, according to a guideline set by governmental growth strategies for the interest and welfare of people.

As to the new issue of money, American Monetary Act suggest as follows:

> Third, new money is introduced into circulation by government spending it into circulation starting with the $2.2 trillion the engineers tell us is needed for infrastructure repair and renewal. In addition, health care and education are included as human infrastructure. Everyone supports the infrastructure, but they worry how to pay for it. That becomes possible with the passage of the American Monetary Act (Zarlenga, 2009, p.12).

Battles to Control A Money System

Human history could be, in a sense, said to be a history of battles to control the issue of money; that is, the battles between a debt money system and a public money system in our terminology here, or between interest-bearing money and interest-free money.

Science of money, according to Zarlenga (2002), was founded by Aristotle (384-322 BC). He viewed that "Money exists not by nature but by law(nomos)" . His view has been supported through the church's condemnation of usury up to the work by the philosopher George Berkeley[8] in his 1735 book of questions "Querest". Neglecting his work, Adam Smith, father of economics, ended the battle by supporting the Bank of England, founded in 1694, as a system of debt money in his book *The Wealth of Nations* in 1776.

> This battle is summarized as Aristotle's science of money vs. Adam Smith's metallic view of money. $\cdots$ Whether money should be tangible wealth and thereby be privately controlled to benefit the wealthy (Smith), or be an abstract legal fiat power publicly controlled to promote the general welfare (Aristotle) (Zarlenga, 2009, p.6).

In the United States, this battle was finalized when the Federal Reserve Act was approved and system of debt money has been introduced Griffin (2006). Since then science of money has been lost and economists showed no doubt on the role of debt money, including Keynes. The lost science has been reflected in many macroeconomics textbooks, including the ones as briefly mentioned above.

The dominance of current macroeconomic system is being challenged again with the introduction of the American Monetary Act under the recent financial crises. As a system dynamics researcher and a professionally trained economist, I'm of the opinion that it is a reclaiming process of *the lost science of money* to construct macroeconomic models which enable us to compare these two systems and evaluate them impartially in terms of economics as a science.

16.4 Macroeconomic System of Debt Money

For the comparative analysis of the two macroeconomic systems, the integrated macroeconomic model developed in chapter 8 is revisited in this chapter[9]. According to the discussions above, the model is classified as a macroeconomic

[8] University of California at Berkeley, where I studied mathematical economics in late 70's and early 80's, was named after the philosopher Berkeley.

[9] This choice of the model is in accordance with my viewpoint that labor market should be abolished from a market economy as a better economic system, which is proposed as the MuRatopian economy in Yamaguchi (1988). The MuRatopian economy is presented as an alternative system, beyond capitalist market economy and planned socialist economy, suitable for the information age of the 21st century. However, money system is missing in the economy, I admit. While writing this chapter, I become convinced that a public money system should be indeed a monetary system of the MuRaopian economy.

system of debt money, in which five macroeconomic sectors are assumed to play interdependent activities simultaneously; that is, producers, consumers, banks, government and the central bank [Companion Model: Design Macro.vpmx]. Foreign sector is excluded from the model.

Under the current macroeconomic system of debt money, transactions by producers, consumers, government, banks and the central bank remain the same as already explained in Chapter 8. Yet, transactions of government, banks and central bank are repeated here as a comparative reference to the revised transactions under a macroeconomic system of public money to be presented below.

Government

Transactions of the government are illustrated in Figure 16.3, some of which are summarized as follows.

- Government receives, as tax revenues, income taxes from consumers and corporate taxes from producers as well as excise tax on production.
- Government spending consists of government expenditures and payments to the consumers for its partial debt redemption and interests against its securities.
- Government expenditures are assumed to be endogenously determined by either the growth-dependent expenditures or tax revenue-dependent expenditures.
- If spending exceeds tax revenues, government has to borrow cash from banks and consumers by newly issuing government securities.

Banks

Transactions of banks are illustrated in Figure 16.4, some of which are summarized as follows.

- Banks receive deposits from consumers, against which they pay interests.
- They are obliged to deposit a fraction of the deposits as the required reserves with the central bank (which is called a fractional reserve banking system).
- Out of the remaining deposits loans are made to producers and banks receive interests for which a prime rate is applied.
- Their retained earnings thus become interest receipts from producers less interest payment to consumers. Positive earning will be distributed among bank workers as consumers.

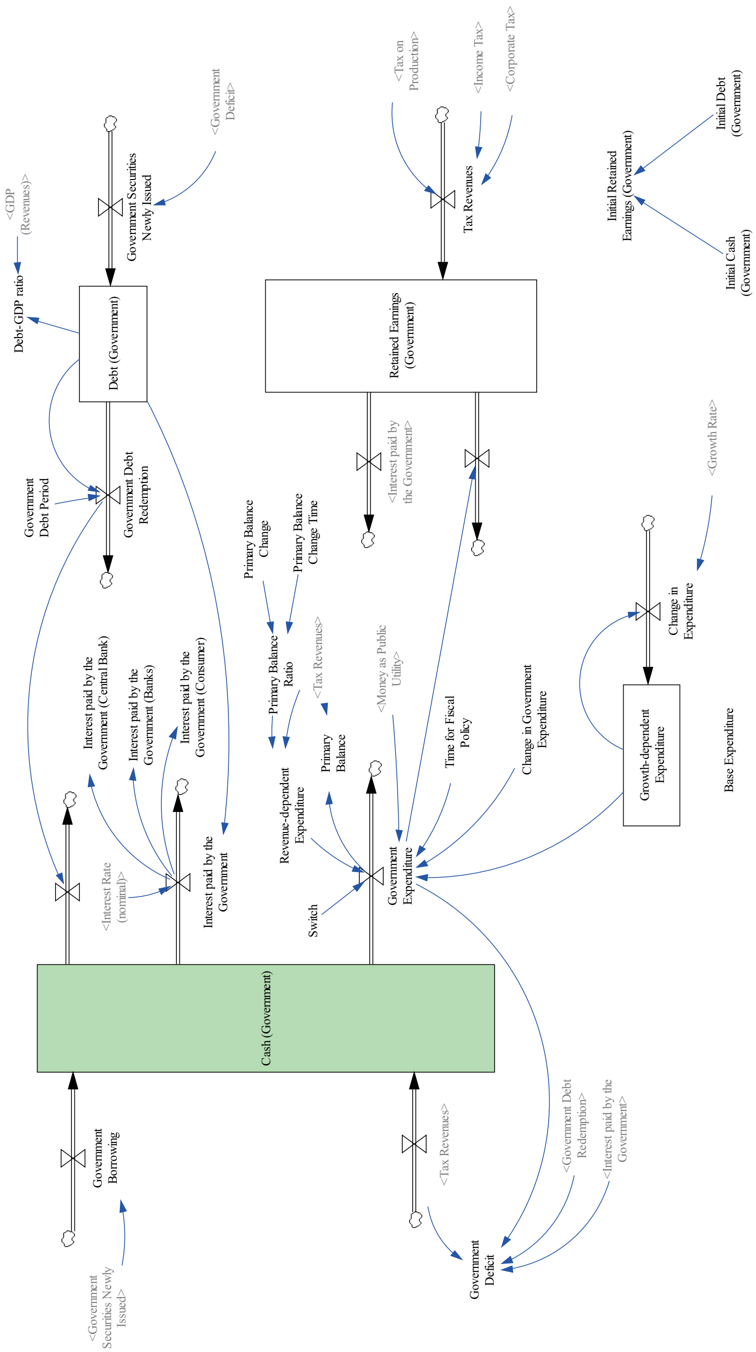

Figure 16.3: Transactions of Government

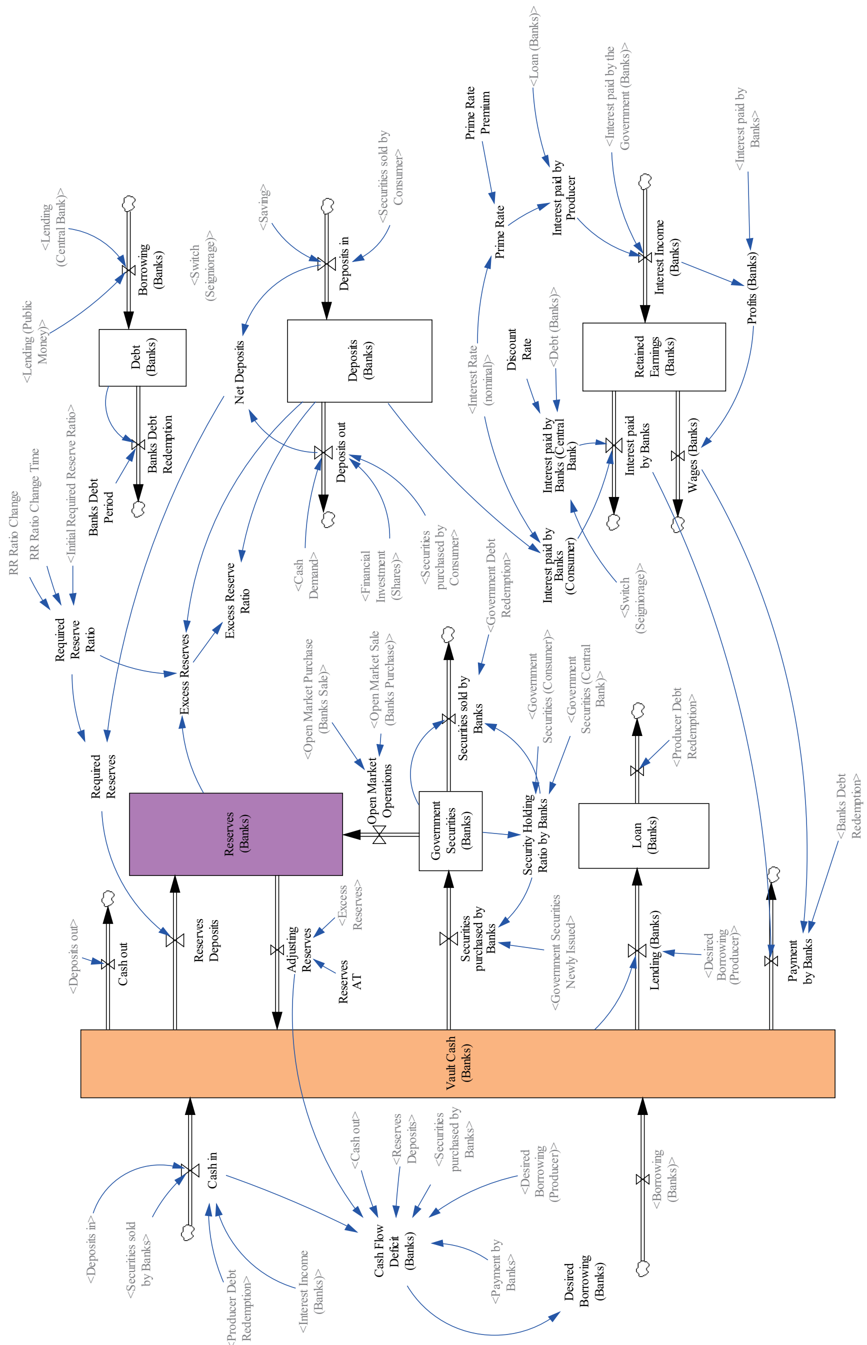

Figure 16.4: Transactions of Banks

Central Bank

The central bank plays an important role of issuing money or currency. Sources of its assets against which money is issued are simply confined to gold, discount loans and government securities. The central bank can control the amount of money stock through the amount of monetary base consisting of currency outstanding and bank reserves. This monetary control can be carried out through monetary policies such as a manipulation of required reserve ratio and open market operations as well as direct control of lending to the banks. Transactions of the central bank are illustrated in Figure 16.5, some of which are summarized as follows.

- The central bank issues money (historically gold certificates) against the gold deposited by the public.
- It can also issue money by accepting government securities through open market operation, specifically by purchasing government securities from the public (consumers) and banks. Moreover, it can issue money by making discount loans to commercial banks. (These activities are sometimes called creation of *money out of nothing*.)
- It can similarly withdraw money by selling government securities to the public (consumers) and banks, and through debt redemption by banks.
- Banks are required by law to reserve a certain fraction of deposits with the central bank. By controlling this required reserve ratio, the central bank can control the monetary base directly.
- The central bank can, thus, control the amount of money stock through monetary policies such as open market operations, reserve ratio and discount rate.
- Another powerful but hidden control method is through its direct influence over the amount of discount loans to banks (known as *window guidance* in Japan.)

16.5 Behaviors of A Debt Money System

Mostly Equilibria in the Real Sector

The macroeconomic model of debt money is now complete. It is a generic model, out of which diverse macroeconomic behaviors will be generated. Let us only focus on an equilibrium growth path of the macroeconomy. As already discussed in chapter 8, an equilibrium state is called *a full capacity aggregate demand equilibrium* if the following three output and demand levels are met:

$$\text{Full Capacity GDP} = \text{Desired Output} = \text{Aggregate Demand} \quad (16.5)$$

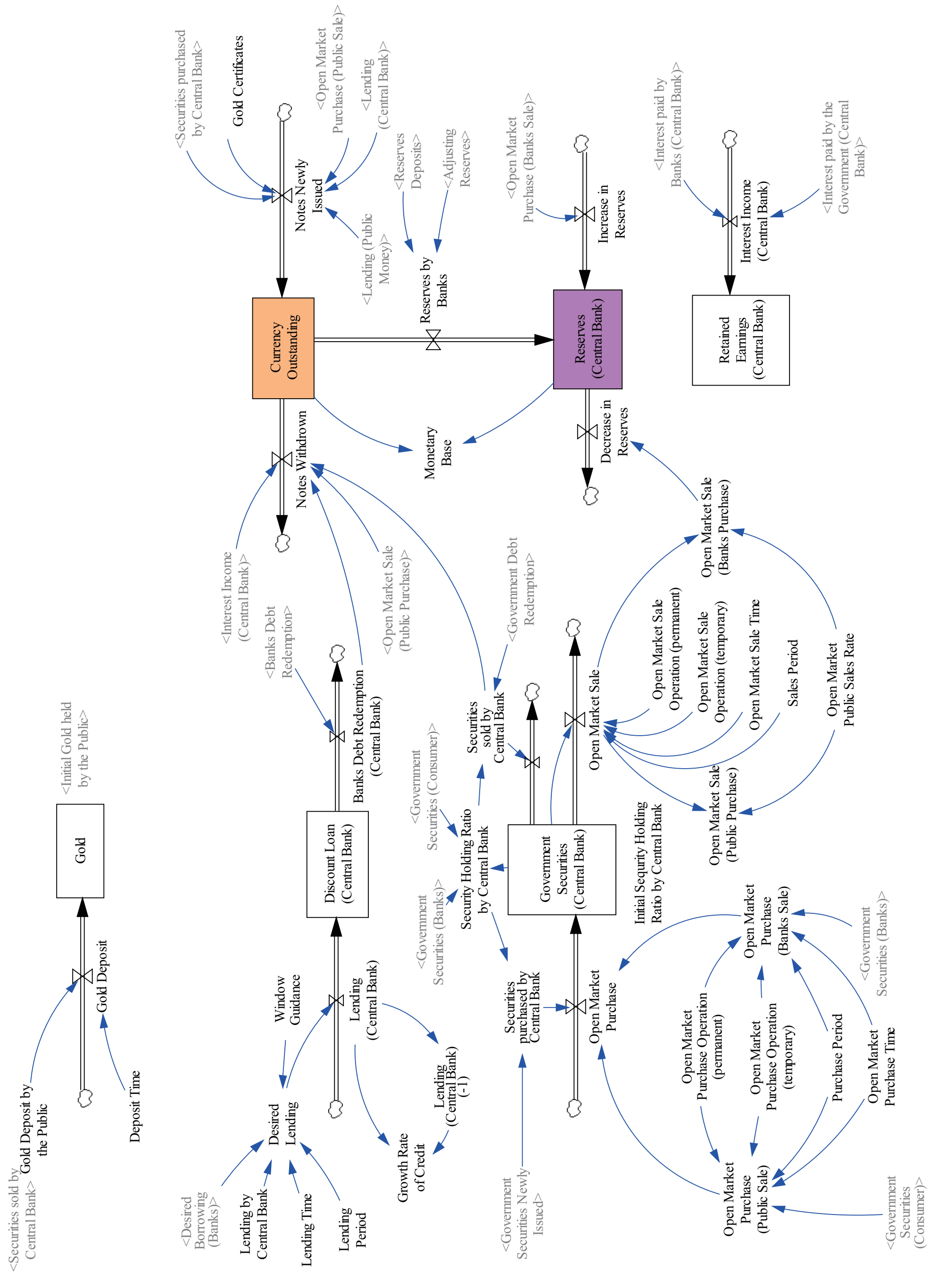

Figure 16.5: Transactions of Central Bank

By trial and error, mostly equilibrium states are acquired, as in chapter 8, when a ratio elasticity of the effect on price e is 1, and a weight of inventory ratio ω is 0.1, as illustrated in Figure 16.6.

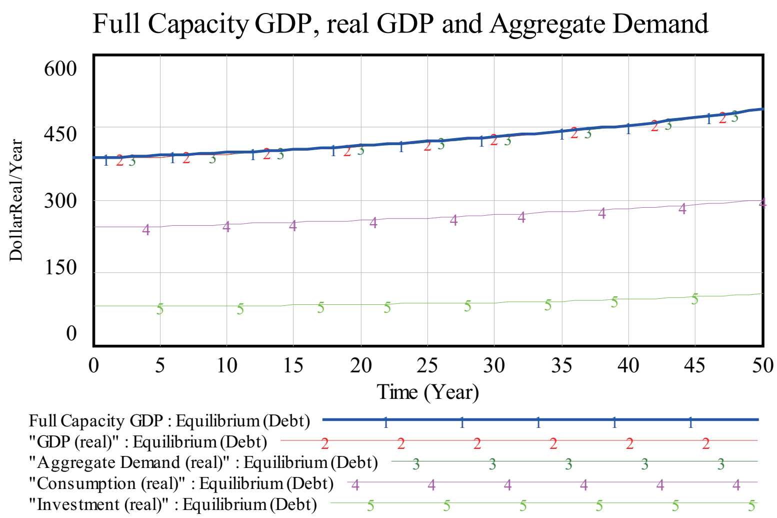

Figure 16.6: Mostly Equilibrium States

These equilibrium states are used in chapter 8 as a benchmarking state for comparisons with various disequilibrium cases such as fix-price disequilibria, business cycles caused by inventory coverage and elastic price fluctuation, and economic recession caused by credit crunch. Moreover, these disequilibria are shown to be fixed toward equilibria through monetary and fiscal policies. In this chapter, our analysis is confined only to the case of liquidation of government debt.

Money out of Nothing

For the attainment of mostly equilibria, enough amount of money has to be put into circulation to avoid recessions caused by credit crunch as analyzed in chapter 8. Demand for money mainly comes from banks and producers. Banks are assumed to make loans to producers as much as desired so long as their vault cash is available. Thus, they are persistently in a state of shortage of cash as well as producers. In the case of producers, they could borrow enough fund from banks. From whom, then, should the banks borrow in case of cash shortage?

In a closed economic system, money has to be issued or created within the system. Under the current financial system of debt money, only the central bank is endowed with a power to issue money within the system, and make loans to the commercial banks directly and to the government indirectly through the open market operations. Commercial banks then create credits under a fractional reserve banking system by making loans to producers and consumers. These credits constitute a major portion of money stock. In this way, money and credits are only created when commercial banks and the government as well as producers and consumers come to borrow at interest. If all debts are repaid, money ceases to exist. This is an essence of a system of debt money. This process of creating money is known as *money out of nothing*.

Figure 16.7 indicates unconditional amount of annual discount loans and its growth rate by the central bank at the request of desired borrowing by banks. In other words, money has to be incessantly created and put into circulation in order to sustain an economic growth under mostly equilibrium states. Roughly speaking, a growth rate of credit creation by the central bank has to be in average equal to or slightly greater than the economic growth rate as suggested by the right hand diagram of Figure 16.7.

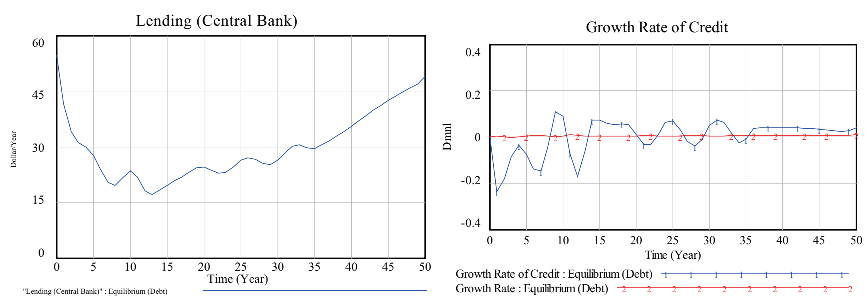

Figure 16.7: Lending by the Central Bank and its Growth Rate

In this way, the central bank begins to exert an enormous power over the economy through its credit control. What happens if the central bank fails to supply enough currency intentionally or unintentionally? An economic recession by credit crunch as analyzed in chapter 8. An influential role of the central bank which caused economic bubbles and the following burst in Japan during 1990's is completely analyzed by Werner in Werner (2003) and Werner (2005).

Accumulation of Government Debt

So long as the mostly equilibria are realized in the economy, through monetary and fiscal policies in the days of recession, no macroeconomic problem seems to exist. This is a positive side of Keynesian macroeconomic theory. Yet behind the full capacity aggregate demand growth path in Figure 16.6 government debt continues to accumulate as the line 1 in the left diagram of Figure 16.8 illustrates. This is a negative side of the Keynesian theory. Yet most macroeconomic textbooks neglect or less emphasize this negative side, partly because their macroeconomic frameworks cannot handle this negative side of the system of debt money.

Primary balance ratio is initially set to be one and balanced budget is assumed here; that is, government expenditure is set to be equal to tax revenues, and no deficit seems to arises. Why, then, does the government continue to accumulate debt? Government deficit is, as discussed in chapter 8, precisely

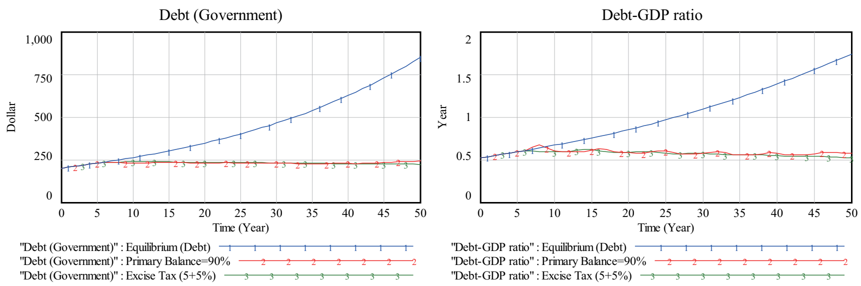

Figure 16.8: Accumulation of Government Debt and Debt-GDP Ratio

defined as

$$\text{Deficit} = \text{Tax Revenues - Expenditure - Debt Redemption - Interest} \quad (16.6)$$

Therefore, even if balanced budget is maintained, the government still has to keep paying its debt redemption and interest. This is why it has to keep borrowing and accumulating its debt. Initial GDP in the model is obtained to be 386, while government debt is initially set to be 200. Hence, the initial debt-GDP ratio is around 0.52 year (similar to the current ratios among EU member countries). Yet, the ratio continues to increase to 1.74 year at the year 50 in the model as illustrated by the line 1 in the right diagram of Figure 16.8. This implies the government debt becomes 1.74 years as high as the annual level of GDP.

Can such a high debt be sustained? Absolutely no. Eventually this runaway accumulation of government debt may cause nominal interest rate to increase, because the government may be forced to keep borrowing by paying higher interests, which may eventually cause hyper-inflation[10].

Higher interest rates may in turn trigger a sudden drop of government security price, deteriorating values of financial assets owned by banks, producers and consumers. The devaluation of financial assets may force some banks and producers to go bankrupt eventually. In this way, another financial crisis becomes inevitable and government is eventually destined to collapse as well. This is one of the hotly debated scenarios about the consequences of the rapidly accumulating debt in Japan, whose debt-GDP ratio in 2009 was 1.893 years; the highest among OECD countries! Compared with this, debt-GDP ratios in the model seem to be still modest.

Remarks: if this scenario of financial breakdown due to the runaway accumulation of debt fails to be observed in the near future, still there exit some legitimate reasons to stop the accumulating debt. First, it continues to create

[10] This feedback loop from the accumulating debt to the higher interest rate is not yet fully incorporated in the model.

unfair income distribution in favor of bankers and financial elite, causing inefficient allocation of resources and economic performances, and eventually social turmoils by the poor. Second, forced payment of interest forces the indebted producers to continue incessant economic growth to the limit of environmental carrying capacity, which eventually leads to the collapse of environment. In short, system of debt money is unsustainable as an economic system.

Liquidation of Government Debt

Let us now consider how to avoid such a financial crisis and collapse. At the face of the financial crisis as discussed above, suppose that the government is forced to reduce its debt-GDP ratio to less than 0.6 by the year 50, as required to all EU members by the Maastricht treaty. To attain this goal, only two policies are available to the government; that is, to spend less or tax more. Let us consider them, respectively.

Policy A: Spend Less

This policy assumes that the government spends 10% less than its equilibrium tax revenues, so that a primary balance ratio has to be reduced to 0.9 in our economy. In other words, the government has to make a strong commitment to repay its debt annually by the amount of 10 % of its tax revenues. Let us assume that this reduction is put into action at the year 6. Line 2 of the left diagram of Figure 16.9 illustrates this reduction of spending.

Under such a radical financial reform, debt-GDP ratio will be reduced to around 0.6 at the year 25, and to around 0.58 at the year 50 as illustrated in line 2 in the right diagram of Figure 16.8. Accordingly, the accumulation of debt will be eventually curved as shown in line 2 in the left diagram.

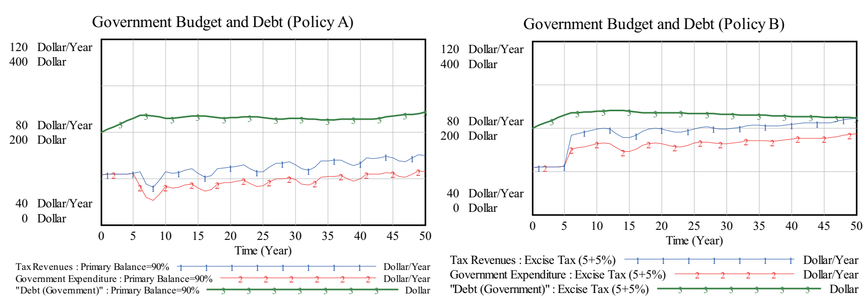

Figure 16.9: Liquidation Policies: Spend Less and Tax More

Policy B: Tax More (and Spend More)

Among various sources of taxes to be levied by the government such as income tax, excise tax, and corporate tax, let us assume here that excise tax is increased, partly because an increase in consumption (or excise) tax has become a hot political issue recently in Japan. Specifically the excise tax is assumed to be increased to 10% from the initial value of 5% in our model; that is, 5% increase. Line 1 of the right diagram of Figure 16.9 illustrates the increased tax revenues.

Out of these increased tax revenues, spending is now reduced by 8.5% to repay the accumulated debt. Though spending is reduced in the sense of primary balance, it has indeed increased in the absolute amount, compared with the original equilibrium spending level, as illustrated by line 2 of the same right diagram of Figure 16.9. Accordingly the government needs not be forced to reduce the equilibrium level of budget.

As a result this policy can also successfully reduces debt-GDP ratio to around 0.575 at the year 25, and to around 0.52 at the year 50 as illustrated in line 3 in the right diagram of Figure 16.8. Accordingly, the accumulation of debt will also be eventually curved as shown in line 3 in the left diagram.

Triggered Recessions

These liquidation policies seem to be working well as debt begins to get reduced. However, the implementation of these policies turns out to be very costly to the government and its people as well.

Let us examine the policy A in detail. At the next year of the implementation of 10 % reduction of a primary balance ratio, growth rate is forced to drop to minus 6 %, and the economy fails to sustain its full capacity aggregate demand equilibrium of line 1 as illustrated by line 2 in Figure 16.10. Compared with the mostly equilibrium path of line 1, debt-reducing path of line 2 brings about business cycles. Similarly, line 3 indicates another business cycle triggered by Policy B; though a recession is triggered to minus 2.6 % of growth rate with a delay at the year 13.

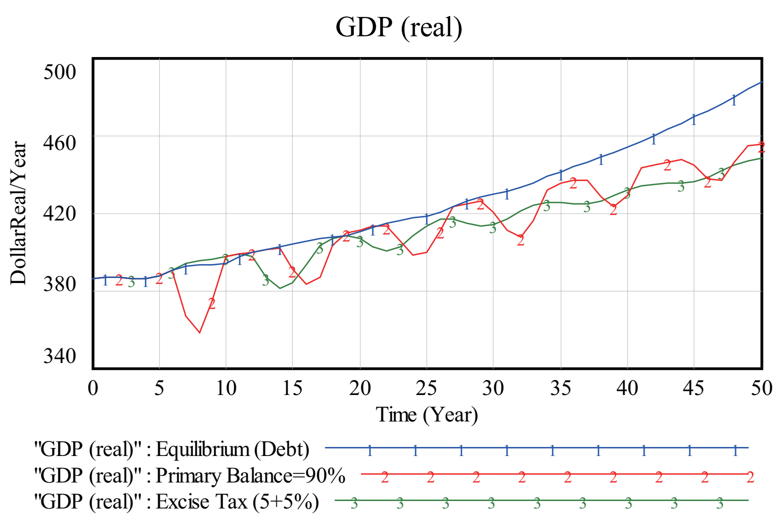

Figure 16.10: Comparison of GDP paths

16.6 Macroeconomic System of Public Money

We are now in a position to implement the alternative macroeconomic system discussed in the introduction, as proposed by the American Monetary Act, in which the central bank is incorporated into the government and a fractional reserve banking system is abolished. Let us call this new system a macroeconomic system of public money. Money issued in this new system plays a role of public utility of medium of exchange. Hence the newly incorporated institution may be appropriately called *the Public Money Administration*.

Under this incorporation, transactions of the government, commercial banks and the public money administration (formally the central bank) need to be revised slightly. Let us start with the description of the revised transactions of the government.

Government

- Balanced budget is assumed to be maintained; that is, a primary balance ratio is unitary. Yet the government may still incur deficit due to the debt redemption and interest payment.
- Government now has the right to newly issue money whenever its deficit needs to be funded. The newly issued money becomes seigniorage inflow of the government into its equity or retained earnings account.
- The newly issued money is simultaneously deposited with the reserve account of the Public Money Administration. It is also booked to its deposits account of the government assets.
- Government could further issue money to fill in GDP gap.

Revised transaction of the government is illustrated in Figure 16.11. Green stock box of deposits is newly added to the assets.

Banks

Revised transactions of commercial banks are summarized as follows.

- Banks are now obliged to fully deposit the amount of deposits they owe as the required reserves with the public money administration. Time deposits are excluded from this obligation.
- When the amount of time deposits is not enough to meet the demand for loans from producers, banks are allowed to borrow from the public money administration free of interest; that is, a former discount rate is now zero. Allocation of loans to the banks will be prioritized according to the public policies of the government. (This constitutes a market-oriented issue of new money. Alternatively, the government can issue new money directly through its public policies to fill in a GDP gap, if any, as already discussed above.)

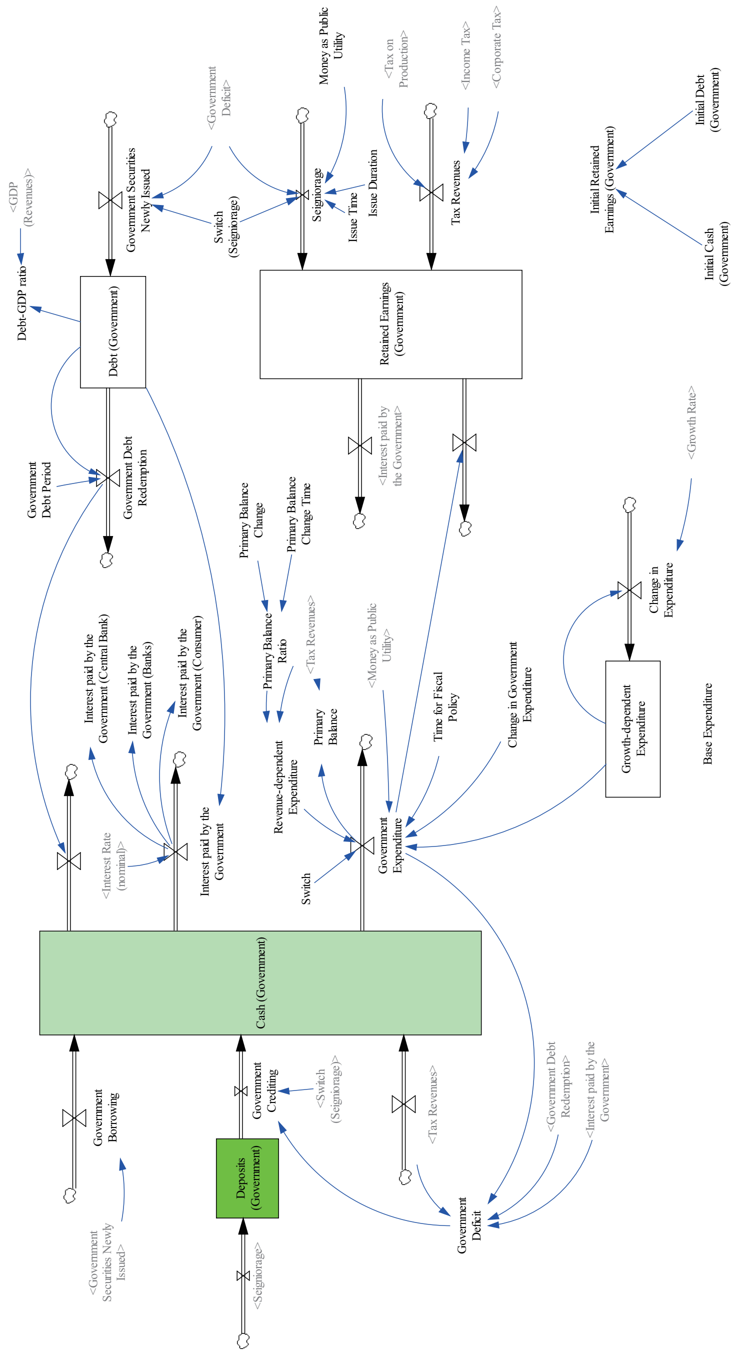

Figure 16.11: Transactions of Government

Line 1 in Figure 16.12 illustrates the originally required reserve ratio of 5%. In addition, three different ways of abolishing a fractional reserve banking system are illustrated, starting at the year 6. Line 2 shows that the 100% fraction (full reserves) is immediately attained in a year. Line 3 shows it is attained in 5 years, and line 4 shows it is gradually attained in 10 years. In our analysis here, 5 year's attainment of 100% fraction will be mainly used as a representative to avoid a complexity of illustration.

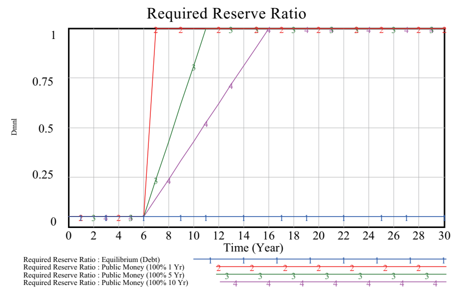

Figure 16.12: 100% Required Reserve Ratios

Public Money Administration (Formerly Central Bank)

The central bank now gets incorporated as one of the governmental organizations which is here called the Public Money Administration (PMA). Its revised transactions now become as follows.

- The PMA accepts newly issued money of the government as seigniorage assets and enter the same amount into the government reserve account. Under this transaction, the government needs not print hard currency, instead it only sends digital figures of the new money to the PMA.

- When the government wants to withdraw money from their reserve accounts at the PMA, the PMA could issue new money according to the requested amount. In this way, for a time being, former central bank notes and government money coexist in the market.

- With the new issue of money the PMA meets the demand for money by commercial banks, free of interest, according to the guideline set by the government public policies.

Under the revised transactions, open market operations of sales and purchases of government securities become ineffective, simply because government debt gradually diminishes to zero. Furthermore, discount loan is replaced with interest-free loan. This lending becomes a sort of open and public *window guidance*, which once led to the rapid economic growth after World War II in Japan Werner (2003). Accordingly, interest incomes from discount loans and government securities are reduced to be zero eventually. Transactions of the public money administration are illustrated in Figure 16.13. Green stock boxes of seigniorage assets and government reserves are newly added.

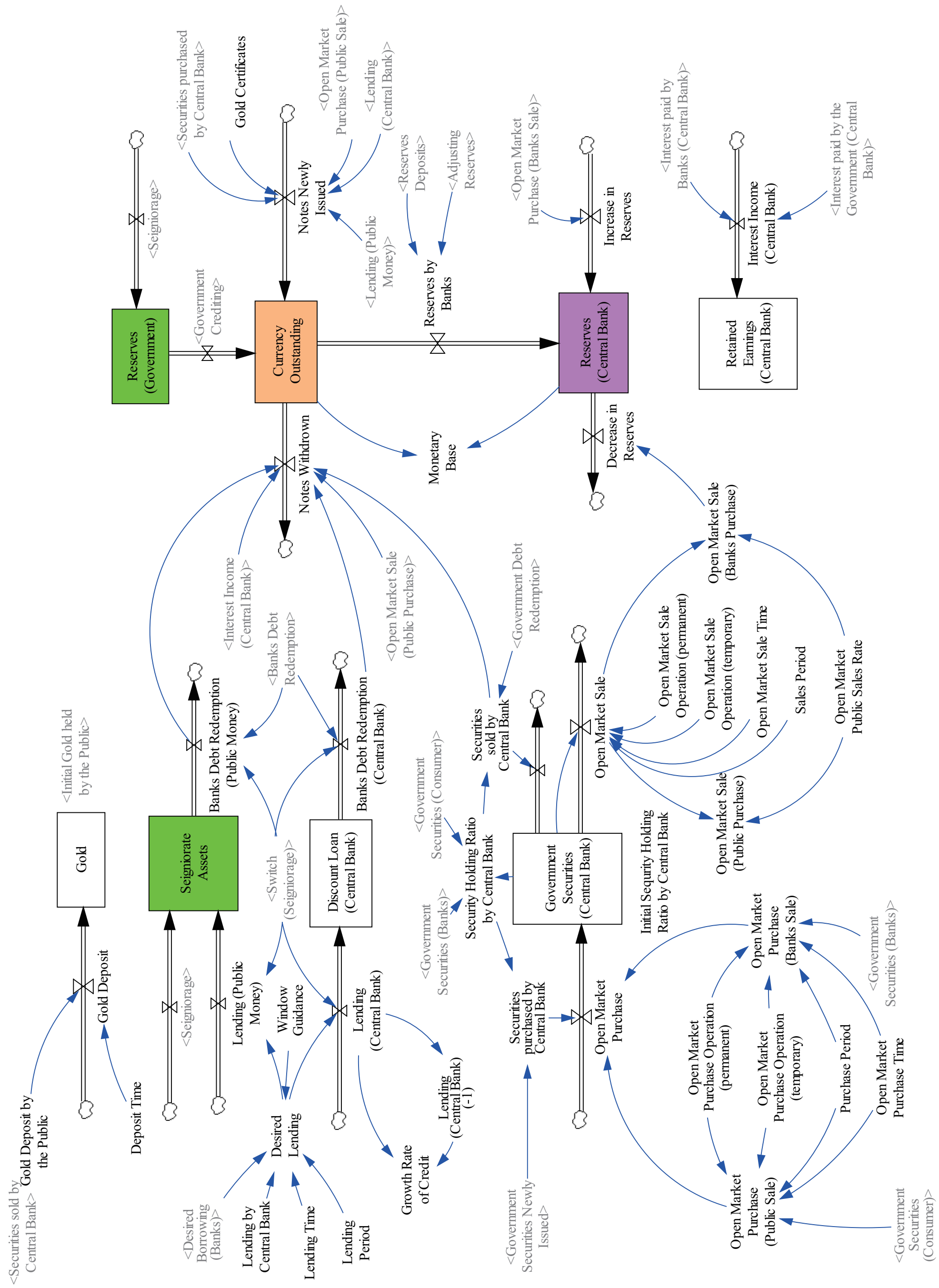

Figure 16.13: Transactions of the Public Money Administration

16.7 Behaviors of A Public Money System

Liquidation of Government Debt

Under this alternative macroeconomic system of public money, the accumulated debt of the government gets gradually liquidated as demonstrated in Figure 16.14, which is the same as Figure 16.8 except that lines 3 is added here. Recollect that line 1 was a benchmark debt of the mostly equilibria under the system of debt money, while line 2 was the decreased debt when debt-ratio is reduced under the same system. Now newly added line 3 indicates that the government debt continues to decline when a 100% fraction ratio is applied in 5 years starting at the year 6. The other two fractional reserve cases - 100% attainment in 1 and 10 years - result in the exactly same declining tendencies. This means that the abolishment methods of a fractional level do not affect the liquidation of the government debt, because banks are allowed to fill in the enough amount of cash shortage by borrowing from the PMA in the model.

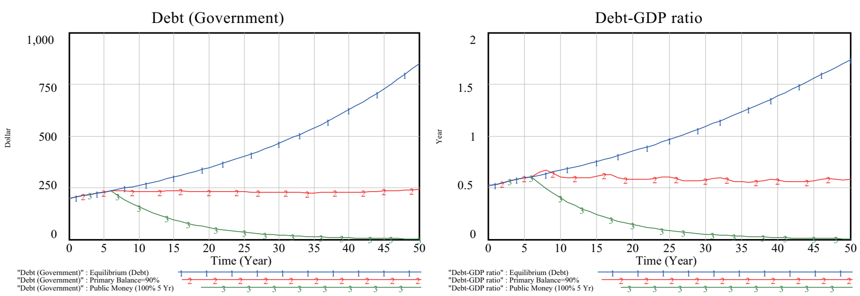

Figure 16.14: Liquidation of Government Debt and Debt-GDP Ratio

Figure 16.15 compares how real GDP growth and growth rates will be affected during the liquidation process under debt money and public money systems. GDP growth path under the public money system (line 3) stays closer to the original equilibrium path (line 1), as illustrated by the left diagram, without triggering economic recession, as illustrated in the right diagram (line 3). In this sense, a public money system can be said to be a far better system because of the accomplishment of higher economic growth compared with the one under a debt money system.

Moreover, this liquidation of government debt can be done without causing inflation. In fact, left diagram in Figure 16.16 illustrates that price of line 3 continues to decrease, and inflation rate of line 3 in the right diagram is constantly below 0

Inflation and GDP Gap

Persistent objection to the system of public money has been that government, once a free-hand power of issuing money is being endowed, tends to issue more

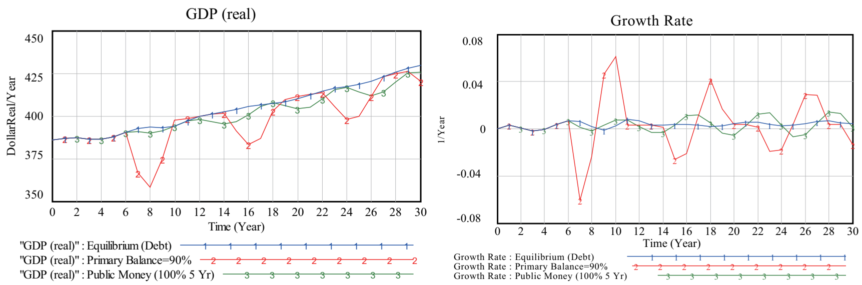

Figure 16.15: Comparison of GDP and Growth Rates

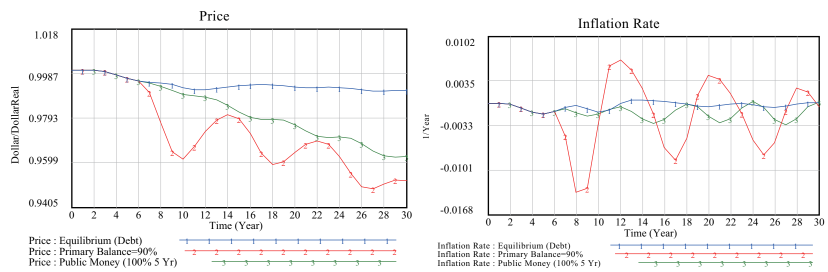

Figure 16.16: Price Level and Inflation Rate

money than necessary, which tends to bring about inflation eventually, though history shows the opposite Zarlenga (2002).

Theoretically, under the existence of GDP gap, increase in the government expenditure by issuing new money would not cause inflation, but stimulate the economic growth instead. To examine this case, let us first create a GDP gap by changing the exponent of capital from 0.4 to 0.43 as illustrated by line 1 in Figure 16.17, in which the GDP gap is observed between the year 5 and 10. Faced with this recession, public money is being newly issued by the amount of 23 for 20 years starting at the year 6. This corresponds to a continual inflow of money into circulation as proposed by the American Monetary Act. As a result equilibrium is attained again as illustrated by line 2 in the left diagram, yet inflation does not seem to appear as line 2 of the right diagram indicates.

Inflation could occur only when government mismanages the money stock. To examine this case, let us take a benchmark state attained by the equilibrium, then assume that the government increases its spending by mistakenly issuing new money by the amount of 10 for 4 years, starting at the year 10; that is, the government expenditure continues to increase to 75 from 65 for four years.

As being expected, the increase in the government expenditure under the equilibrium state surely causes inflation, 1.8% at the year 13, as illustrated by line 2 of the left diagram of Figure 16.18, followed by the deflation of -3% at the year 17. To be worse, this inflation triggers economic recession of -13% at the year 16 as illustrated by line 2 in the right diagram. Figure 16.19 shows

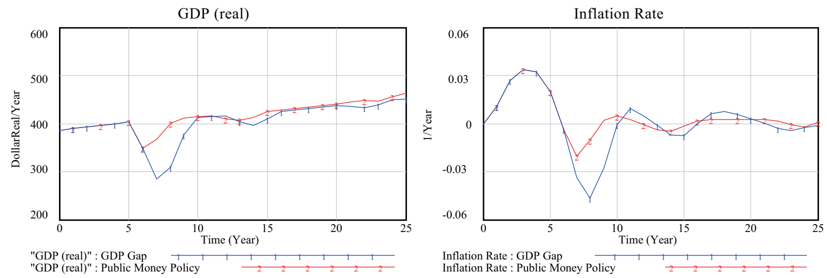

Figure 16.17: No Inflation under GDP Gap

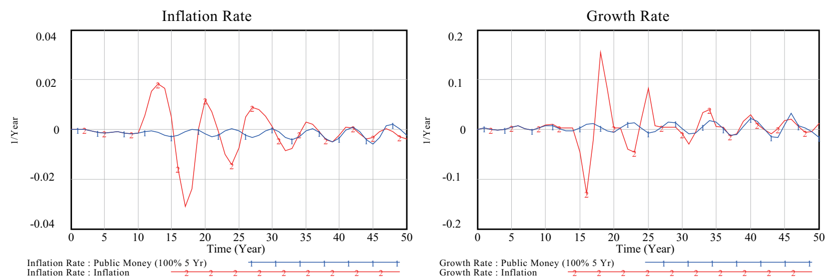

Figure 16.18: Inflation under No GDP Gap

business cycles caused by the mismanagement of the increase in money stock when no GDP gap exists.

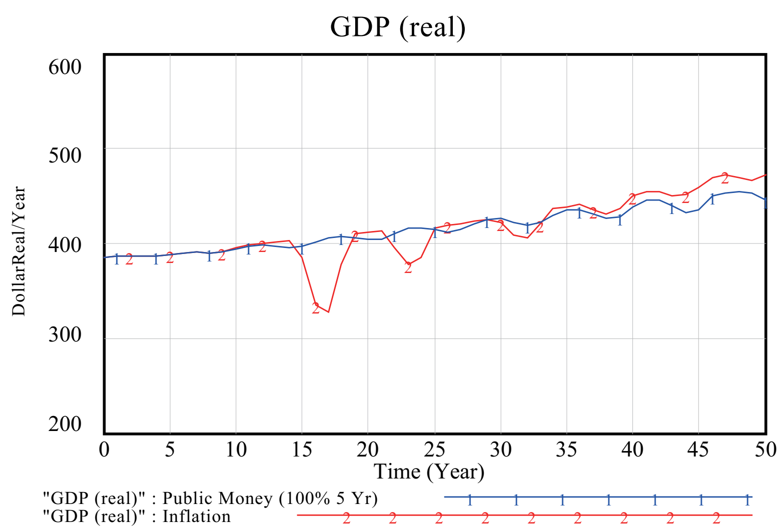

Figure 16.19: Business Cycles caused by Inflation under No GDP Gap

Maximum Tolerable Inflation

This could be a serious moral hazard lying under the system of public money, because the incumbent government tries to cling to the power by unnecessarily stimulating the economy in the years of election as history demonstrates. Business cycle thus spawned is called *political business cycle*. "There is some evidence that such a political business cycle exits in the United States, and the Federal Reserve under the control of Congress or the president might make the cycle even more pronounced (Mishkin, 2006, p.353)." Proponents of the central bank take advantage of this cycle as an excuse for establishing the independence of the central bank from the intervention by the government. On the contrary, recent financial crises and runaway accumulation of government debt are caused, indeed, by the independence of the central bank under the system of debt money.

How can we avoid the political business cycle, then, without resorting to the independence of the central bank? As a system dynamics researcher, I suggest an introduction, by law, of a feedback loop of stabilizing monetary value which forces a resignation of the government in case of higher inflation, or at least the head of the Public Money Administration to step down.

How high inflation, then, can we be tolerant of? The American Monetary Act stipulates the maximum interest rate of 8% per year, including all fees.

> Because before 1980/1981, forty nine States had "anti-usury" laws which limited normal interest rates to a maximum of between 6% and 10% p.a. (one state had 12%). The American Monetary Act takes the middle of this range to represent a restoration of the interest limits prevailing across the country prior to 1980/1981 (Zarlenga, 2009, p.27).

From the following relation,

$$\text{Nominal interest rate} = \text{Real interest rate} + \text{Inflation rate} \tag{16.7}$$

we have, for non-negative real interest rate ≥ 0,

$$\text{Maximum Nominal interest rate } (= 8\%) \geq \text{Inflation rate} \tag{16.8}$$

That is to say, the maximum tolerable inflation rate becomes 8% under the system of public money. The success of the system depends on the legalization of a forced step down of the government in case of an inflation rate higher than 8%.

Public Money Policy

The role of the public money administration under the macroeconomic system of public money is to maintain the monetary value, similar to the role assigned to the central banks under the system of debt money. Interest rate is no longer controlled by the public money administration, and left to be determined in the market. History shows that an economic bubble and its burst have been caused by the purposive manipulation of the interest rates such as overnight call rate and federal fund rate by the privately-owned central bank for the benefits of financial elite. In this sense, we will be finally freed from the control of the central bank.

Accordingly, the only tool to stabilize the monetary value is through the public management of the amount of money in circulation. This could be carried out through the control of lending money to commercial banks and through the fiscal policy. Specifically, in case of an inflationary state, lending money to the banks may be curbed, or the money in circulation could be sucked back by raising taxes or cutting government spending. In case of deflation, demand for money by the banks would be weak, so that government has to take a strong leadership by spending more than tax revenues with newly issued money. In this way, complicated monetary policies such as the manipulation of required reserve ratio, discount ratio, and open market operations under the system of debt money are no longer required.

Finally, it would be worth mentioning that system of public money is ecologically friendly to the environment, because forced payment of interest will be replaced with interest-free money, and borrowers of money, mainly producers, need not be driven into forced economic growth at the cost of environmental destruction. System of public money is indeed a foundation for sustainability.

16.8 Conclusion

This chapter investigates how to liquidate runaway government debt under the current financial crises. First, the current system is identified as a macroeconomic system of money as debt, under which the accumulation of government debt is built into the system by the Keynesian theory, and the reduction of debt-GDP ratio becomes, it is demonstrated, very costly, triggering economic recessions and business cycles.

Then, an alternative system is suggested as the system of public money, in which only the government can issue money, and the government debt, it is shown, can be gradually eliminated. Moreover, it turns out that higher economic growth is simultaneously attained.

In this sense, the alternative macroeconomic system, from a viewpoint of system design, seems to be worth being implemented if we wish to avoid accumulating government debt, unfair income distribution, repeated financial crises, war and environmental destruction.

Chapter 17

Workings of A Public Money System

Being intensified by the recent financial crisis in 2008, debt crises seem to be looming ahead among many OECD countries due to the runaway accumulation of government debts. This chapter[1] first explores them as a systemic failure of the current *debt money system*. Secondly, with an introduction of open macroeconomies, it examines how the current system can cope with the liquidation of government debt, and obtains that the liquidation of debts triggers recessions, unemployment and foreign economic recessions contagiously. Thirdly, it explores the workings of a *public money system* proposed by the American Monetary Act and finds that the liquidation under this alternative system can be put into effect without causing recessions, unemployment and inflation as well as foreign recessions, and simultaneously attain a higher economic growth. Finally, public money policies that incorporate balancing feedback loops such as anti-recession and anti-inflation are introduced for curbing GDP gap and inflation. They are posed to be simpler and more effective than the complicated Keynesian policies.

17.1 Modeling A Debt Money System

We have explored in the previous chapter how accumulating government debts could be liquidated under two different macroeconomic systems; that is, a current macroeconomic system of debt money, and a macroeconomic system of public money advocated by the American Monetary Act. What we have found is that the liquidation of government debt under the current macroeconomic system of debt money is very costly; that is, it triggers economic recessions,

[1]This chapter is based on the paper: Workings of A Public Money System of Open Macroeconomies – Modeling the American Monetary Act Completed – submitted to the 29th International Conference of the System Dynamics Society, Washington D.C., USA, July 25 - 29, 2011.

while the liquidation process under a public money system can be accomplished without causing recessions and inflations. The results are, however, obtained in a simplified closed macroeconomic system in which no labor market exists.

Accordingly, the purpose of this chapter is to expand the previous simple macroeconomic system to complete open macroeconomies in which labor market and foreign exchange market exist, and analyze if similar results could be obtained in the open macroeconomies for a debt money and a public money system.

For the comparative analysis of the two open macroeconomic systems, the open macaroeconomic model as a closed economic system developed in chapter 11 is revisited in this chapter [Companion Model: Design OpenMacro2-6.vpmx]. The model of a debt money system is the same as the model in chapter 11. Yet for the convenience of the reader, transactions of the open macroeconomies by government, banks and the central bank are replicated here as a comparative reference to the revised transactions of government, banks and the central bank under a public money system of open macroeconomies to be presented below.

Government

Transactions of the government are illustrated in Figure 17.12 in the appendix, some of which are summarized as follows.

- Government receives, as tax revenues, income taxes from consumers and corporate taxes from producers.
- Government spending consists of government expenditures and payments to the consumers for its partial debt redemption and interests against its securities.
- Government expenditures are assumed to be endogenously determined by either the growth-dependent expenditures or tax revenue-dependent expenditures.
- If spending exceeds tax revenues, government has to borrow cash from consumers and banks by newly issuing government securities.
- Foreign government is assumed to behave in a similar fashion as a mirror image of domestic government.

Banks

Main transactions of banks, which are illustrated in Figure **??** in the appendix, are summarized as follows.

- Banks receive deposits from consumers and consumers abroad as foreign investors, against which they pay interests.
- They are obliged to deposit a portion of the deposits as the required reserves with the central bank.

- Out of the remaining deposits, loans are made to producers and banks receive interests to which a prime rate is applied.
- If loanable fund is not enough, banks can borrow from the central bank to which discount rate is applied.
- Their retained earnings thus become interest receipts from producers less interest payment to consumers and to the central bank. Positive earnings will be distributed among bank workers as consumers.
- Banks buy and sell foreign exchange at the request of producers, consumers and the central bank.
- Their foreign exchange are held as bank reserves and evaluated in terms of book value. In other words, foreign exchange reserves are not deposited with foreign banks. Thus net gains realized by the changes in foreign exchange rate become part of their retained earnings (or losses).
- Foreign currency (dollars in our model) is assumed to play a role of *key* currency or *vehicle* currency. Accordingly foreign banks need not set up foreign exchange account. This is a point where a mirror image of open macroeconomic symmetry breaks down.

Central Bank

Main transactions of the central bank, which are illustrated in Figure 17.14 in the appendix, are summarized as follows.

- The central bank issues currencies against the gold deposited by the public.
- It can also issue currency by accepting government securities through open market operation, specifically by purchasing government securities from the public (consumers) and banks. Moreover, it can issue currency by making credit loans to commercial banks. (These activities are sometimes called *money out of nothing*.)
- It can similarly withdraw currencies by selling government securities to the public (consumers) and banks, and through debt redemption by banks.
- Banks are required by law to reserve a certain amount of deposits with the central bank. By controlling this required reserve ratio, the central bank can control the monetary base directly.
- The central bank can additionally control the amount of money stock through monetary policies such as open market operations and discount rate.
- Another powerful but hidden control method is through its direct influence over the amount of credit loans to banks (known as *window guidance* in Japan.)

- The central bank is allowed to intervene foreign exchange market; that is, it can buy and sell foreign exchange to keep a foreign exchange ratio stable (though this intervention is actually exerted by the Ministry of Finance in Japan, it is regarded as a part of policy by the central bank in our model).

- Foreign exchange reserves held by the central bank is usually reinvested with foreign deposits and foreign government securities, which are, however, not assumed here as inessential.

17.2 Behaviors of A Debt Money System

Mostly Equilibria in the Real Sector

Our open macroeconomic model is now completely presented. It is a generic model, out of which diverse macroeconomic behaviors are generated, depending on the purpose of simulations. In this paper let us focus on an equilibrium growth path as a benchmark for our analysis to follow. An equilibrium state is called *a full capacity aggregate demand equilibrium* if the following three output and demand levels are met:

$$\text{Full Capacity GDP} = \text{Desired Output} = \text{Aggregate Demand} \tag{17.1}$$

If the economy is not in the equilibrium state, then actual GDP is determined by

$$\text{GDP} = \text{MIN (Full Capacity GDP, Desired Output)} \tag{17.2}$$

In other words, if desired output is greater than full capacity GDP, then actual GDP is constrained by the production capacity, meanwhile in the opposite case, GDP is determined by the amount of desired output which producers wish to produce, leaving the capacity idle, and workers being laid off.

Even though full capacity GDP is attained, full employment may not be realized unless the following equation is not met;

$$\text{Potential GDP} = \text{Full Capacity GDP}. \tag{17.3}$$

Does the equilibrium state, then, exist in the sense of full capacity GDP and full employment? To answer these questions, let us define GDP gap as a difference between potential GDP and actual GDP, and its ratio to the potential GDP as

$$\text{GDP Gap Ratio} = \frac{\text{Potential GDP - GDP}}{\text{Potential GDP}} \tag{17.4}$$

By trial and error, mostly equilibrium states are attained when price elasticity e is 3, together with all other adjusted parameters, as illustrated in Figure 17.1.

Our open macrodynamic model has more than 900 variables that are interrelated one another, among which, as benchmark variables for comparative analyses in this paper, we mainly focus on two variables: GDP gap ratio and

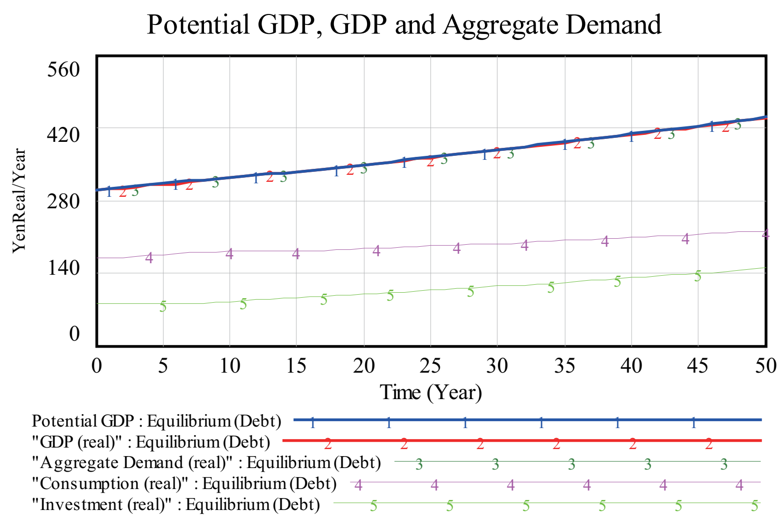

Figure 17.1: Mostly Equilibrium States

unemployment rate. Figure 17.2 illustrates these two figures at the mostly equilibrium states. GDP gap ratios are maintained below 1% after the year 6, and unemployment ratios are less than 0.65% at their highest around the year 6, approaching to zero; that is, full employment. The reader may wonder why these are a state of mostly equilibria, because some fluctuations are being observed. Economic activities are alive like human bodies, whose heart pulse rates, even of healthy persons, fluctuate between 60 and 70 per minute in average. Yet, they are a normal state. In a similar fashion, it is reasonable to consider these fluctuations as normal equilibrium states.

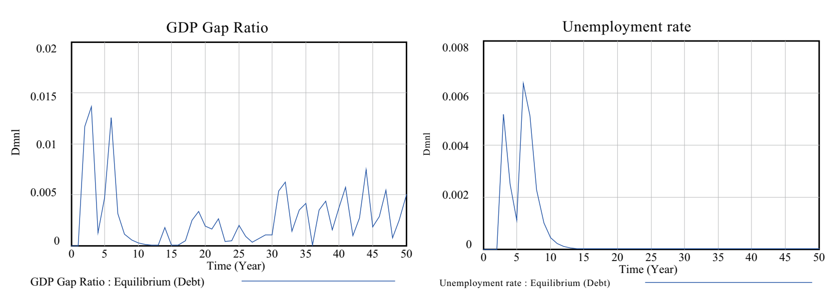

Figure 17.2: GDP Gap and Unemployment Rate of Mostly Equilibrium States

Money out of Nothing

For the attainment of mostly equilibria, enough amount of money has to be put into circulation to avoid recessions caused by credit crunch as analyzed in

Yamaguchi (2006). Demand for money mainly comes from banks and producers. Banks are assumed to make loans to producers as much as desired so long as their vault cash is available. Thus, they are persistently in a state of shortage of cash as well as producers. In the case of producers, they could borrow enough fund from banks. From whom, then, should the banks borrow in case of cash shortage?

In a closed economic system, money has to be issued or created within the system. Under the current financial system of debt money, only the central bank is endowed with a power to issue money within the system, and make loans to the commercial banks directly and to the government indirectly through the open market operations. Commercial banks then create credits under a fractional reserve banking system by making loans to producers and consumers. These credits constitute a great portion of money stock. In this way, money and credits are only crated when commercial banks and government as well as producers and consumers come to borrow at interest. Under such circumstances, if all debts are repaid, money ceases to exit. This is an essence of a debt money system. The process of creating money is known as *money out of nothing*.

Figure 17.3 indicates unconditional amount of annual discount loans and its growth rate by the central bank at the request of desired borrowing by banks. In other words, money has to be incessantly created and put into circulation in order to sustain an economic growth under mostly equilibrium states. Roughly speaking, a growth rate of credit creation by the central bank has to be in average equal to or slightly greater than the economic growth rate as suggested by the right hand diagram of Figure 17.3, in which line 1 is a growth rate of

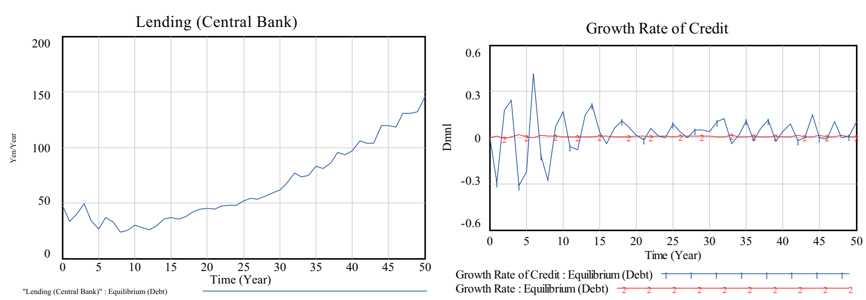

Figure 17.3: Lending by the Central Bank and its Growth Rate

credit and line 2 is an economic growth rate. In this way, the central bank begins to exert an enormous power over the economy through its credit control.

Accumulation of Government Debt

So long as the mostly equilibria are realized in the economy, through monetary and fiscal policies in the days of recession, no macroeconomic problem seems to exist. This is a positive side of the Keynesian macroeconomic theory. Yet behind the full capacity aggregate demand growth path in Figure 17.1 government debt continues to accumulate as the line 1 in the left diagram of Figure 17.4 illustrates. This is a negative side of the Keynesian theory. Yet most macroeconomic textbooks neglect or less emphasize this negative side, partly because their macroeconomic frameworks cannot handle this negative side of the debt money system.

In the model here primary balance ratio is initially set to be one and balanced budget is assumed to the effect that government expenditure is set to be equal to tax revenues, and no deficit arises. Why, then, does the government continue to accumulate debt? Government deficit is precisely defined as

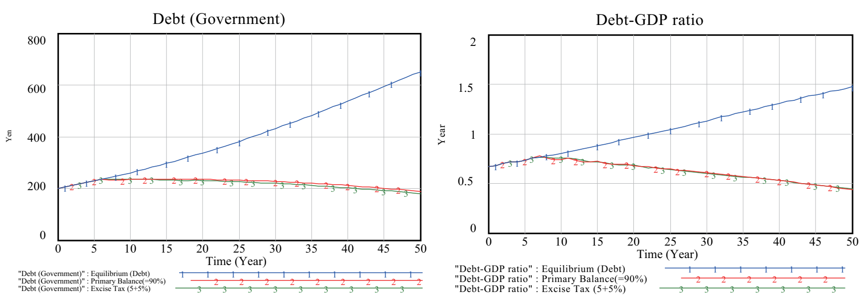

Figure 17.4: Accumulation of Government Debt and Debt-GDP Ratio

$$\text{Deficit} = \text{Tax Revenues - Expenditure - Debt Redemption - Interest} \quad (17.5)$$

Therefore, even if balanced budget is maintained, government still has to keep paying its debt redemption and interest. This is why it has to keep borrowing and accumulating its debt; that is to say, it is not balanced in an expanded sense of budget. Initial GDP in the model is attained to be 300, while government debt is initially set to be 200. Hence, the initial debt-GDP ratio is around 0.667 year. Yet, the ratio continues to increase to 1.473 year at the year 50 in the model as illustrated by the line 1 in the right diagram of Figure 17.4. This implies the government debt becomes 1.473 years as high as the annual level of GDP.

Remarks: Even if a debt crisis due to the runaway accumulation of debt fails to be observed in the near future, still there exit some ethical reasons to stop accumulating debts. First, it continues to create unfair income distribution in favor of creditors, that is, bankers and financial elite, causing inefficient allocation of resources and economic performances, and eventually social turmoils among the poor. Secondly, obligatory payment of interest forces the indebted producers to drive incessant economic growth to the limit of environmental carrying capacity, which eventually leads to the collapse of environment. In short, a debt money system is unsustainable as a macroeconomic system.

Liquidation of Government Debt

Let us now consider how we could avoid such a debt crisis under the current debt money system. At the face of the debt crisis as discussed above, suppose that government is forced to reduce its debt-GDP ratio to less than 0.6 by the year 50, as currently required to all EU members by the Maastricht treaty.

To attain this goal, though, only two policies are available to the government; that is, to spend less or to tax more. Let us consider them, respectively.

Policy A: Spend Less

This policy assumes that the government spend 10% less than its equilibrium tax revenues, so that a primary balance ratio is reduced to 0.9 in our economy. In other words, the government has to make a strong commitment to repay its debt annually by the amount of 10 % of its tax revenues. Let us assume that this reduction is put into action at the year 6. Line 2 of the left diagram of Figure 17.5 illustrates this reduction of spending.

Under such a radical financial reform, debt-GDP ratio will begin to get reduced to around 0.65 at the year 25, and to around 0.44 at the year 50 as illustrated by line 2 in the right diagram of Figure 17.4. Accordingly, the accumulation of debt will be eventually curved as shown by line 2 in the left diagram of Figure 17.4.

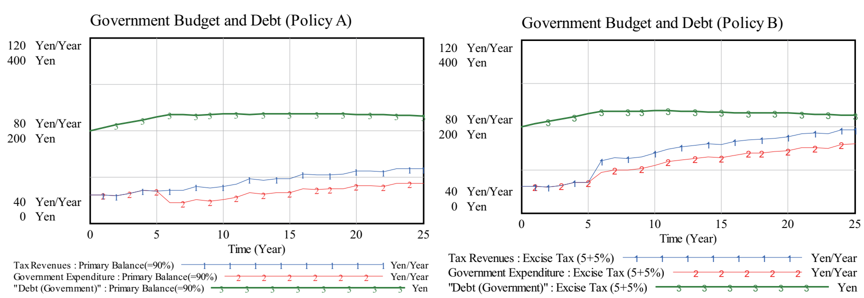

Figure 17.5: Liquidation Policies: Spend Less and Tax More

Policy B: Tax More (and Spend More)

Among various sources of taxes to be levied by the government such as income tax, excise tax, and corporate tax, let us assume here that excise tax is increased, partly because an increase in consumption (or excise) tax has become a hot political issue recently in Japan. Specifically the excise tax is assumed to be increased to 10% from the initial value of 5% in our model; that is, 5% increase. Line 1 of the right diagram of Figure 17.5 illustrates the increased tax revenues.

Out of these increased tax revenues, spending is now reduced by 8.5% to repay the accumulated debt. Though spending is reduced in the sense of primary balance, it has indeed increased in the absolute amount, compared with the original equilibrium spending level, as illustrated by line 2 of the same right diagram of Figure 17.5. Accordingly the government needs not be forced to reduce the equilibrium level of budget.

As a result this policy can also successfully reduces debt as illustrated by line 3 of the same diagram up to the year 25, and further up to the year 50 as illustrated by line 3 in the left diagram of Figure 17.4.

Triggered Recession and Unemployment

These liquidation policies seem to be working well as debt begins to get reduced. However, the implementation of these policies turns out to be very costly to the government and its people as well.

Let us examine the policy A in detail. At the next year of the implementation of 10 % reduction of a primary balance ratio, growth rate is forced to drop to minus 2 %, and the economy fails to sustain its full capacity aggregate demand equilibrium of line 1 as illustrated by line 2 in Figure 17.6. Compared with the mostly equilibrium path of line 1, debt-reducing path of line 2 brings about business cycles. Similarly, line 3 indicates another business cycle triggered by Policy B.

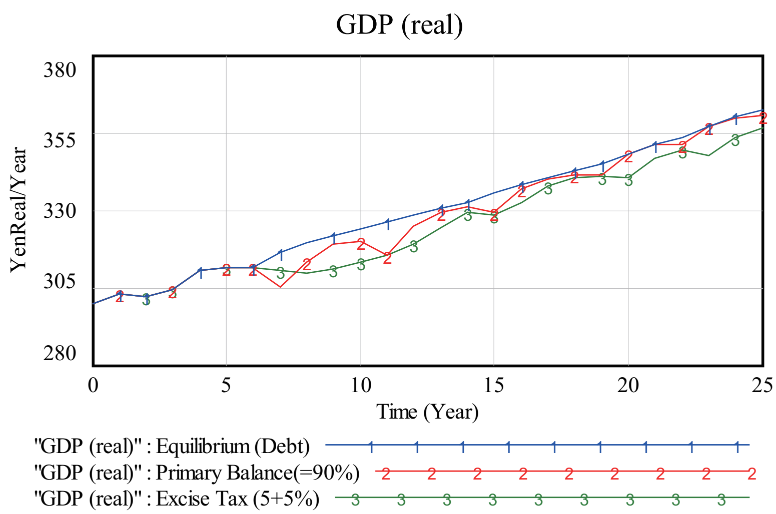

Figure 17.6: Recessions triggered by Debt Liquidation

Figure 17.7 (lines 2) shows how this policy of debt liquidation triggers GDP gap and unemployment. GDP gap jumps from 0.3% to 3.9% at the year 7, an increase of 13 times. Unemployment jumps from 0.5% to 4.8% at the year 7, more than 9 times. In similar fashion, lines 3 indicate another gaps triggered by Policy B.

In the previous paper Yamaguchi (2010), unemployment was left unanalyzed. In this sense, the result here is a new finding on the effect of debt liquidation under the current debt money system. The reader should understand that the absolute number is not essential here, because our analysis is based on arbitrary numerical values. Instead, comparative changes in factors need be paid more attention.

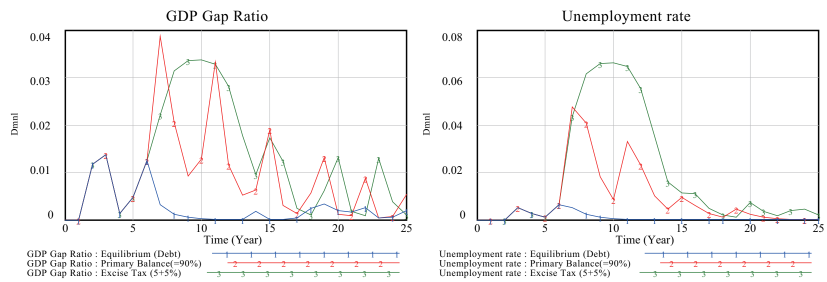

Figure 17.7: GDP Gap and Unemployment

Figure 17.8 illustrates how fast wage rate plummets (line 2 in the left diagram) - another finding in this paper. Concurrently inflation rate plunges to -0.98% from -0.16%, close to 6 times drop, that is, the economy becomes deflationary (line 2 in the right diagram). Lines 3, likewise, indicate another behaviors triggered by Policy B.

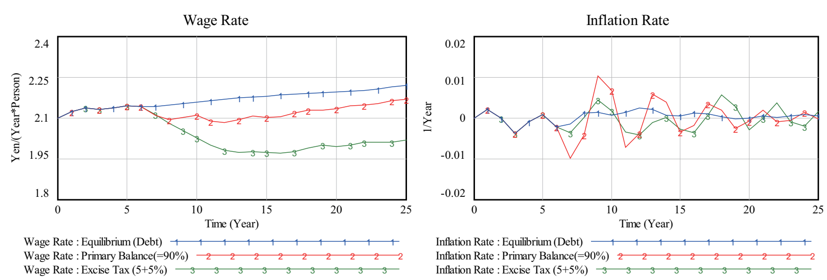

Figure 17.8: Wage Rate and Inflation

These recessionary effects triggered by the liquidation of debt turn out to cross over a national border and become contagious to foreign countries. Figure 17.9 illustrates how GDP gap and unemployment in a foreign country get worsened by the domestic liquidation policy A (lines 2) and policy B (lines 3). These contagious effects under open macroeconomies are observed for the first time in our expanded macroeconomic model - the third finding in this paper. In this sense, in a global world economy, no country can be free from a contagious effect of recessions caused by the debt liquidation policy in other country.

A Liquidation Trap of Government Debt

Under a debt money system, liquidation policy of government dept will be eventually captured into a liquidation trap as follows. The liquidation policy

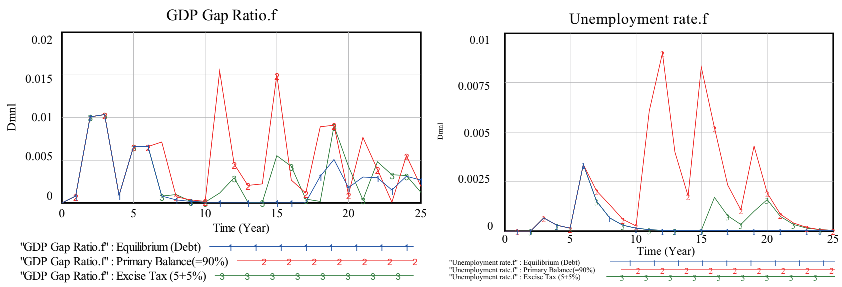

Figure 17.9: Foreign Recessions Contagiously Triggered

is only implemented with the reduction of budget deficit by spending less or levying tax; that is; policy A or B in our case. Whichever policy is taken, it causes an economic recession as analyzed above.

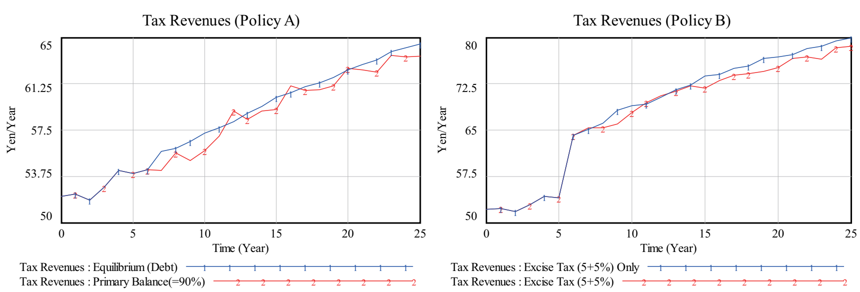

Figure 17.10: Liquidation Traps of Debt

The immediate effects of recession either by policy A or B are the reduction of tax revenues as illustrated by lines 2 in Figure 17.10. Eventually revenue reduction will worsen budget deficit. In other words, policies to reduce deficit result in an increase in deficit. This constitutes a typical balancing feedback loop, which is illustrated as “Revenues Crisis” loop in Figure 17.11.

The other effect of recession will be a forced bailout/stimulus package by the government, which in turn increases government expenditures, worsening budget deficit again. This adds up a second balancing feedback loop, which is illustrated as “Spending Crisis” loop in Figure 17.11.

In this way the liquidation policies of government debt are retarded by two balancing feedback loops of revenues crisis and spending crisis, making up liquidation traps of government debt. This indicates that the debt money system combined with the traditional Keynesian fiscal policy becomes a dead end as a macroeconomic monetary system.

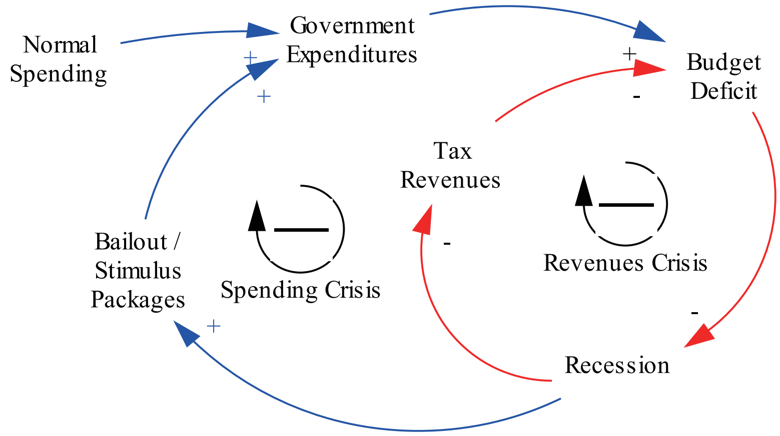

Figure 17.11: Causal Loop Diagram of Liquidation Traps of Debt

17.3 Modeling A Public Money System

We are now in a position to implement the alternative macroeconomic system discussed in the introduction, as proposed by the American Monetary Act, in which central bank is incorporated into a branch of government and a fractional reserve banking system is abolished. Let us call this new system a public money system of open macroeconomies. Money issued under this new system plays a role of public utility of medium of exchange. Hence the newly incorporated institution may be appropriately called *the Public Money Administration (PMA)* as in the previous chapter.

Under the new system, transactions of only government, commercial banks and the public money administration (formally the central bank) need be revised slightly. Let us start with the description of the revised transactions of the government.

Government

- Balanced budget is assumed to be maintained; that is, a primary balance ratio is unitary. Yet the government may still incur deficit due to the debt redemption and interest payment.
- Government now has the right to newly issue money whenever its deficit needs to be funded. The newly issued money becomes seigniorage inflow of the government into its equity or retained earnings account.
- The newly issued money is simultaneously deposited with the reserve account of the Public Money Administration. It is also booked to its deposits account of the government assets.
- Government could further issue money to fill in GDP gap.

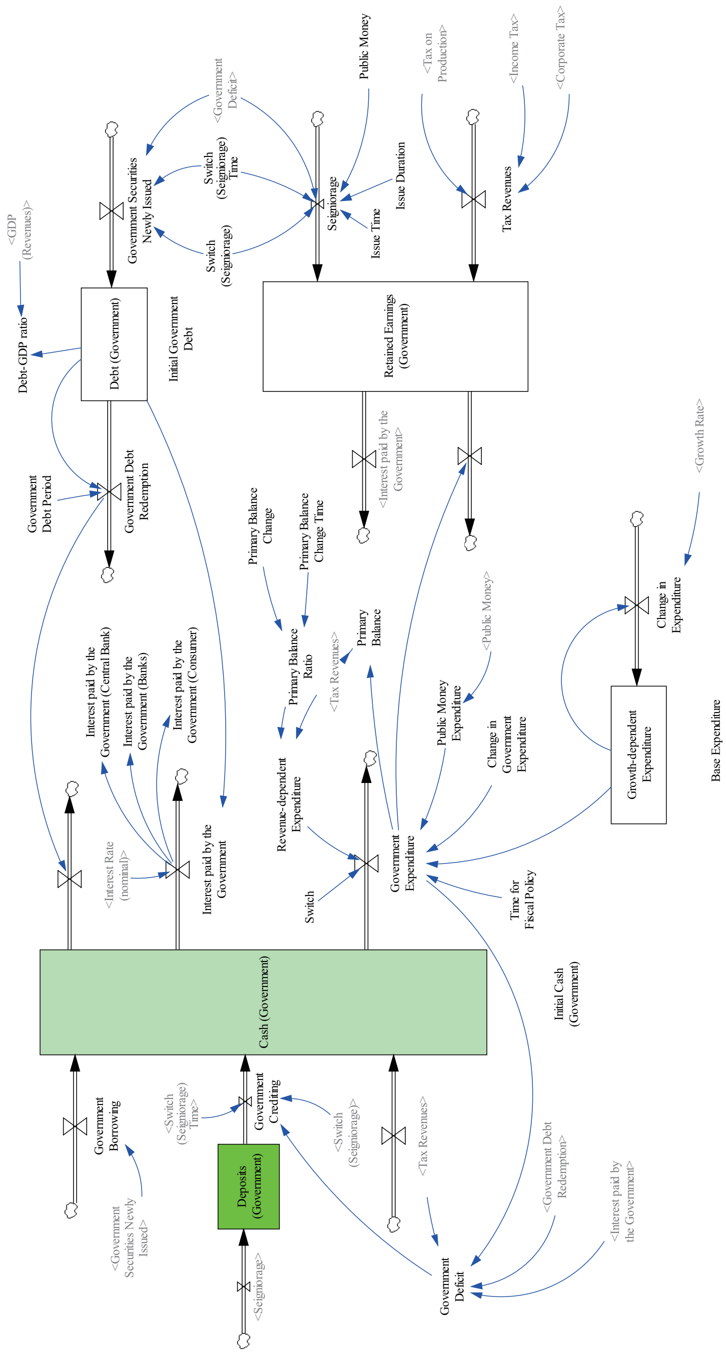

Figure 17.12: Transactions of Government

Revised transaction of the government is illustrated in Figure 17.12 where green stock box of deposits is newly added to the assets.

Banks

Revised transactions of commercial banks are summarized as follows.

- Banks are now obliged to deposit a 100% fraction of the deposits as the required reserves with the public money administration. Time deposits are excluded from this obligation.
- When the amount of time deposits is not enough to meet the demand for loans from producers, banks are allowed to borrow from the public money administration free of interest; that is, former discount rate is now zero. Allocation of loans to the banks will be prioritized according to the public policies of the government. (This constitutes a market-oriented issue of new money. Alternatively, the government can also issue new money directly through its public policies to fill in GDP gap as already discussed above.)

Line 1 in Figure 17.13 illustrates the initial required reserve ratio of 5% in our model. As in the previous chapter, we have here assumed three different ways of abolishing a fractional reserve banking system. Line 2 shows that a 100% fraction is immediately attained in the following year of its implementation, while line 3 illustrates it is attained in 5 years. Line 4 indicates it it gradually attained in 10 years, starting from the year 6, In our analysis below, 100% fraction will be assumed to be attained in 5 years as a representative illustration of fractional behaviors.

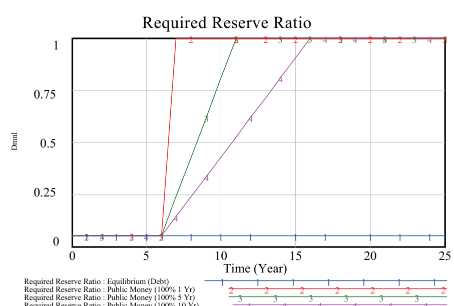

Figure 17.13: 100% Required Reserve Ratios

Public Money Administration (Formerly Central Bank)

The central bank is now incorporated as one of the governmental organizations which is here called the Public Money Administration (PMA). Its revised transactions become as follows.

- The PMA accepts newly issued money of the government as seigniorage assets and enter the same amount into the government reserve account. Under this transaction, the government needs not print hard currency, instead it only sends digital figures of the new money to the PMA.

- When the government want to withdraw money from their reserve accounts at the PMA, the PMA could issue new money according to the requested amount. In this way, for a time being, former central bank note and government money coexist in the market.

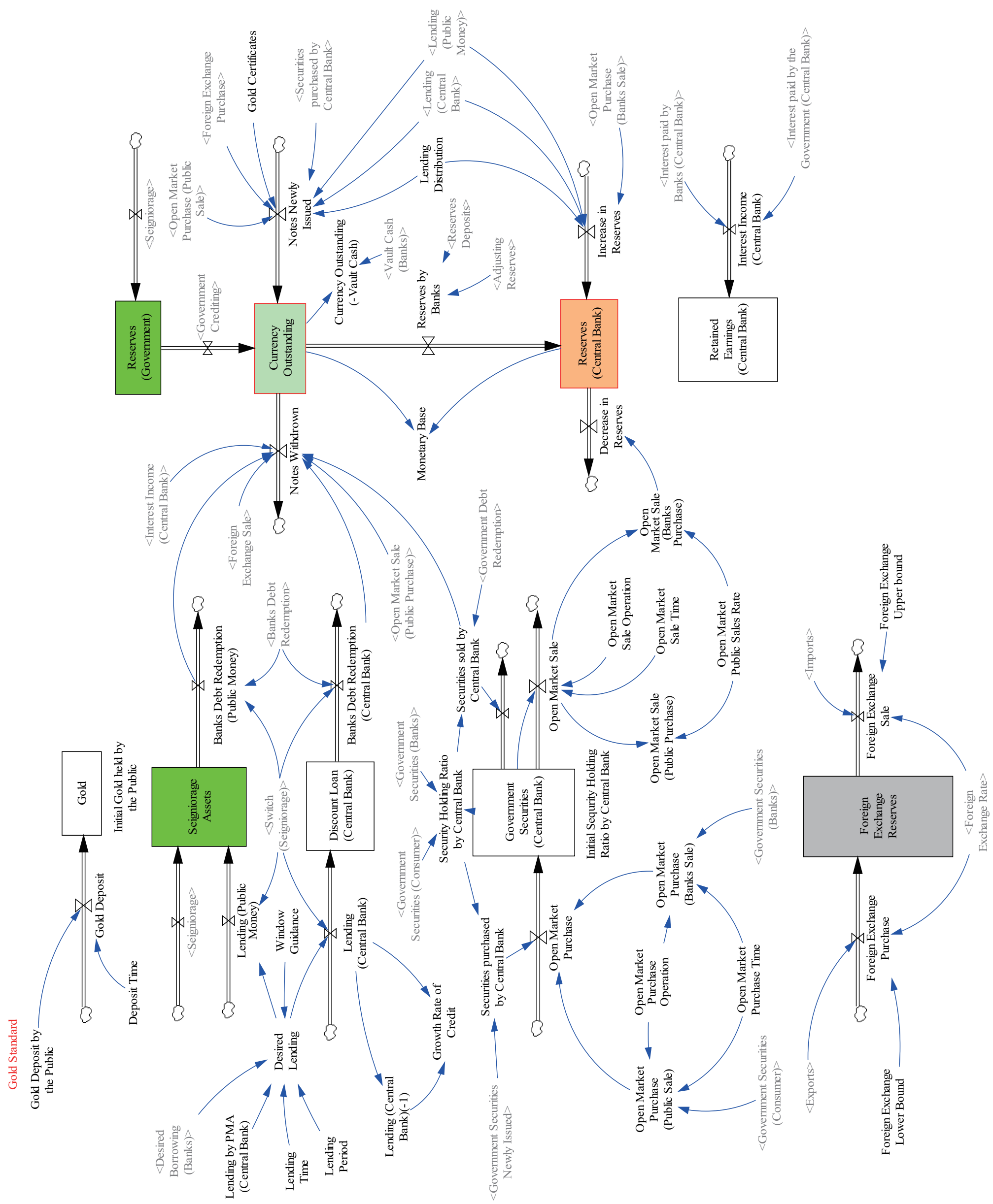

Figure 17.14: Transactions of Public Money Administration (Central Bank)

- With the new issue of money the PMA meets the demand for money by commercial banks, free of interest, according to the guideline set by the government public policies.

Under the revised transactions, open market operations of sales and purchases of government securities become ineffective, simply because government debt gradually diminishes to zero. Furthermore, discount loan is replaced with interest-free loan. This lending procedure becomes a sort of open and public *window guidance*, which once led to the rapid economic growth after world war II in Japan Werner (2003). Accordingly, interest incomes from discount loans and government securities are reduced to be zero eventually. Transactions of the public money administration are illustrated in Figure 17.14 where green stock boxes of seigniorage assets and government reserves are newly added.

17.4 Behaviors of A Public Money System

Liquidation of Government Debt

Under the public money system of open macroeconomies, the accumulated debt of the government gets gradually liquidated as demonstrated by line 4 in the left diagram of Figure 17.15, which is the same as the left diagram of Figure 17.4 except the line 4. Recollect that line 1 is a benchmark debt accumulation of

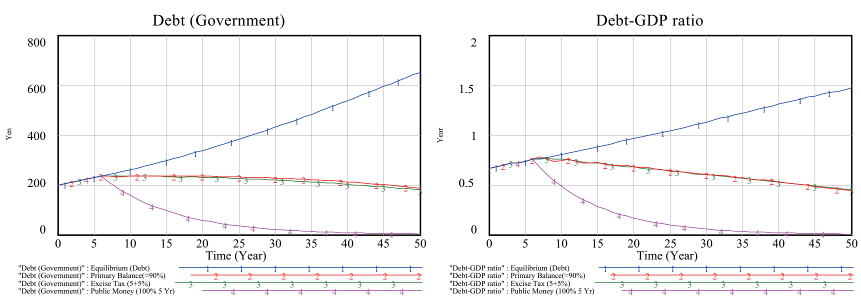

Figure 17.15: Liquidation of Government Debt and Debt-GDP Ratio

the mostly equilibria under the debt money system, while lines 2 and 3 are the decreasing debt lines when debt-ratio are reduced under the same system. Now newly added line 4 indicates that the government debt continues to decline when a 100% fraction ratio is applied in 5 years, starting at the year 6. The other two cases of attaining the 100% fractional reserve discussed above, that is, in a year or 10 years, reduce the debts exactly in a similar fashion. This means that the abolishment period of a fractional level does not affect the liquidation of the government debt, because banks are allowed to fill in the sufficient amount of cash shortage by borrowing from the PMA in the model.

It is shown in Figure 17.16 that the liquidation of government debt (line 4) is performed without triggering economic recession contrary to the case of debt money system (lines 2 and 3). To observe these comparisons in detail, let us illustrate GDP gap ratios and unemployment rates in Figure 17.17, in which the same line numbers apply as in the above figures. The liquidation of government debt under the public money system (line 4) can be said to be far

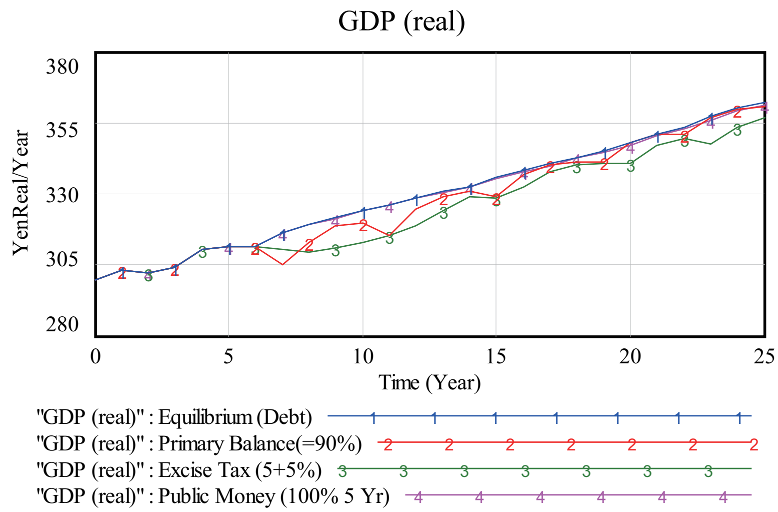

Figure 17.16: No Recessions Triggered by A Public Money System

better performed than the current debt system because of its accomplishment without recession and unemployment.

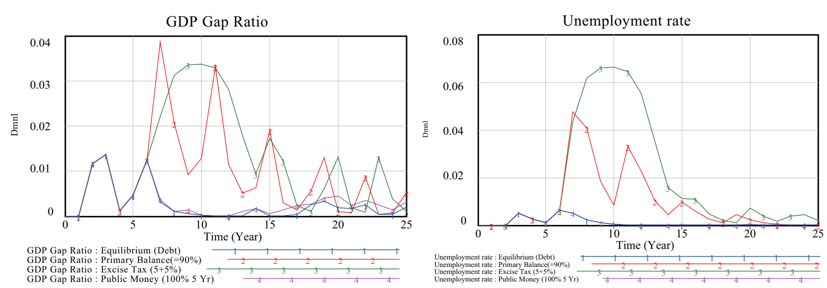

Figure 17.17: GDP Gap and Unemployment

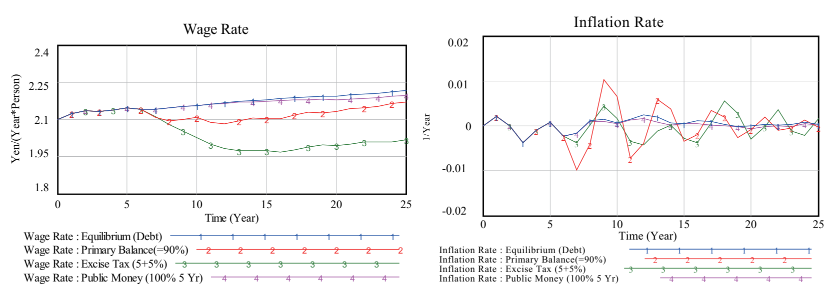

Figure 17.18: Wage Rate and Inflation

Moreover, Figure 17.18 illustrates that wage rate and inflation rates (lines 4) stay closer to the rates of mostly equilibria. Accordingly, the liquidation of debt under the public money system can be said to be attained without reducing wage rate and setting off inflation.

Furthermore, the liquidation of debt under the public money system is not contagious to foreign countries as illustrated by lines 4 in Figure 17.19. That is, GDP gap and unemployment in a foreign country (lines 4) remain closer to their almost equilibria states (lines 1).

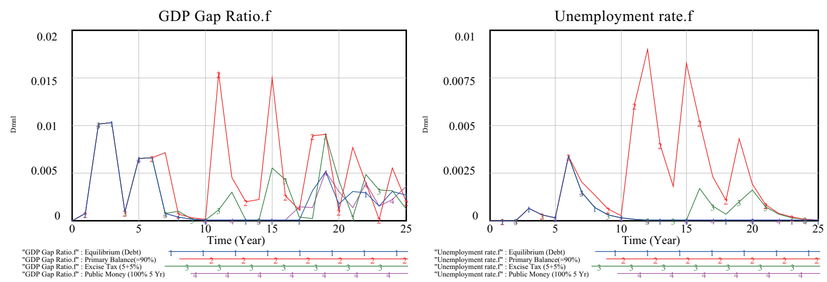

Figure 17.19: Foreign Recessions are Not Triggered

Debt Crises can be Subdued!

In sum, the pubic money system is, from the results of the above analyses, demonstrated as a superior alternative system for liquidating government debt in a sense that its implementation does not trigger recessions and unemployment both in domestic and foreign economies. In other words, looming debt crises caused by the accumulation of government debt under a current debt money system can be thoroughly subdued without causing recessions, unemployment, inflation, and contagious recessions in a foreign economy.

17.5 Public Money Policies

The role of a newly established public money administration under a public money system is to maintain a monetary value, similar to the role assigned to the central banks under the debt money system. Keynesian monetary policy under the debt money system controls money stock indirectly through the manipulation of required reserve ratio, discount ratio, and open market operations. Accordingly its effect is after all limited, as demonstrated by a failure of stimulating the prolonged recessions in Japan during 1990s through 2000s with the adjustment of the interest rates, specifically with zero interest rate policies.

Compared with these ineffective Keynesian monetary and fiscal policies, public money policies we have introduced here are simpler and more direct; that is, they are made up of the management of the amount of public money in circulation through governmental spending and tax policies. Interest rate is no longer

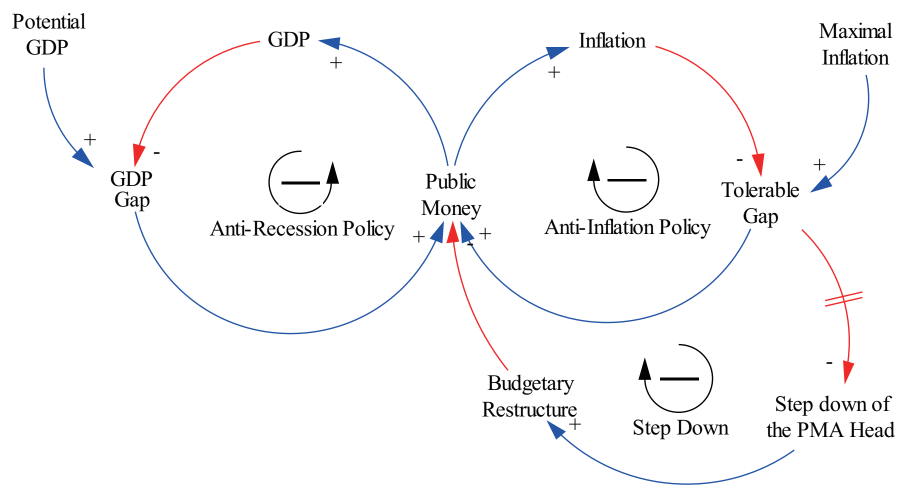

Figure 17.20: Public Money Policies

used by the public money administration as a policy instrument and left to be determined in the market.

More specifically, our public money policies consist of three balancing feedback loops as shown in Figure 17.20. Anti-recession policy is taken in the case of economic recession to fill in a GDP gap; that is, government spends more than tax revenues by newly issuing public money. On the other hand, in the case of inflationary state, anti-inflation policy of managing public money is conducted such that public money in circulation is sucked back by raising taxes or cutting government spending. As a supplement to this policy in the case of an unusually higher inflation rate that is overshooting a maximum tolerable level, a step down policy of budgetary restructure will be carried out so that a head of the public monetary administration is forced to resign for his or her mismanagement of holding a value of public money.

Recession

Let us now examine in detail how anti-recession policy help restore the economy. For this purpose a recession or GDP gap is purposefully produced by changing the value of Normal Inventory Coverage from 0.1 to 0.5 months and Output Ratio Elasticity (Effect on Price) from 3 to 1, as illustrated in the left diagram of Figure 17.21.

To fill a GDP gap under such a recessionary situation, let us continue to newly issue public money by the amount of 5 annually for 20 years, starting at t=7. The right diagram of Figure 17.21 confirms that the GDP gap now gets completely filled in. More specifically, Figure 17.22 demonstrates how GDP gap ratio and unemployment rate caused by this recession (lines 1) are recovered by the public money policy as illustrated by lines 2.

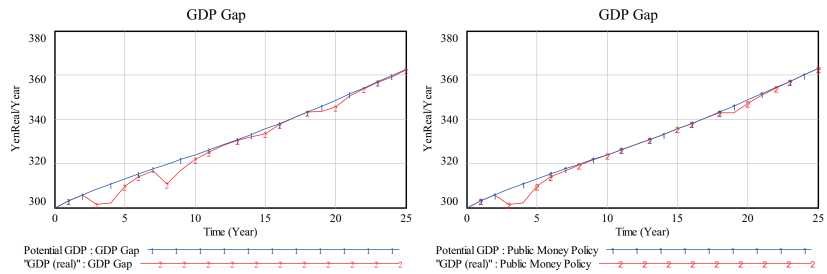

Figure 17.21: GDP Gap and Its Public Money Policy

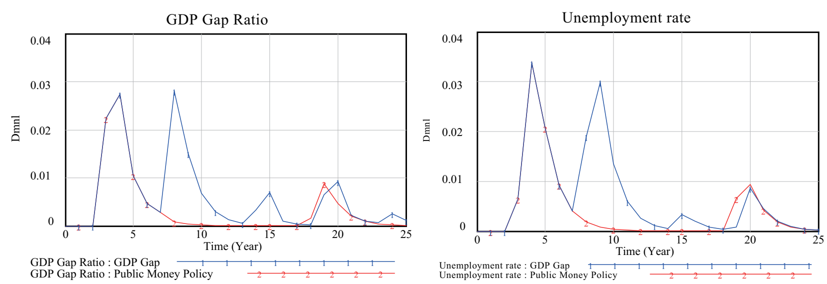

Figure 17.22: GDP Gap and Unemployment Recovered

Inflation

As shown above, so long as a GDP gap exists, an increase in the government expenditure by newly issuing public money can restore the equilibrium by stimulating the economic growth. Yet, this money policy does not trigger a price hike and inflation as illustrated by lines 2 in Figure 17.23 in comparison with lines 1 of GDP gap.

Yet, inflation could occur if government happens to mismanage the amount of public money. To examine the case, let us take a benchmark equilibrium state attained by the public money policy as above (lines 2), then assume that the government overly increases public money to 15 instead of 5 at t=7 for 25 years in the above case. This corresponds to a continual inflow of money into circulation. Under such situations, Figure 17.23 shows how price goes up and inflation rate jumps to 1.3% (line 3) from the level of 0.3% attained by the public money policy (line 2), 4 times hike, at the year 9.

The inflation thus caused by the excessive supply of money also triggers a GDP gap of 5% at the year 12 (or -3.1% of economic growth or recession), and an unemployment rate of 7.7% at the year 13 as illustrated by lines 3 in Figure 17.24.

Persistent objection to the public money system has been that government, once a free-hand power of issuing money is being endowed, tends to issue more money than necessary, which tends to bring about inflation eventually, though

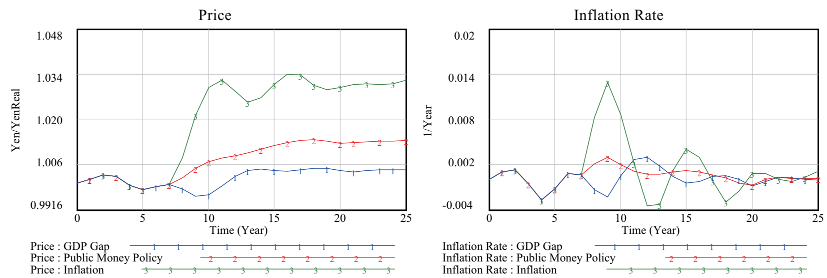

Figure 17.23: Price and Inflation Rate

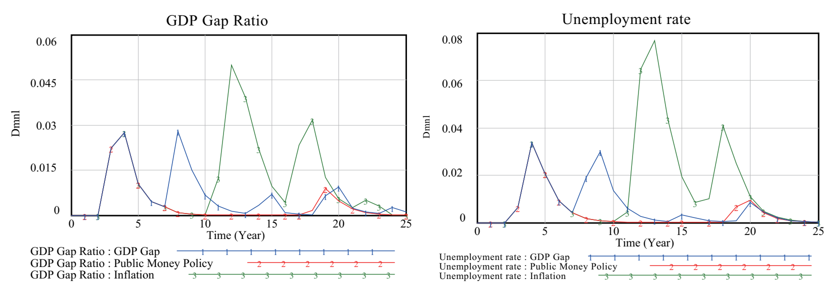

Figure 17.24: GDP Gap and Unemployment

history shows the opposite Zarlenga (2002). The above case could be unfortunately one such example. With the introduction of anti-inflationary policy, however, this type of inflation can be easily curbed by the decrease in public money. Let us define maximal inflation as a maximum tolerable inflation rate set by the government. For instance, it was set to be 8% in Yamaguchi (2010), as suggested by the American Monetary Act. Then, anti-inflationary policy works such that if an inflation rate approaches to the maximal level and a tolerable gap decreases to zero, the amount of public money will be reduced to curb the inflation through the decrease in government spendings and/or the increase in taxes.

Step Down

What will happen if the tolerable gap becomes negative; that is, current inflation rate becomes higher than the maximal inflation? This could occur, for instance, when the incumbent government tries to cling to the power by unnecessarily stimulating the economy in the years of election as history demonstrates. Business cycle thus spawned is called *political business cycle*. "There is some evidence that such a political business cycle exits in the United States, and the Federal Reserve under the control of Congress or the president might make the cycle even more pronounced (Mishkin, 2006, p.353)." Indeed Figure 17.25, obtained from the above analysis of inflation, shows how business cycles could be caused by the mismanagement of the increase in public money (line 3) when no GDP gap exists (line 2). This could be a serious moral hazard lying under the public money system.

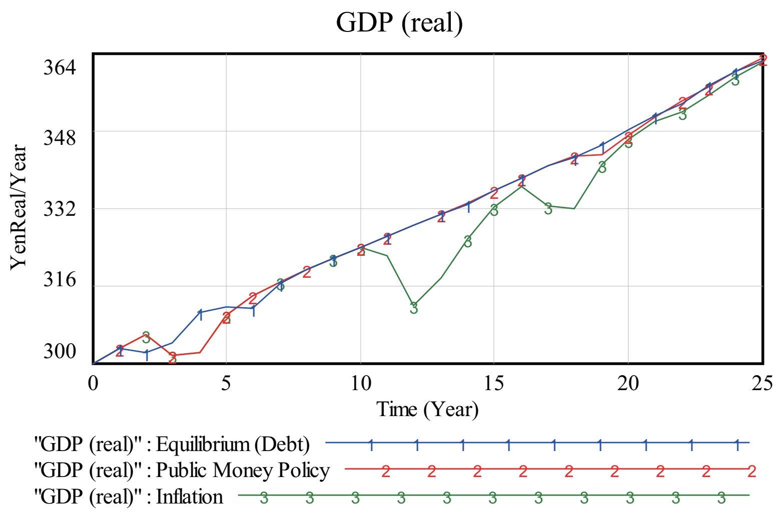

Figure 17.25: Business Cycles caused by Inflation under No GDP Gap

Proponents of the central bank may take advantage of this cycle as an excuse for establishing the independence of the central bank from the intervention by the government. How can we avoid the political business cycle, then, without resorting to the independence of the central bank? As a system dynamics researcher, I suggest an introduction of the third balancing feedback loop of *Step Down* as illustrated in Figure 17.20. This loop forces, by law, a head of the Public Money Administration to step down in case a tolerable gap becomes negative; that is, an inflation rate gets higher than its maximum tolerable rate. Then a newly appointed head is obliged to restructure a budgetary spending policy to stabilize a monetary value. The stability of a public money system depends on the legalization of a forced step down of the head of the public money administration.

Conclusion

Money is, by Aristotle (384 - 322 BC), fiat money as legal tender and has been historically created either as public money or debt money. Current macroeconomies in many countries are built on a debt money system, which, however, failed to create enough amount of money to meet an increasing demand for growing transactions. Gold standard failed in 1930s and was replaced with gold-dollar standard after World War II, which alas failed in 1971. Then current dollar standard was established, allowing free hand of creating money by central banks, from which, unfortunately, current runaway government debt has been derived. The accumulation of debt will sooner or later lead to impasses of defaults, financial meltdown or hyper-inflation; in other words current debt money system is facing its systemic failure.

Under such circumstances it is shown that it becomes very costly to save the current debt money system by reducing government debt and debt-GDP ratio; that is, a liquidation process of debt inevitably triggers economic recessions and unemployment of both domestic and foreign economies.

An alternative system, then, is presented as a public money system of open macroeconomies as proposed by the American Monetary Act in which only government can issue money with a full reserve banking system. It is shown that under the public money system government debt can be liquidated without triggering recession, unemployment and inflation.

Finally, in place of the current Keynesian monetary and fiscal policies, public money policies are introduced, consisting of three balancing feedback loops of anti-recession policy, anti-inflation policy and restructuring policy of step down of a head of PMA (Public Money Administration). Public money policies thus become simpler and can affect directly to the workings of the economy.

Accordingly, from a viewpoint of system design, a public money system of macroeconomies as proposed by the American Monetary Act seems to be worth being implemented if we wish to avoid impasses such as defaults, financial meltdown and hyper-inflation[2].

[2]This implementation might bring about fortunate by-products. A debt money system of the current macroeconomy has been pointed out to constitute a root cause of unfair income distribution between haves and haves-not, wars due to recessions, and environmental destruction due to a forced economic growth to pay interest on debt. Accordingly, a public money system remove the root cause of these problems and could be panacea for solving them. Due to the limited space, further examination will be left to the reader

Chapter 18

Monetary and Financial Stability

Our economies are currently facing systemic failures of financial and debt crises. To overcome these, an alternative public money system is proposed by the American Monetary Act. This chapter[1], following the previous two chapters, tries to examine the feasibility of the public money system. Previous two chapters have focused on the liquidation of government debt. This chapter explores monetary and financial stability under the public money system in comparison with the current debt money system, by constructing a simplified macroeconomic model. It demonstrates through simulation that monetary and financial instability is built into the current debt money system and "booms and depressions" become inescapable. On the other hand, monetary and financial stability is shown to be accomplished under the public money system.

18.1 The Chicago Plan Revisited

This chapter examines the feasibility of the American Monetary Act, following the previous two chapters. The Act endeavors to restore the proposals of the Chicago Plan and 100% Money by repealing the Federal Reserve Act of 1913. Specifically, it tries to incorporate the following three features. For details see Yamaguchi (2010) and Zarlenga (2002, 2009).

- Governmental control over the issue of money
- Abolishment of credit creation with full (100%) reserve ratio
- Constant flow of money into circulation to sustain economic growth and welfare

[1]This chapter is based on the paper: On the Monetary and Financial Stability under A Public Money System – Modeling the American Monetary Act Simplified – submitted to the 30th International Conference of the System Dynamics Society, St. Gallen, Switzerland, July 22-26, 2012.

The macroeconomic system which meets the above conditions is called the *public money* system in Yamaguchi (2011), while the current system is called the *debt money* system.

Chapter 12 investigated how accumulating government debts could be liquidated under the above two different macroeconomic systems Yamaguchi (2010) . What was found is that the liquidation of government debt under the current macroeconomic system of debt money is very costly; that is, it triggers economic recessions, while the liquidation process under the public money system can be accomplished without causing recessions and inflations. Chapter 13 expanded the analysis to the open macroeconomies and found that government liquidation can be attained without causing economic recession, unemployment and inflation in both domestic and foreign economies Yamaguchi (2011). These two chapters have focused on the liquidation of government debts, because national debts are the most imminent issues many OECD economies are now facing.

Having solved the liquidation issue of national debts, I've strongly felt that something essential might have been missing in these researches. This reflection has led me to revisit the Chicago Plan, specifically a mimeograph called *A Program for Monetary Reform* that had been circulated among American economists in July, 1939, as already examined in Chapter 12. It turned out that the liquidation of national debt is "a by-product" of the Chicago Plan or the 100% reserve system.

What is "a main-product", then, that we have missed in our previous analyses? Revisit of the Chicago Plan, specifically the above mimeograph, convinced me that its main concern was the monetary instability under the fractional reserve system as the following section 9 indicates:

> (9) Fractional reserves give our thousands of commercial banks the power to increase or decrease the volume of our circulating medium by increasing or decreasing bank loans and investments. The banks thus exercise what has always, and justly, been considered a prerogative of sovereign power. As each bank exercises this power independently without any centralized control, the resulting changes in the volume of the circulating medium are largely haphazard. This situation is a most important factor in booms and depressions (Fisher, 1945, p.169).

Irving Fisher himself emphasized in his book that the 100% Money plan "would remove the chief cause of both booms and depressions, namely, the instability of demand deposits, tied as they are now, to bank loans." (Fisher, 2009, p.8)

The purpose of this chapter is, therefore, to examine the main-product of the Chicago Plan; that is, how monetary and financial stability can be attained under the public money system that incorporates 100% reserve system or the Chicago Plan.

Having inherited the academic tradition of the Chicago Plan, Milton Friedman, Nobel laureate proponent of free market economy, also supported the plan as follows;

> One major reform that I recommended in the third lecture to achieve that objective was 100% reserve banking, a proposal that had been made by a group of economists at the University of Chicago during the 1930s and that was strongly supported by the greatest of American economists, Irving Fisher. The proposal is "to require any institution which accepts deposits transferable by check to have one dollar in high-powered money [i.e., currency plus deposits at Federal Reserve Banks] for every dollar in deposit liabilities, ... that is, to have 100% reserves." (Friedman, 1992, p.X)
>
> It means that the central problem is not to construct a highly sensitive instrument that can continuously offset instability introduced by other factors, but rather to prevent monetary arrangements from themselves becoming a primary source of instability (Friedman, 1992, p.23).

In other words, monetary and financial stability has been the most important concern of all economists among different schools of economic profession. This chapter challenges to demonstrate how it can be attained under the public money system, while monetary and financial instability of "booms and depressions" is inevitably caused under the current debt money system. This chapter, then, completes the validation of the proposals made by the Chicago Plan and the American Monetary Act.

18.2 Debt vs Public Money Systems Simplified

I have already presented two macroeconomic models of the American Monetary Act in Yamaguchi (2010) and Yamaguchi (2011) based on the method of accounting system dynamics developed in Yamaguchi (2003). To focus on our main concern of the monetary and financial stability in this chapter, a simplified model is constructed here Yamaguchi (2012), consisting of three economic sectors such as producers, consumers and commercial banks[2] [Companion Model: MonetaryStability.vpmx].

Producers

Main transactions of producers are illustrated in Figure 18.1, which are summarized as follows.

- Producers' income is, under the accounting principle, booked as an inflow of the stock of retained earnings when production of GDP is completed, and at the same time inventory is increased by the same amount.
- Their actual income is realized when GDP are sold out and shipped from the inventory to consumers and bankers as consumption and to producers as investment.

[2]The model is also motivated by the work of Steve Keen (Keen, 2011, 2011), specifically his monetary model of capitalism in chapter 14.

- Out of the income thus realized, capital depreciation is subtracted first and interests of their debt are paid to the banks.
- Next, a portion of GDP (say, 20%) are assumed to be made as mark-up profits, and paid to their shareholders (that is, consumers) as dividends. The remaining amount is paid to workers (as consumers) as wages. That implies that workers are placed in a relatively weaker position against shareholders. (Surely, this assumption could be reversed in simulation).
- Producers are thus constantly in a state of cash flow deficits, since all income are paid out to consumers and bankers as factor income and interest income. To make new investment, therefore, they have to borrow money from banks and pay interest to the banks.
- Their debt is assumed to be a long term debt of 10 years.

Consumers

Main transactions of consumers are illustrated in Figure 18.2, which are summarized as follows.

- Consumers receive wages and dividends from producers and interest from banks.
- They spend 80% of the income on the consumption, and the remaining will be saved.
- In this model, their cash/deposits asset is assumed to include demand deposit only when credits are created by banks and lent to producers who pay factor income with credits as well as cash. In other words, demand deposits by consumers are not liabilities of commercial banks.
- Their demand for cash/deposits as transaction payment out of saving account will be constantly adjusted by the currency ratio (of 20%) they wish to hold at hand.

Banks

Main transactions of banks are illustrated in Figure 18.3. Transactions under the debt money system are summarized as follows (transactions under the public money system are explained below in Section 4).

- Banks receive deposits from consumers, against which they pay interests.
- Out of the deposits, loans are made to producers according to the demand for desired borrowing by producers.

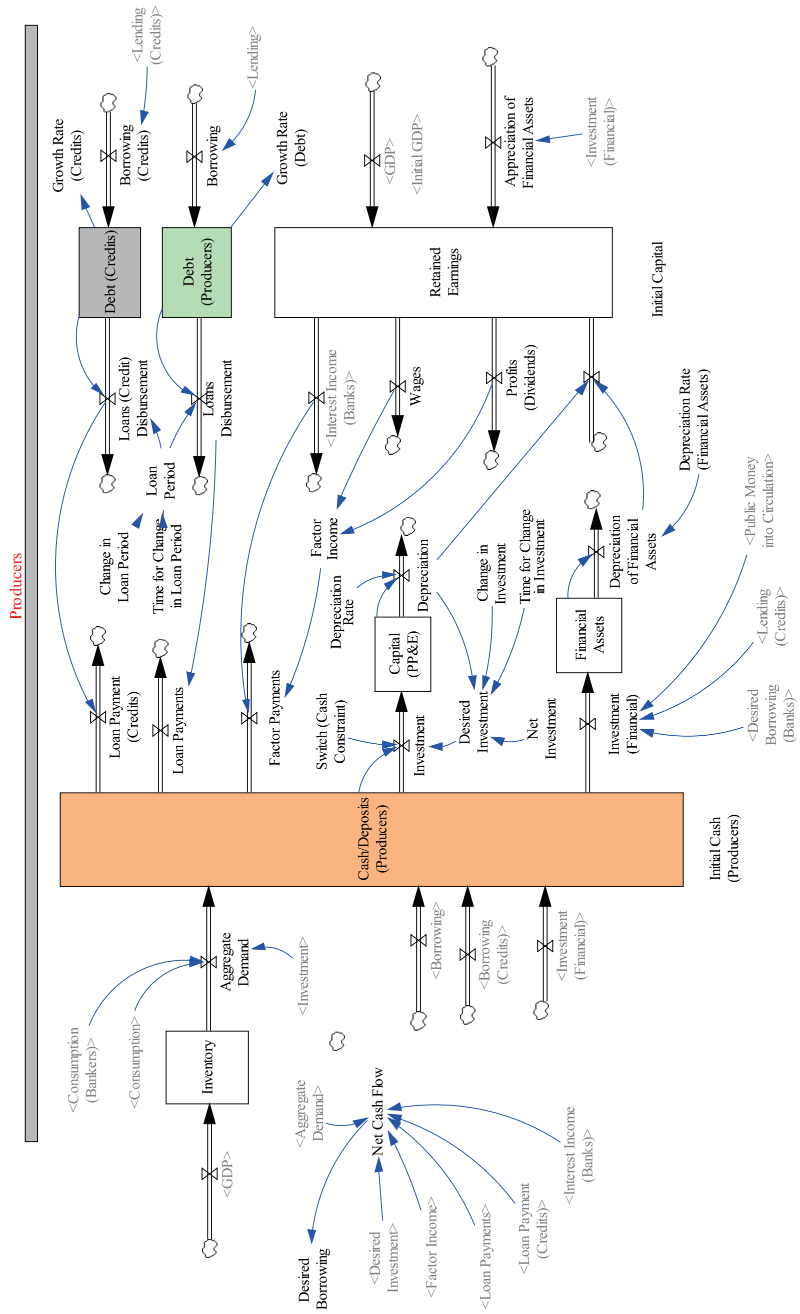

Figure 18.1: Transactions of Producers

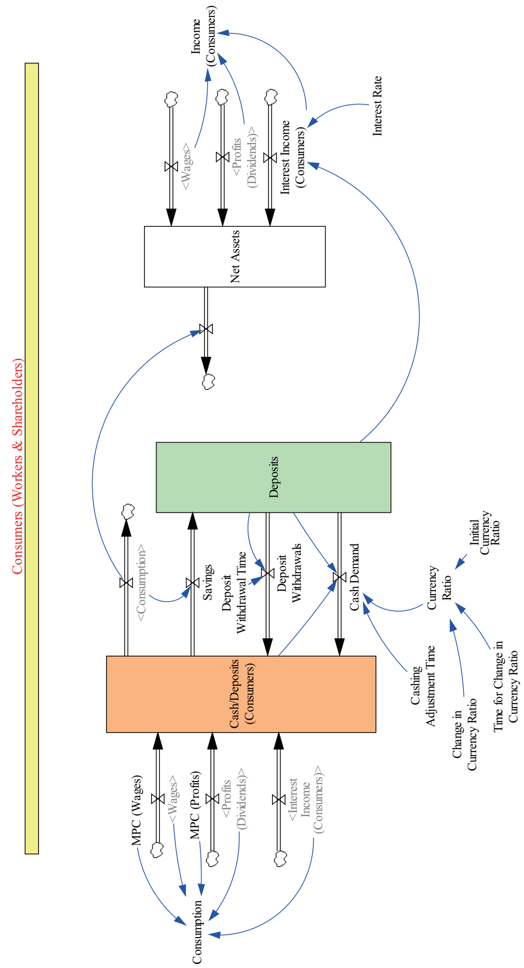

Figure 18.2: Transactions of Consumers

- If loanable fund is not enough under the debt money system, banks can create credits and put them into the demand deposits account of producers. In this process, vault cash asset is assumed to play a role of the required reserve as well (with the central bank behind the screen), against which credits are created. (This process of credit creation is called money out of nothing under a fractional reserve banking.) The upper limit of the credit is set by a required reserve ratio or a required equity ratio of loans imposed by the BIS rule[3].
- Banks receive income as prime rate interests against their loans. 80% of the income is assumed to be spent on consumption, and the remaining

[3]This limit is not explicitly considered in our model

will be retained as equity.

Remarks: In our simplified model, the total amount of cash in circulation such as the ones in the cash assets of producers, consumers and banks is considered as base money (M0) (or monetary base, or high-powered money) initially provided by the central bank.

18.3 Behaviors of A Debt Money System

Determination of GDP

Our model is one of the most simplified models of macroeconomy with a focus on the monetary and financial stability. For this purpose, Keynesian determination of GDP is simplified as follows. First, aggregate demand (AD) consists of consumption (C) and investment (I), and investment is assumed to be exogenously determined together with depreciation.

$$AD = C + I \tag{18.1}$$

Next, consumption demand is determined as a portion of actual Gross Domestic Products (GDP or Y), where c is a marginal propensity to consume (whose value is set at $c = 0.8$ in this model).

$$C = cY \tag{18.2}$$

Keynesian model claims that GDP is determined by the level of aggregate demand;

$$Y = AD. \tag{18.3}$$

From these three equations, Keynesian equilibrium of GDP is determined by the following equation:

$$Y = \frac{1}{1-c} I. \tag{18.4}$$

For instance, when exogenous amount of investment without depreciation are $I =$ 80, 100, and 120, respectively, equilibrium GDP are determined at $Y = 400$, 500, and 600.

Analysis of determining GDP at the different levels of exogenous investment is called a comparative static analysis. System dynamics modeling method can easily convert this static analysis to

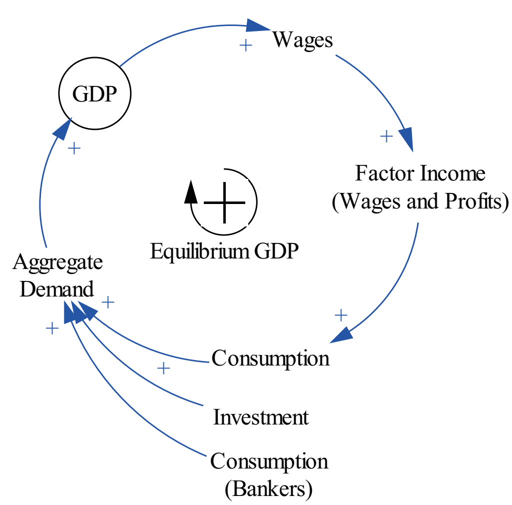

Figure 18.4: Keynesian GDP Determination

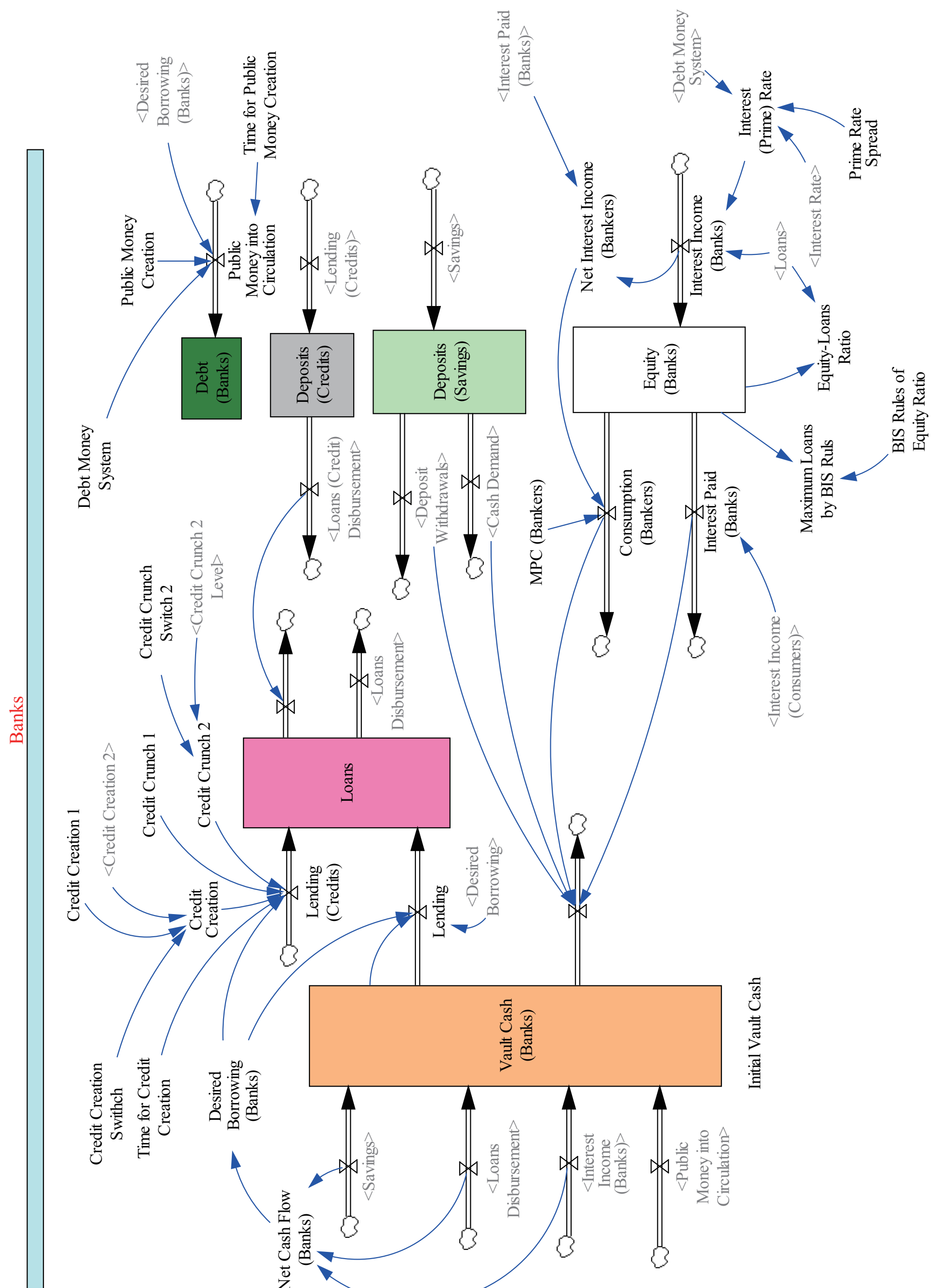

Figure 18.3: Transactions of Banks

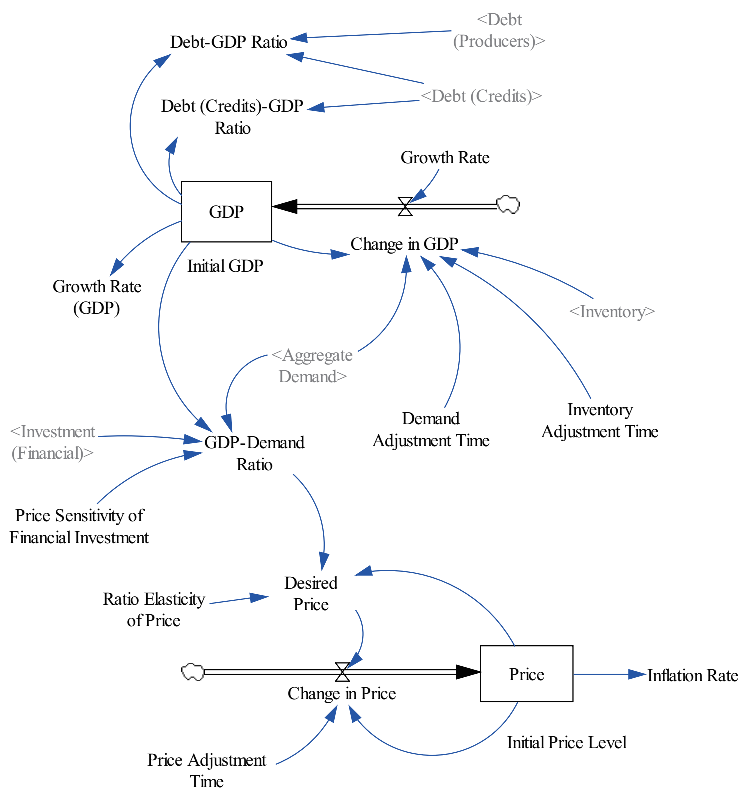

Figure 18.5: Determination of GDP and Price

a dynamic process of GDP determination as follows:

$$\frac{d\,Y}{dt} = \frac{AD - Y}{AT} \qquad (18.5)$$

where AT is an adjustment time. In our simplified model, this dynamic process is assumed to be further affected by an inventory level, as illustrated in Figure 18.5, such that

$$\frac{d\,Y}{dt} = \frac{AD - Y}{AT} - \frac{I_{inv}}{AT_{inv}} \qquad (18.6)$$

where AT_{inv} is an adjustment time of inventory.

Figure 18.6 illustrates how GDP are determined by the increase in investment by 20 and 40 at t=10 from the initial investment level of $I = 80$. Specifically, lines 1, 2 and 3 correspond to the investment levels of 80, 100 and 120, respectively, while lines 4, 5 and 6 correspond to the same investment levels with 4% depreciation of the existing capital. Surely GDP will become larger to replace capital depreciation, yet capital levels stay the same for the same net investment. Whatever levels of investment, these behaviors demonstrate that an equilibrium GDP will be eventually attained through the over-shooting fluctuations.

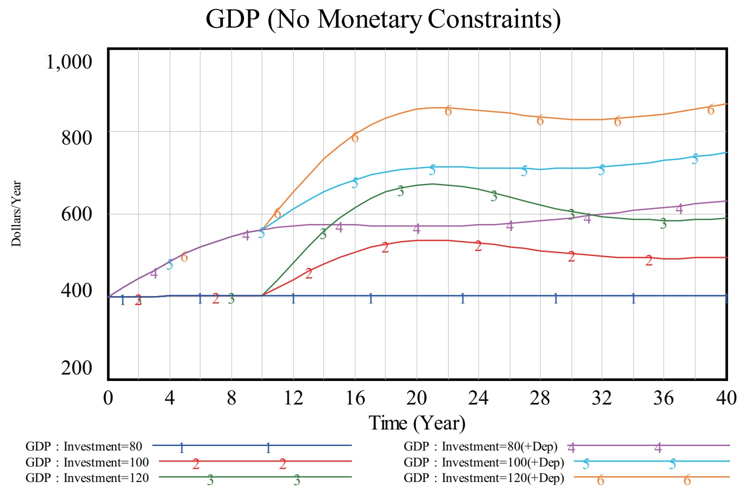

Figure 18.6: Keynesian Determination of GDP

Price Determination

Monetary stability is measured by the price stability or inflation rate. For this purpose, we assume a passive mechanism of the determination of price level. By the passive mechanism, we mean that a price level has no feedback effect on the determination of GDP in our simplified model. Specifically, the price level is, as illustrated in Figure 18.5, assumed to be adjusted by the following dynamics:

$$\frac{dP}{dt} = \frac{P^* - P}{AT} \tag{18.7}$$

in which the desired price P^* is obtained as

$$P^* = \frac{P}{\left(\frac{Y}{AD}\right)^e} \tag{18.8}$$

where e is a GDP-AD ratio elasticity of price[4].

On the other hand financial stability is hard to measure in our simplified model. "To finance" literally means "to provide money". Hence, financial stability is related with credit-creating (crunching) and stable lending behaviors of bankers at a microeconomic level of activities. These micro-level activities affect macro-level behaviors collectively in terms of loan and debt. Since our

[4]This is a simplified equation of price flexibility presented in Yamaguchi (2010).

macroeconomic model, though simplified, is based on micro-foundation behaviors, it would be appropriate to use monetary and financial stability inseparably here.

Monetary Constraints

Dynamical equilibria in Figure 18.6 can be attained only when producers have enough amount of money to pay factor incomes such as wages and profits (dividends) and investment, etc. Most macroeconomic textbook analyses are based on this assumption of unconstrained availability of money or liquidity for transaction.

To examine the effect of monetary constraint on the determination of GDP, let us first calculate net cash flow of producers. It is obtained as inflow and outflow of producers' cash stock in Figure 18.1. Thus, it is calculated as follows:

$$\begin{aligned}\text{Net Cash Flow } &= \text{Cash Inflow - Cash Outflow} \\ &= \text{Consumption (Consumers and Bankers)} + \text{Investment} \\ &\quad \text{- Factor Income - Interest Income (Banks) - Investment} \\ &\quad \text{ - Loan Payments} \\ &= \text{- Savings (Consumers and Bankers) - Loan Payments}\end{aligned} \tag{18.9}$$

where Factor Income is defined as the sum of wages and profits (dividends).

Net cash flow of producers thus obtained becomes equal to the sum of negative amount of savings by consumers and bankers and loan payments. In other words, producers are destined to be in a state of cash deficiency in a capitalist monetary economy. Accordingly, to make new investment and reimburse loans, they are obliged to constantly raise funds. This amount of fund is called here a desired borrowing amount. This becomes a fundamental framework of our macroeconomy constrained by the liquidity availability.

Theoretically, there are only four ways to raise desired borrowing fund as follows:

- Borrowing from banks (bank loans)
- Issuing corporate bonds (borrowing from the public)
- Issuing corporate shares (sharing ownership)
- Retaining earnings for investment (retained saving)

In this chapter we assume that producers can raise all necessary funds by borrowing from commercial banks.

Now suppose that producers initially have \$300 (the reader may consider its unit as billion dollar), while banks have \$500 as their initial vault cash. That is, the monetary base of our economy is \$800. This amount of currency could be interpreted as coins and banknotes in a debt money system, or public money issued by the government in a public money system. From now on, GDP is assumed to be determined by the investment consisting of the net investment of \$80 and capital depreciates of 4%; that is line 4 in Figure 18.6. Accordingly, (gross) investment becomes a sum of net investment and depreciation. Then GDP will be determined as illustrated by line 1 in the left-hand diagram of Figure 18.7. Line 1 in the right-hand diagram shows that cash assets of producers are running out by the amount of -\$517 at the year 40.

Now suppose that producers fail to raise the desired borrowing amount. Under such monetary constraint, produces cannot fully meet their net cash flow deficits; specifically they cannot make desired amount of investment due to the shortage of fund. This in turn decreases aggregate demand, toward which GDP will be eventually pulled back. In short, GDP begins to shrink due to the constraint of the shortage of cash. Line 2 in the left-hand diagram of Figure 18.7 illustrates how GDP gets reduced, while that of the right-hand diagram indicates that producers' cash is getting depleted to zero.

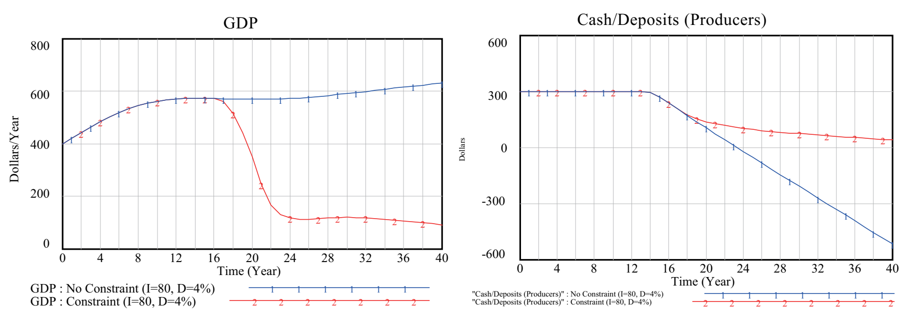

Figure 18.7: Monetary Constraint GDP

This implies that money or liquidity does indeed matter for the attainment of equilibrium GDP. Unfortunately, most macroeconomic textbooks neglect this important role of money, and assume that macroeconomic behaviors are not constrained by the availability of money or liquidity.

Money out of Nothing

How can our economy avoid this monetary constraint and create enough money to attain the equilibrium GDP ? In order to meet the demand for the desired borrowing amount under the current fractional reserve banking system, banks can make loans to producers by creating credits against the bank reserves with the central bank. The credits thus created are put into the demand deposits account of producers. In our model it is denoted as the stock of Deposits (Credits) under the liabilities of banks. In this way, banks are able to create demand deposits out of nothing for producers, who then utilize them for their transactions. Figure 18.8 illustrates how money is created and put into circulation as credit creation.

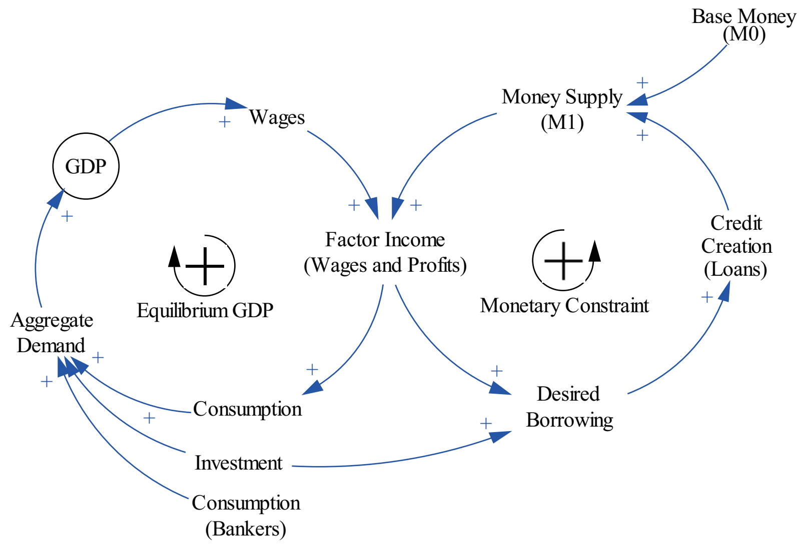

Figure 18.8: Credit Creation

In this way, whenever producers can raise desired borrowing amount successfully, the equilibrium GDP is attained. Figure 18.9 illustrates how equilibrium GDP is restored by banks who create enough credits and make loans to the producers. In our model, the amount of money banks have to create to attain the equilibrium GDP is denoted as "Desired Borrowing (Banks). In the figure, the data file name of Credit Creation(100%) implies that this amount is fully created; that is, 100% of what banks want to borrow to meet their cash deficiency. Consumption (Bankers) (line 4) will become zero if (prime) interest rate is zero and bankers have no income. In this case, lines 5 and 6 become identical and net investment becomes equal to saving.

It is often said that without credit creation by banks, no growth can be attained. And this reasoning is used as a justification that credit creation through a fractional reserve banking system is essential for economic growth and prosperity. In other words, activities of bankers are good to the society, because they are providing enough money or liquidity for the prosperity of society! If that's the only way to create money for economic growth, we have to be grateful for their banking services of credit creation out of nothing.

Money Stock

Before we examine this justification of banking services of credit creation, let us define the amount of money that is created and put into circulation. In our model, initial currency in circulation is the sum of cash held initially by producers ($300) and banks ($500)); in total, $800. This amount of currency is assumed to be provided by the central bank or the public money administration.

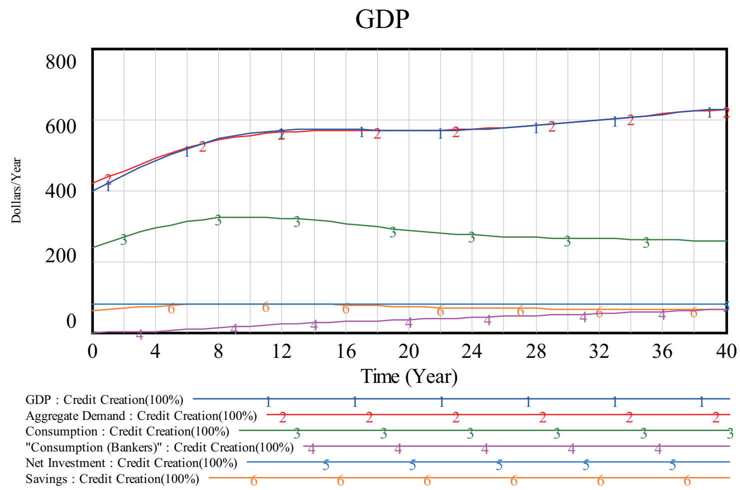

Figure 18.9: Equilibrium GDP by Credit Creation(100%)

Hence,

$$\text{Initial Base Money} = \text{Initial Cash (Producers)} + \text{Initial Vault Cash (Banks)} \quad (18.10)$$

Base money (M0) is increased whenever banks borrow money from the central bank or the public money administration. For the analysis of the current debt money system, money is assumed to be endogenously created as credits by banks. Under a public money system, banks are assumed to borrow money from the public money administration. Hence,

$$\text{Base Money (M0)} = \text{Initial Base Money} + \text{Debt (Banks)} \quad (18.11)$$

where Debt (Banks) constitutes a liability of banks for the money they borrow from the central bank or the public money administration.

Money stock (M1) is generally defined as[5]

$$\text{Money Stock (M1)} = \text{Currency in Circulation} + \text{Demand Deposits} \quad (18.13)$$

Under the debt money system, banks can create credits by setting up new deposit account for producers and typing in the digital figures of credit or loan on it. Nowadays this can be done electronically. This amount of money thus created by banks becomes demand deposits. In the balance sheet of producers this implies that their debt as liability and deposits as asset are simultaneously increase by the same amount. Now producers are ready to use this credit money

[5]Money stock is also defined in terms of base money (M0) as

$$\text{Money Stock} = m * \text{Base Money} \quad (18.12)$$

where m is a money multiplier.

for factor payments together with original base money. When this payment is done electronically to the deposit account of consumers, their cash account increase by the same amount. As a result, it becomes very difficult to distinguish this amount of payment by credit from that of base money as currency. Accordingly, their cash account need to be reinterpreted as cash/deposits account.

Hence, money stock (M1) is also redefined as

$$\text{Money Stock (M1)} = \text{Currency in Circulation} \quad (18.14)$$
$$= \text{Cash/Deposits(Producers)} + \text{Cash/Deposits (Consumers)} + \text{Vault Cash (Banks)}. \quad (18.15)$$

The difference between money stock (M1) and base money (M0) is nothing but the money endogenously created by banks out of nothing (or thin air):

$$\text{Money out of Nothing} = \text{Money Stock (M1)} - \text{Base Money (M0)} \quad (18.16)$$

Deposits of consumers are made out of their cash/deposits assets as savings after consumption expenditure is made. Accordingly, it could be interpreted as time deposits. Money stock (M2) is then defined as

$$\text{Money Stock (M2)} = \text{Money Stock (M1)} + \text{Time Deposits} \quad (18.17)$$

With these dentitions of money in mind, let us examine how money is created. In Figure 18.10, line 1 represents initial base money that is made initially available, which is also regarded as base money (M0) of line 2. On the other hand, demand deposits are created by bank loans as credit creation, which is illustrated by line 5. Hence, M1 is obtained here by adding line 2 and line 5 as line 3. At the year 40, the amount of credit creation or money out of nothing becomes $918. Accordingly, M1 becomes $1,718 together with the base money (M0) of $800.

In conclusion, the Keynesian equilibrium GDP can only be attained with the appropriate amount of money, half of which is in our model created by commercial banks out of nothing under the current fractional reserve banking system of debt money. Most macroeconomic textbooks neglect this important role of money in the process of GDP determination, while many monetary economists defend credit creation process as an essential banking service to drive economic growth.

Driving Forces of Credit Creation: Greed

We are now in a position to explore the motives of bankers to create credits by making loans. Generally speaking, for the attainment of mostly equilibria, enough amount of money has to be put into circulation to avoid recessions caused by credit crunches such as analyzed in Yamaguchi (2006). This amount is denoted in our analysis by the file name of Credit Creation (100%). What

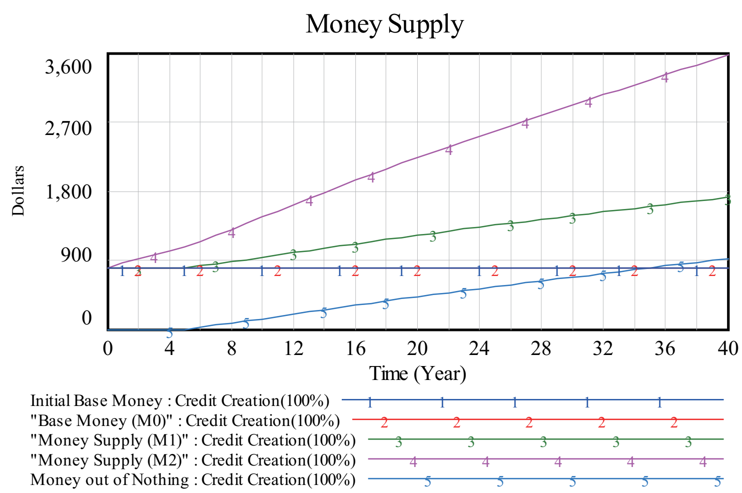

Figure 18.10: Money Stock: M0, M1 and M2

drives bankers to create credits, then? Are they really social philanthropists, as often claimed, who create credits for the economic growth and welfare of people?

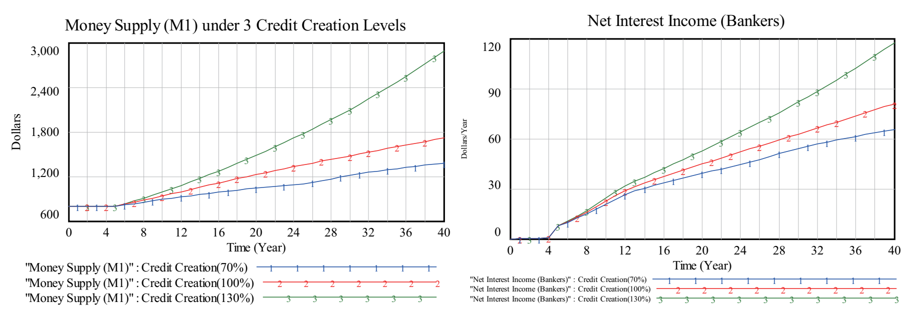

Figure 18.11: Changes in Money Stock and Net Interest Income of Bankers

Left-hand diagram of Figure 18.11 illustrates three different levels of money stock (M1) created by banks. M1 increases as the level of credit creation by banks increases from 70% (line 1) to 100% (line 2), then to 130% (line 3). Right-hand diagram indicates how net interest income of bankers increases as credit creation expands by increasing loans. It costs almost nothing for bankers to create credit. Accordingly, their income will be increased as they make more loans. Since interest income is increased without incurring cost, all bankers will surely tend to make more loans. It may be concluded, thus, that greed is the motive of bankers for their credit creation.

Even so, their greedy behaviors may be justified as rational ones in a market economy, because all agents are allowed to pursue their own self-interest according to market rules. Accordingly, a fractional reserves banking system or debt money system which allows greedy behaviors of bankers should be to blame.

Figure 18.12 demonstrates the existence of a built-in positive feedback loop that enhances credit creation in our debt money system. It is called "Bankers' Greed" loop in this chapter.

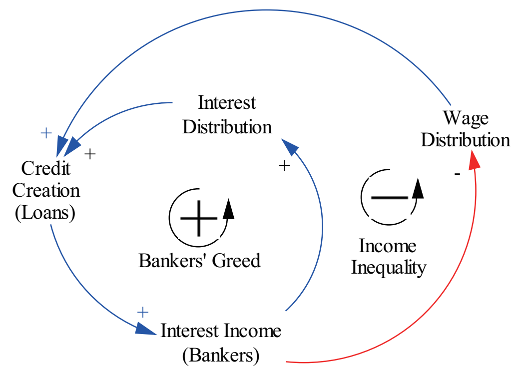

Figure 18.12: Greed of Bankers

Consequences of Greed

Now we have identified a positive feedback loop of bankers' greed built in the debt money system. This has been a driving force of capitalist economic development, and justified by its proponents. What will happen if credit creation of banks overshoots 100% level of desired borrowing of banks for further loans and interest income? Figure 18.13 of prices and inflation rates indicates how our economy tends to become inflationary as a consequence of bankers' greed to make more loans than 100%.

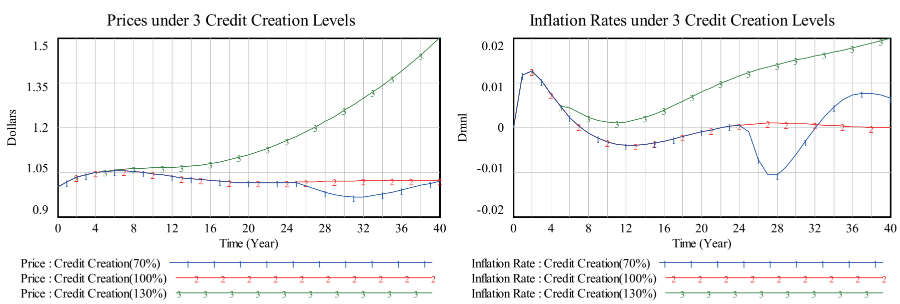

Figure 18.13: Price Levels and Inflation Rates with Credit Overshooting

The other consequence is the inequality of income distribution in terms of wage distribution. It is defined as a portion of wages out of net national income (NNI); that is, wage/NNI. NNI here becomes the same as GDP less Depreciation in our model. Left-hand diagram of Figure 18.14 illustrates a decreasing trend of wage distribution irrespective of the levels of credit creation from 70% through 130%! Furthermore, it is observed that income inequalities at the credit creation levels of 70% and 130% (lines 1 and 3) get worsened compared with the level of 100% credit creation (line 2).

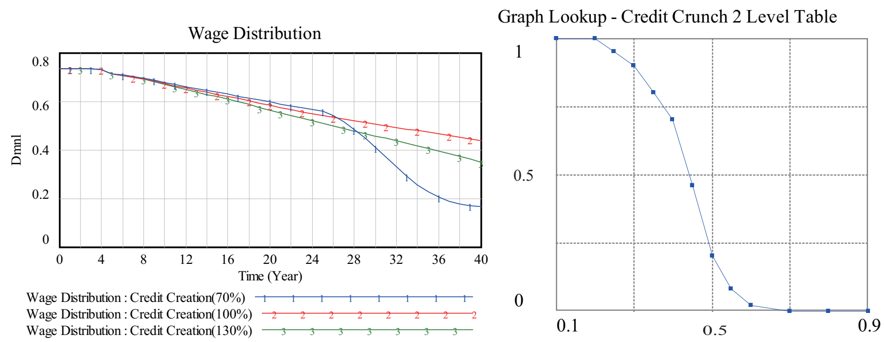

Figure 18.14: Interest-Wage Ratio and Wage Distribution

When income inequality gets worsened for workers, their income is reduced, followed by the deduction of their consumption, which in turn reduces aggregate demand. That is, bankers' greed to create more credits to increase their own income, sooner or later, triggers the decrease in GDP and economic recession. Once recession gets started, bankers lose confidence in the safety of their loans, and surely try to reduce and/or retrieve them. This reducing behavior is called "Kashi-shiburi", and retrieving one is called "Kashi-hagashi" in Japanese. There two terminologies became household names in Japan during the lost two decades starting 1990's. This balancing feedback loop is called "Income Inequality" loop in Figure 18.12. Once this loop gets triggered, positive feedback loop of Bankers' Greed may begin to be dominated by this balancing feedback loop. In other words, under the debt money system, a reinforcing process of credit creation could be easily reversed into the process of credit crunch.

These observations suggest that it is legitimate to assume that the level of credit creation is forced to be reduced according to the reduction of wage distribution. To bring this feedback structure to the model, a table function is constructed such that a level of credit creation is determined by the wage distribution. Specifically, it is assumed that whenever wage distribution drops to 50%, credit creation level gets reduced by 20%, as illustrated in the right-hand diagram of Figure 18.14.

In the case of 100% level of credit creation, wage distribution drops to 50% at the year 30, as shown by line 2 in the left-hand diagram of Figure 18.14; that is, a start of credit crunch of 20%. Left-hand diagram of Figure 18.15 illustrates how this credit crunch reduces credit creation of money out of nothing (line 2), which triggers deflation as shown by line 2 in the right-hand diagram. Figure 18.16 illustrates how this credit crunch affects GDP level and its growth rate.

As seen above, the balancing loop of "Income Inequality" we have observed here is the most fundamental endogenous feedback mechanism, built in our simple debt money system, that causes "booms and depressions" as criticized by the Chicago Plan.

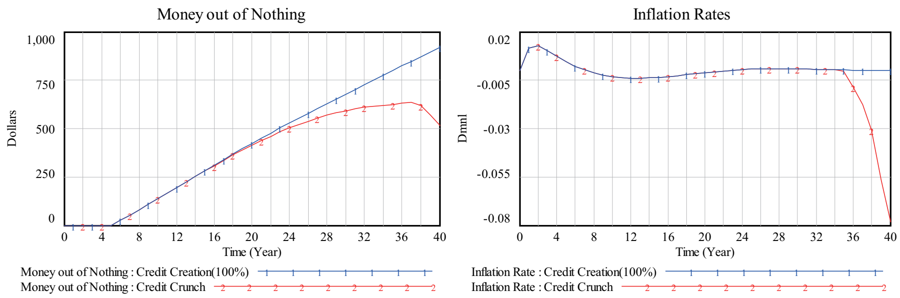

Figure 18.15: Reduction of M1 and Deflation by Credit Crunch

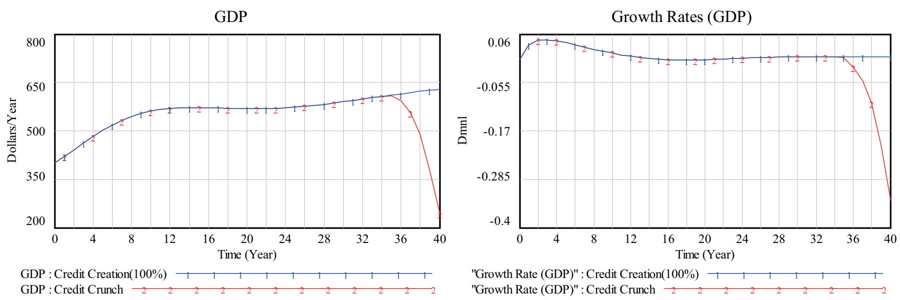

Figure 18.16: Recession (GDP and Growth Rate) triggered by Credit Crunch

Monetary and Financial Instability

In a closed economic system, money has to be issued or created within the system. Under the current debt money system, only the central bank is endowed with a power to issue money (called base money or monetary base) within the system, and make loans to the commercial banks directly and to the government indirectly through the open market operations. With this base money, commercial banks create credits under a fractional reserve banking system by making loans to producers and consumers. These credits constitute a great portion of money stock. In Japan, 82.5% of money stock (M1) in 2009 was credit loans and deposits. In this way , money and credits are only created when commercial banks and government as well as producers and consumers come to borrow at interest. Under such circumstances, if all debts are to be repaid, money ceases to exist. This is an essence of the endogenous money stock in a debt money system.

In our simplified model, this process is summarized as a causal loop diagram of debt money system in Figure 18.17. In the diagram, there are 4 reinforcing loops to stimulate economic growth through credit creation, meanwhile there is only one balancing feedback loop of Income Inequality. Yet, it could trigger credit crunch easily, because money created by loans can be easily crunched by the restriction and withdrawal of loans.

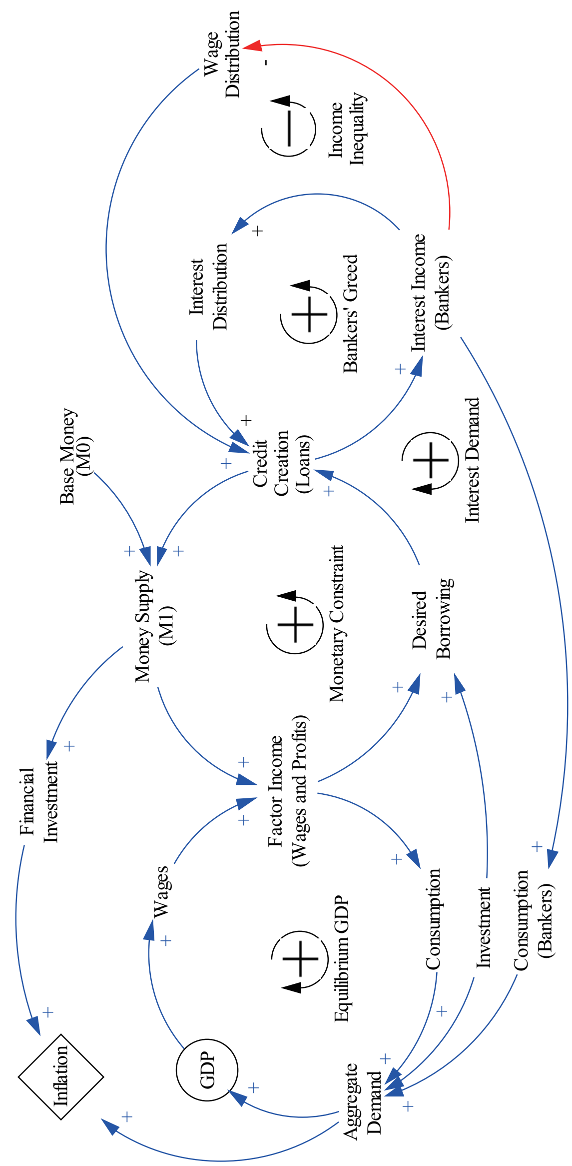

Figure 18.17: Causal Loop Diagram of Debt Money System

From the left-hand diagram of wage distribution in Figure 18.14, income inequality gets worsened whenever the level of credit creation under-shoot or over-shoot the 100% desired borrowing level of credit creation, causing credit crunch, price fluctuation and recessions. Since these feedback mechanism is built in the debt money system, no one in the system cannot control these cycles of "booms and depressions". To see these effects of monetary and financial instability, let us run sensitivity analysis using random normal distribution with mean value of 0 and standard deviation of 0.2 around the 100% level of credit creation. That is, 68% of credit creation levels occur within the range of 80% level through 120%.

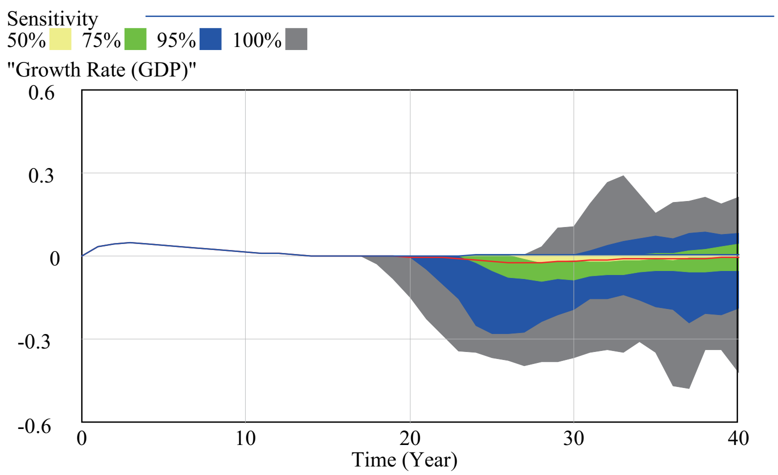

Figure 18.18: Sensitivity of Credit Creation on Growth Rates

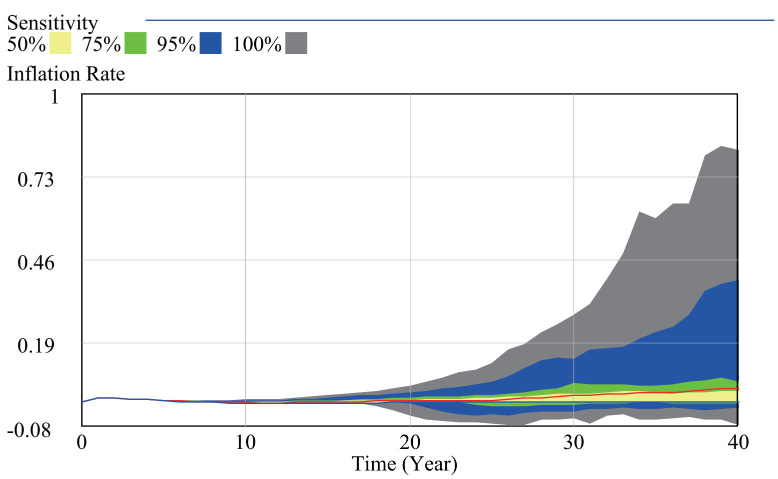

Figure 18.19: Sensitivity of Credit Creation on Inflation Rates

Figure 18.18 illustrates how economic growth rates are affected by the monetary and financial instability, while Figure 18.19 shows how inflation rates fluctuate along with the fluctuation of growth rates.

18.4 Behaviors of A Public Money System

We are now in a position to explore monetary and financial stability under the public money system where the central bank is incorporated as one of the governmental organization. In our simplified model, however, the central bank is not explicitly modeled and left out of the model boundary. Transactions of commercial banks under the public money system are now revised as follows (transactions of producers and consumers remain the same).

- Banks are obliged to deposit a 100% fraction of the demand deposits as the required reserves with the public money administration. Specifically, this requirement is assumed to be met and demand deposits are accordingly left behind the balance sheet of bankers in the model. Hence, cash in the vault cash stock becomes the only source for bankers to make loans.

- When the amount of vault cash is not enough to meet the demand for loans from producers, banks are allowed to borrow from the public money administration free of interest; that is, discount rate of public money now becomes zero. In the model, it is done as a flow of money into circulation that is managed by a level of public money creation (similar to the level of credit creation under the debt money system) by the Public Money Administration (PMA) (see Yamaguchi (2010) and Yamaguchi (2011)).

Monetary Constraints

Let us now explore monetary and financial behaviors under the public money system in comparison with those under the debt money system. To attain equilibrium GDP, banks have to create enough amount of money which is denoted as "Desired Borrowing (Banks)" in the model. In what follows, a data file name of "Public Money Creation (100%)" implies that this desired amount of borrowing by banks is 100% met by the PMA, while that of "Credit Creation (100%)" means that it is 100% met by the credit creation activities of the banks as already analyzed above.

Figure 18.20 illustrates how different levels of GDP are determined under the debt and public money systems. When money stock is only met by 70%, equilibrium GDP cannot be attained under both systems (lines 1 and 4), though GDP under the public money system is slightly higher. Only when more than 100% money is created, equilibrium GDP are attained (lines 2, 3, 5, 6) under both systems. As lines 3 and 6 indicate, over-supply of money (130%) could only be justified for the attainment of equilibrium GDP. In other words, it becomes necessary to provide more than enough amount of money to attain an equilibrium GDP by avoiding the constrained levels of GDP.

Monetary Stability

Doesn't the over-supply of money, however, cause monetary instability? Before answering this question, let us revisit the definition of money. When full reserve

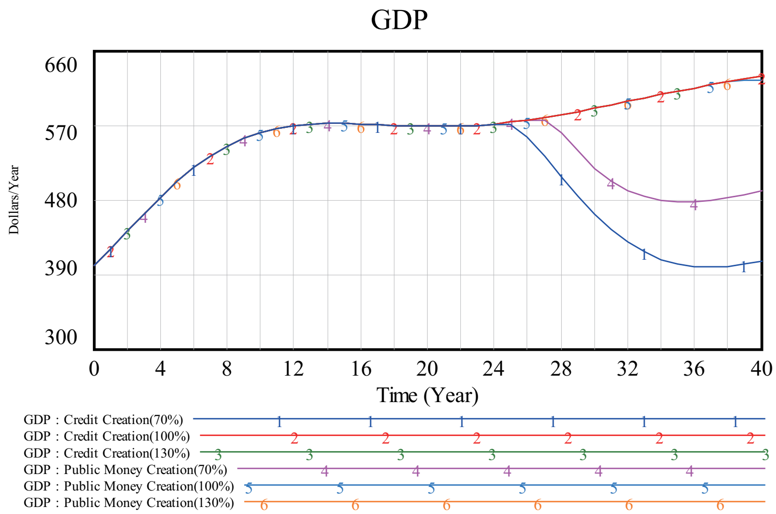

Figure 18.20: GDP under Debt vs Public Money System

system is implemented in the public money system, bank reserves become equal to deposits so that we have

$$\begin{aligned}\text{Money Stock (M1)} &= \text{Currency in Circulation} + \text{Demand Deposits}\\ &= \text{Currency in Circulation} + \text{Reserves}\\ &= \text{Base Money (M0)} \qquad (18.18)\end{aligned}$$

Accordingly, under the public money system, money stock (M1) becomes equivalent to base money (M0)[6].

With these in mind, let us examine the effect of over-supply of money on monetary stability. Left-hand diagram of Figure 18.21 shows that the equilibrium GDPs are attained by the similar amounts of money supply (M1) under debt and public money systems (lines 1 and 3). When over-supply of money (130%) is newly provided, money stock (M1) becomes larger under the debt money system (line 2) than that under the public money system (line 4). This indicates that money stock tends to be inflated under the debt money system by the same amount of newly created credit. Right-hand diagram demonstrates that inflation rates tend to become larger under the debt money system (line 2) than under the public money system (line 4) against the over-supply of money (130%). From these observations, it is concluded that monetary stability is

[6]Money stock is also defined in terms of base money as

$$\text{Money Stock (M1)} = m * \text{Base Money (M0)} \qquad (18.19)$$

where m is a money multiplier. Under a full reserve system, money multiplier becomes unitary, $m = 1$, so that no more money can be created by commercial banks than base money; that is to say, no money out of nothing is created.

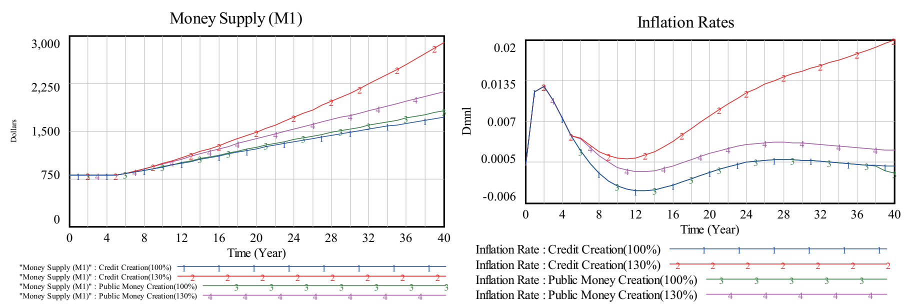

Figure 18.21: Money Stock and Inflation under Debt vs Public Money

better preserved under the public money system than under the debt money system.

Greed and Income Inequality

Under the debt money system, greed becomes a driving force to expand credit creation due to the increase in interest income of bankers. This drive is shown to worsen wage distribution simultaneously, triggering credit crunch and economic recession. In short, debt money system is demonstrated to be a system of monetary and financial instability. This can be reconfirmed here by Figure 18.22. Specifically, lines 1 and 2 in the left-hand diagram show that net interest income of bankers under a debt money system increases for a higher level of credit creation, as already shown above. Compared with these behaviors, lines 3 and 4 indicate that net interest income of bankers does not increase extremely for a higher level of public money creation under the public money system. Moreover, net interest incomes of bankers (lines 1 and 2) become all the time higher than those of bankers under a public money system (lines 3 and 4).

This may systemically discourage bankers to borrow more money from the Public Money Administration for higher interest income, compared with the case of debt money system in which they can create credits by themselves unboundedly. In other words, greed will be subdued under the public money system. This doesn't imply that the banking activities to pursue their self-interest are suppressed. On the contrary, they will become more competitive one another in a more fair financial market under the public money system.

Lines 1 and 2 in the right-hand diagram show that wage distributions get worsened under a debt money system, while lines 3 and 4 show that wage distributions do not so seriously get worsened for a higher level of public money creation under the pubic money system. In addition, they stay closer one another at a higher level compared with those under the debt money system. In the case of debt money system, worsening distribution is shown to trigger credit crunch. On the contrary, no such credit crunch will occur under the public money system, simply because money (M0=M1) created by the PMA never get crunched, and continue to stay in circulation, and be efficiently used for higher

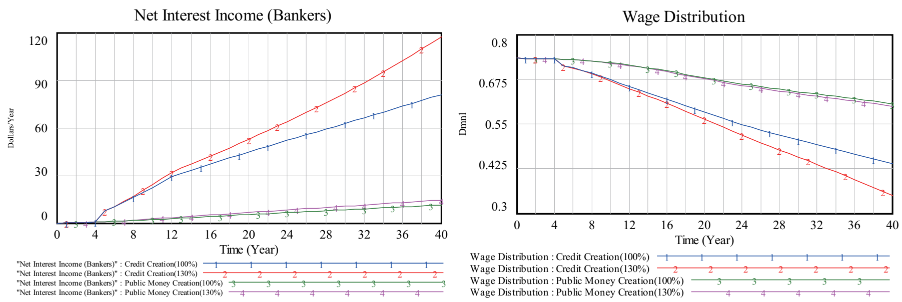

Figure 18.22: Interest Income and Wage Distribution under Debt vs Public Money

opportunities. Hence, financial stability can be more likely accomplished under the public money system. Quoting Irving Fisher's words again, "it would remove the chief cause of both booms and depressions (Fisher, 2009, p.8, 1936)".

Monetary and Financial Stability

From the behavioral analyses above, it could be concluded that monetary and financial stability can be better attained under the public money system than the debt money system. This feature of stability can be fully illustrated by the causal loop diagram of the public money system in Figure 18.23. Compared with the causal loop diagram of the debt money system in Figure 18.17, bankers'greed loop no longer exits. This implies that the reinforcing loop of credit creation (or bankers' greed loop) is gone. Moreover, the balancing loop of credit crunch (or income inequality loop) which has played a decisive role of causing "booms and depressions" fails to find its place under the public money system.

To examine these qualitative differences, comparative sensitivity tests are performed for the variable of Desired Borrowing (Banks) that is the amount of money banks want to raise to meet the loan demand from producers. Specifically, this amount is assumed to change between 20% and 180% according to random normal distribution with mean = 1 and standard deviation = 0.2:

$$20\% \leq \text{Level of Desired Borrowing(Banks)} \leq 180\% \qquad (18.20)$$

Figure 18.24 compares how inflation rates tend to occur under debt and public money systems. Under the debt money system, inflation rates approximately range between -1.1% and 3% with 95% of chance, while its range only falls, roughly speaking, between -0.1% and 0.5%, a factor of 7 smaller under the public money system! Indeed, monetary stability is shown to be most likely attained under the public money system.

Figure 18.25 compares how wage distributions tend to get worsened. Under the public money system wage distribution is maintained above 53% with 95% of chance. On the contrary, the minimum range seems to further decline to 15%

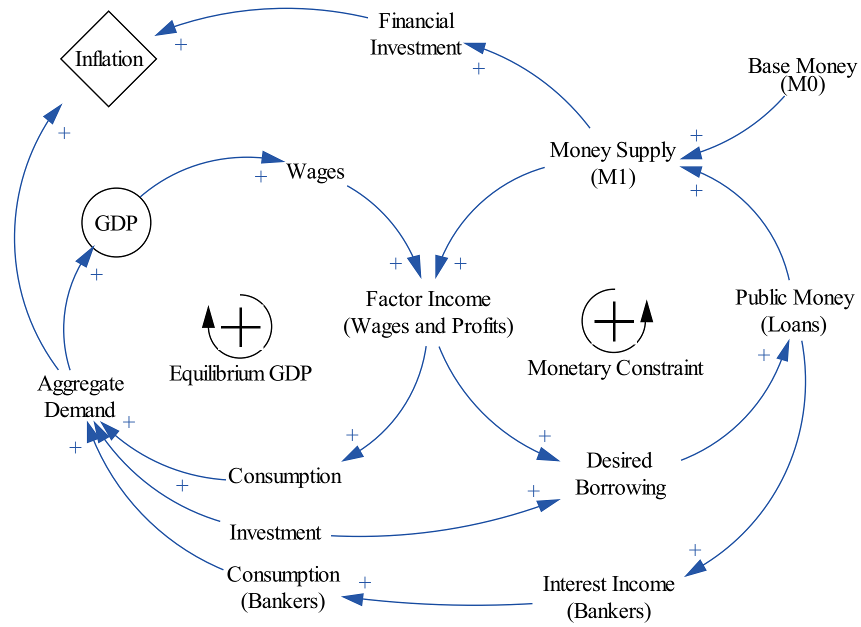

Figure 18.23: Causal Loop Diagram of Public Money System

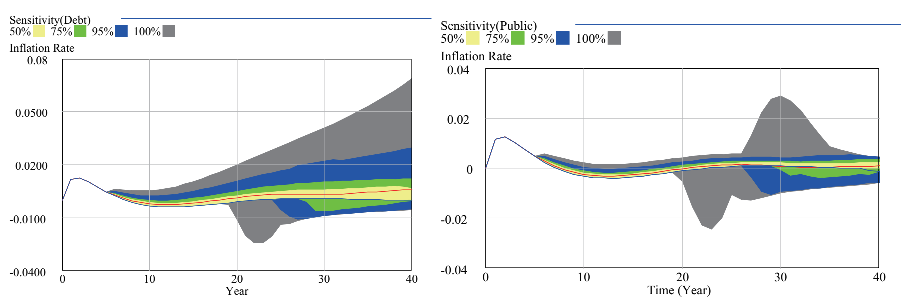

Figure 18.24: Debt-vs-Public System Sensitivity: Inflation Rates

with the same 95% of chance under the debt money system due to the existence of bankers' greed loop as discussed above.

These substantial differences of wage distribution affect the behaviors of GDP. Figure 18.26 compares how GDP are attained. With 95% of chance, GDP will remain within the range of \$460 and\$630 under the public money system, while GDP ranges from \$380 to \$630. This may be due to the financial instability under the debt money system so that producers cannot rely on the stable loans.

These comparative analyses, however, do not imply that the public money system fully attains monetary and financial stability and becomes free from "booms and depressions" as Irving Fisher correctly pointed out that "The 100%

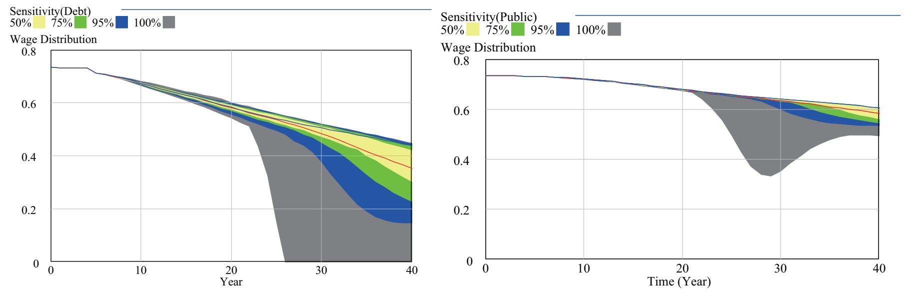

Figure 18.25: Debt-vs-Public System Sensitivity: Wage Distribution

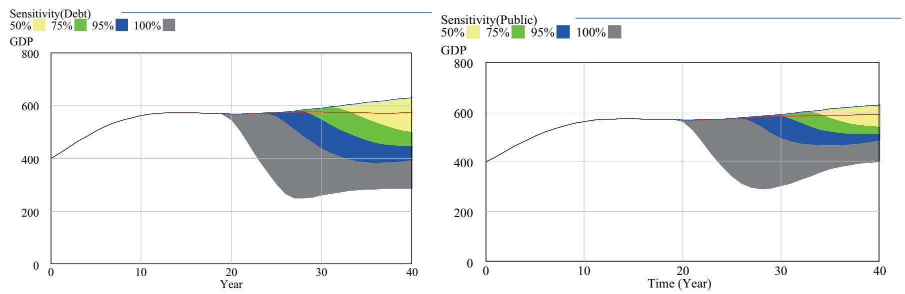

Figure 18.26: Debt-vs-Public System Sensitivity: GDP

system would be no cure-all for business fluctuations though it would help reduce them (Fisher, 1945, p.216)." Yet, as I have demonstrated in Yamaguchi (2011), monetary and financial instabilities, once triggered by inflation and recession, can be better managed by applying public money policies under the public money system than traditional Keynesian monetary policies under the current debt money system.

Conclusion

This chapter tries to comparatively explore monetary and financial stability under the current debt money system and alternative public money system (proposed by the American Monetary Act) by constructing a simplified macroeconomic model of endogenous money creation. In the debt money system we have identified a reinforcing loop of credit creation called "Bankers' Greed", and a balancing loop of credit crunch called "Income Inequality". Due to these two opposing loops built in the system, our simulation analysis found, unstable behaviors of economic growth and inflation rates are inescapably triggered. In other words, monetary and financial instability is built in the debt money system.

On the other hand, Bankers' Greed motives that increase bankers' interest income and worsen income inequality are shown to be averted under the public money system, because bankers lose their power to create credit. In addition, a relatively small income inequality that still remains does not trigger credit crunch, simply because public money never get crunched. Hence, two opposing loops that cause credit creation and crunch are shown to be gone from the public money system, subduing "boom and depressions".

From these analyses it is concluded that the current debt money system is a system of monetary and financial instability, while the public money system is a system of the true monetary and financial stability.

Chapter 19

Public Money and Sustainability

This chapter[1] searches for a better design of our economic system toward our sustainable futures. First, it briefly reviews our public money system analyzed so far in Part IV in comparison with the current debt money system in Parts II and III in terms of its system structures and behaviors. It is reconfirmed here that the public money system works better than the debt money system in terms of monetary and financial stability, government debt and equality in income distribution. Then, the MuRatopian economy that was proposed in the early 1980's as a new economic paradigm suitable for the coming information age is revisited for comparison. Based on our new monetary analysis in this book, it turns out that the economy has been built without paying attention to the monetary system. Finally, in order to create the best system design for sustainability, the public money system is incorporated with the MuRatopian economic system.

19.1 Public vs Debt Money System Structures

We have used system dynamics as a new method of analyzing macroeconomic system structures and behaviors. The main reason for using system dynamics is because the behaviors of any system are dependent on its system structures. What's the best design of our economic system, then, which attains sustainable behaviors? This chapter tries to answer this question.

So far we have examined two macroeconomic systems: debt money and public money systems. The superiority of one system over another will depends

[1]The writing of this chapter was suggested by Joe Bongiovanni, a devoted monetary reformer, at the 39th Annual Conference of the Eastern Economic Association at the Sheraon Hotel & Towers, New York, May 9, 2013. The author is very thankful to his thoughtful feedback comments. Sections 1 and 2 of this chapter were presented at the 9th Annual AMI Monetary Reform Conf. in Chicago, Sept. 19-22, 2013.

on the economic criteria we choose. Before discussing specific criteria, let us first briefly compare the system structures of these two monetary systems.

The public money system has been proposed by the American Monetary Act as discussed in chapter 13 in order to restore the original proposals of the Chicago Plan and 100% Money Plan, both proclaimed in 1930's to avoid such economic disasters as the Great Depression in the future. The proposal of the American Monetary Act consists of the following three features.

- Governmental control over the issue of money
- Abolishment of credit creation with full (100%) reserve ratio
- Constant flow of money into circulation to sustain economic growth and welfare

The macroeconomic system that meets these three conditions is called the *public money* system in this book, while the current monetary system is called the *debt money* system. Table 19.1 compares system structures of these two systems. Let us examine their structural differences one by one.

	Public Money System	**Debt Money System**
Money Issuer Its Owner	Public Money Administration Government (Public)	Central Bank Private Banks and Financiers
Bank Reserves	100% Reserve	Fractional Reserve
Money Stock	Public Money directly put into Circulation as Economy grows Private Banking unaffected	Base Money: by Central Bank Deposits: by Bank Loans Money in Circulation: by Public
Interest	Interest-free	Interest-bearing Debt
Economic Policies	Public Money Policy (Public Money Financing)	Monetary Policy: Central Bank Fiscal Policy: Government

Table 19.1: Public Money vs Debt Money System Structures

Money Issuer and its Owner

Under the current debt money system, money consists of coins and paper notes. Coins are minted by the government, and bank notes are printed by the central bank. Money of this kind is called base money or monetary base M_0, and its large amount is being used as currency (or money) in circulation as analyzed in chapter 5. Since coins only constitute a small amount of the base money, its large amount is bank notes printed for central issuance.

Who owns our central banks, then? To the best of our knowledge, for instance, the Federal Reserve System in the US is owned by its member Banks, which are in turn owned by private bankers and financiers. That is to say, it is 100% privately owned. The Bank of Japan is 55% owned by the Government and the remaining 45% are privately owned. The Bank of England was nationalized in 1946.

Under the public money system, money such as paper notes and coins are solely created by the Public Money Administration. As such, the money issuer is completely owned by the government, or the public.

Bank Reserves

Under the debt money system, commercial banks are obliged to hold only a fraction of deposits as bank reserves with the central bank, and the remaining amount are loaned out as if the deposited money belongs to the banks. This money management is called a fractional reserve banking system, which empowers the banks to create credits (as deposits) out of nothing. Again, this process is fully analyzed in chapter 5.

Under the public money system, commercial banks are fully obliged to keep the whole amount of deposits with the Public Money Administration. Thus, they begin to perform a traditional role of bankers as financial intermediaries. On this full reserve basis, demand depositors can no longer expect interest payment from their deposits. Instead they can be requested to pay service fees for their transaction services offered by the banks. These service charges become an important source of income for banks.

The 100% reserve principle only applies to the demand deposits or checking account deposits. This means banks can still make loans out of time deposits, which is the amount of money consumers need not use for their daily transactions, and therefore save as investment. Consumer and business saving thus becomes the main source of loanable fund for banks to make investment at risk. In other words, time deposits are the money invested to the banks by savers for higher returns in the future. Accordingly, the banks own the customers' deposits, and the principal amount may no longer be fully guaranteed.

Money Stock

Money stock is herein defined as the sum of currency in circulation plus demand deposits, which is usually denoted as M_1. When time deposits are added to M_1, it is denoted as M_2. Currency in circulation, which consists of banks notes and coins, is the amount of cash used by the public (mainly consumers) for their daily transactions. Coins constitute only a negligible portion of 0.9%, while bank notes constitute about 16% of M_1 in Japan. On the other hand, demand deposits are created by bank loans to households as consumer loans and mortgages, and to businesses and producers as commercial loans. These bank loans constitute more than 80% of M_1 in Japan.

The money stock under the public money system is provided by the Public Money Administration as public money which consists of government notes and coins, and publicly-issued digital money. Since banks no longer create credit, demand deposits are only made by depositors out of their public money. Accordingly, we have $M_0 = M_1$ all the time.

Interest

Under the debt money system, base money M_0 is only created when someone comes to the central bank to borrow; that is, when government indirectly borrow from the central bank through the central bank's open market operations at interest, or when commercial banks borrow from the central bank at a discount rate. Among these borrowers, only the government can be the persistent borrower to keep increasing money stock for the growing economy. Accordingly, taxpayers are forced to pay interest constantly to the central bank and commercial banks who own government securities.

Demand deposits of M_1 are created when commercial banks make loans at interest. Accordingly, borrowers such as households and producers are incessantly forced to pay interest to bankers. To pay interest as well as principals, borrowers are forced to earn extra money, thus forcing increased economic growth, with further destruction of the environment, or simply by borrowing more, thus accumulating even further debts.

Under the public money system, public money is constantly made available without debt issuance, because public money assumes a true public utility function for supporting both commercial transactions and public welfare.

Economic Policies

Under the debt money system, the economic policies available to restore market equilibrium out of recession, inflation and unemployment are traditional Keynesian monetary and fiscal policies. Monetary policy by the central bank primarily targets price stability by further targeting changes in interest rates such as the federal funds rate (on which all other interest rates are based in the US) of overnight interbank liquidity transactions through the quantity of base money M_0. This is done with a hope that interest rate changes encourages or discourages investment, which in turn affects the economy's aggregate demand. Fiscal policy by the government directly changes government expenditures through spending or taxing practices so that the aggregate demand will also be affected.

After the bursting of the financial and real estate bubbles in the 1990's in Japan, followed by the worldwide financial crises in 2008, these traditional Keynesian policies mentioned above entirely failed to restore the economy's equilibrium. As a result, the central banks have been forced to introduce non-orthodox policies such as paying interest on reserves and so-called quantitative easing (QE), through which bank reserves, a portion of M_0, are directly increased by the central banks' direct purchases of governmental and commercial securities, primarily held by commercial banks.

Under the proposed public money system, needed restorative economic policy initiatives becomes very simple and direct, such that the quantity of public money in circulation can directly manage to attain price stability, through the spending and taxing practices of the government. Additionally, public money in circulation needs be constantly increased as the economy continues to grow. Since public money enters economic circulation interest-free, the government and Public Money Administration need no longer utilize traditional policy tools such as interest rate and discount rate. Determination of all interest rates is entirely left to the market activities of the private sector.

19.2 Public vs Debt Money System Behaviors

System structures of the public and debt money thus framed above produce very different system behaviors. Let us examine how they behave dissimilarly and divergently.

	Public Money System	**Debt Money System**
Monetary Stability	Stable Money Stock Stable Price Level	Bubbles and Credit Crunches Inflation & Deflation
Financial Stability	No Bank-runs	Business Cycles (Booms and Depressions)
Employment	Full Employment	Involuntary Unemployment
Government Debt	No Government Debt	Built-in Debt Accumulation → Recession & Unemployment
Inequality	Income Inequality between Workers and Capitalists	Income Inequality between Financiers and Non-financiers
Sustainability	Sustainability is Possible	Accumulated Debt → Forced Growth → Environmental Destruction

Table 19.2: Public Money vs Debt Money System Behaviors

Monetary Stability

Money stock under the debt money system is very unstable. First, currency in circulation is determined by the capricious minds of consumers and producers for the liquidity demand against risky financial assets. Second, demand deposits are at the mercy of bankers' attitudes to make loans and create credits. Under such circumstances, the central bank can only control the base money of M_0, but has no direct power to control money stock M_1. For instance,let us consider money multiplier equation discussed in chapter 5 here again by assuming the equality of high-powered money and monetary base such that

$$\text{Money Stock } (M_1) = \frac{\alpha + 1}{\alpha + \beta} * M_0 \tag{19.1}$$

where α is the currency ratio and β is the reserve ratio.

When the currency ratio and required reserve ratio are set to be $(\alpha, \beta) = (0.2,\ 0.1)$, and $M_0 = 100$, money multiplier becomes $(0.2 + 1)/(0.2 + 0.1) = 4$, and money stock becomes 400. Now suppose the currency ratio increases to 1 from 0.2 due to the recession and consumers and producers begin to prefer liquidity at hand. Money multiplier drops to $(1 + 1)/(1 + 0.1) = 1.82$, and money stock contracts to 182, far less than half of the original amount!. This is an example of the so-called *credit crunch*. To be worse, this sudden contraction of money stock or credit crunch is out of the central bank's control.

Under such circumstances, the only policy left to the central bank is to increase base money M_0 desperately through quantitative easing (QE) policy.

For instance, suppose that the base money is doubled such that $M_0 = 200$ as being hastily maneuvered by the Fed and Bank of England after the financial crises in 2008. In our numerical example here, this QE policy only sustain money stock at the level of 364 (= 1.82 x 200), which is alas still below the original level of 400. Thus, our economy is not stimulated and the central bank's QE policy failed.

This monetary instability inherent to the debt money system was already pointed out by the economists who proposed the Chicago Plan in 1930s as already discussed in chapter 14:

> (9) Fractional reserves give our thousands of commercial banks the power to increase or decrease the volume of our circulating medium by increasing or decreasing bank loans and investments. ... As each bank exercises this power independently without any centralized control, the resulting changes in the volume of the circulating medium are largely haphazard. This situation is a most important factor in booms and depressions (Fisher et al., 1939, p.19).

This monetary instability under the debt money system becomes the root cause of bubbles and credit crunches. In Parts II and III we have repeatedly observed how our economy gets affected by the amount of currency in circulation. Specifically, many business cycles are convincingly shown by our macroeconomic simulations, based on the accounting system dynamics method, to be triggered by the instability of money

On the contrary, the proposed public money system does not cause such monetary instability, and the amount of public money becomes stable, because under the 100% reserve we have $\beta = 1$ and money multiplier becomes unitary so that we have money stock $= M_0$. That is, we have

$$\text{Money Stock } (M_1) = \frac{\alpha + 1}{\alpha + \beta} * M_0 = M_0. \tag{19.2}$$

Money stock M_1 can no longer be affected by the capricious behaviors of consumers and producers to demand for liquidity. As a result, the money stock in our example becomes the same as the monetary base of 400, which is put into circulation by the Public Money Administration. Accordingly, the amount of the money stock never gets contracted and continues to be used for economic transactions. In this way, the public money system becomes free from inflation and deflation, and the general price level will be easily stabilized because currency in circulation is completely under the control of the Public Money Administration.

Financial Stability

Under the debt money system, our economy is not free from business cycles such as "booms and depressions" as discussed above, which surely causes financial instability at the microeconomic level, affecting bank activities. Moreover, we identified the existence of the reinforcing loop of credit creation called "Bankers'

Greed" and the balancing loop of credit cruch called "Income Inequality" in chapter 14. Due to these opposing loops, unstable behaviors of economic growth and inflation are inescapably triggered. Combined with monetary instability, the economic system of debt money is constantly struck by bubbles and busts, and results in financial system instability.

The public money systems eliminates such financial system instability, and as a result, no bank-runs can occur. Moreove, the above two opposing loops that causes credit creation and crunch are thoroughly eliminated, subduing "booms and depressions".

Employment

Under the debt money system, our economy is repeatedly hit by booms and busts, or recessions and under such circumstances involuntary unemployment becomes inevitable. Under the pubic money system, booms and busts can be avoided, which implies that the involuntary unemployment can be constantly mitigated. Moreover, public money policies discussed in chapter 13 can directly reduce the unemployment level. To attain full employment, however, the economy needs be further transformed to the MuRatopian economy as discussed below.

Government Debt

Our analyses in Parts II and III have revealed that the debt accumulation of government is build into the debt money system simply because government is destined to keep borrowing to provide sufficient money supply for the growing economy. This built-in effect is already pointed out by the economists of the Chicago Plan:

> (17a) Under the present fractional reserve system, the only way to provide the nation with circulating medium for its growing needs is to add continually to our Government's huge bonded debt (Fisher et al., 1939, pp.39,40).

Sooner or later, government is forced to reduce the accumulated debt to avoid its total default. The debt reduction can only be done by spending less (which is called an austerity economic policy) or levying increased taxation. Whichever policy is taken it triggers economic recessions as demonstrated in chapter 13, which in turn reduces tax revenues, accumulating government debts furthermore. This paradox is revealed by the causal loop analysis as "Liquidation Traps of Debt" in chapter 13. In other words, our debt money system becomes dead-end, or "debt-end" as commented by the Congressman Denith Kuchinich to my US Congressional Briefing presentation on July 26, 2011.

No such debt accumulation can occur under the public money system due to the public money financing as pointed out by the Chicago Plan economists:

> (17a) Under the 100% reserve system the needed increase in the circulation medium can be accomplished without increasing the interest bearing debt of the Government (Fisher et al., 1939, pp.39,40).

They called this effect “a by-product of the 100% reserve system”.

Inequality
In order to attain an understanding of the root cause of inequality in income distribution, it’s essential to classify sources of income into interest, profits (such as dividends and rents) and wages. Those who receive interest income are called financiers and those who receive profits are called shareholders(capitalists) and employers here. Meanwhile, workers receive wages. Figure 19.1 illustrates these three groups. Inequality in income distribution within these groups is not brought into our discussions.

Under the debt money system, equity distributions between banks and non-financial sectors tend to broaden as demonstrated in chapter 6, due to the flow of interest income toward bankers. In fact, since the financial crises in 2008, rent-seeking inequality between financiers and non-financiers has been rapidly widening as pointed out by the Nobel laureate economist Joseph Stiglitz recently in Stiglitz (2012).

This type of income inequality is completely eliminated under the pubic money system. However, the inequality between workers and and shareholders (and employers) still remains. To remove this type of inequality, the economy needs to be further transformed to the MuRatopian economy as proposed in Yamaguchi Yamaguchi (1988).

Sustainability
Under the debt money system, producers and government are obliged to borrow at interest, and their debts continue to accumulate exponentially due to the compound interest rate. As shown in chapter 1, a doubling time of debts is a constant period of about 70 divided by the interest rate. For instance, it is about 14 years if the interest rate is 5%, and our debts continues to double every 14 years!

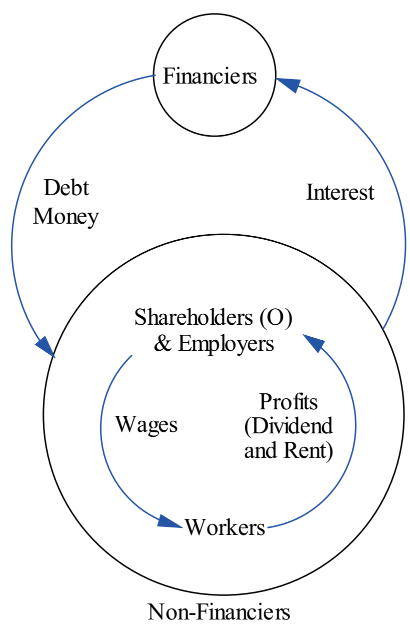

Figure 19.1: Inequality under Debt Money System

Under such circumstances, borrowers are forced to pay an increasing amount of interest as well as principals. If borrowers are producers, they are forced to produce more, leading eventually to a complete depletion of non-renewable resources and destruction of environment. If government is a borrower, it is forced to borrow more to pay interest by issuing government securities at a faster speed, potentially leading to an eventual default of the government. In short, the debt money system is, in principle, unsustainable. Yet, much of the literature on sustainability fail to point out the inter-relationship between the debt money system and both economic and environmental non-sustainability.

On the other hand, the public money system can effectively remove or reduce the above causes of non-sustainability. Interest rates may be reduced partly due to the elimination of interest income to financiers, and partly due to increased competition among banks for making loans, reducing the burden of interest payments by producers and consumers. Government can now become debt-free, and needs not be constrained by the tax-and debt budgetary spending, because it can put the desired amount of public money into circulation for the welfare of the public, such as preservation of the environment.

We have now completed the comparative analyses of system behaviors between public money and debt money. If we are rational, more than 99% of non-financiers will prefer the public money system. Moreover, as pointed out in chapter 12, our current debt money system is suffering from a systemic failure such as the impasses of defaults, financial meltdown and hyper-inflation, and only the alternative system of public money can cure our systemic sufferings of debt money. In this sense, the public money system could be a savior to that less-than-1% of us who are financiers as well.

Can we say that the public money system is an ideal economic system, then? Not necessarily. For instance, inequality between shareholders and workers, and therefrom unemployment, still remains. Hence, our off-road journey to search for a better design of economic system cannot finish here.

19.3 The MuRatopian Economy Revisited

My search for a better societal economic system design has started, as briefly discussed in Preface, during my UC Berkeley days in the early 1980's. I was striving to envision a future economy as a new social design in place of the capitalist economy that was getting effete under the coming transition toward the so-called information society. The future economy of my new social design was called the MuRatopian economy in Yamaguchi Yamaguchi (1988).

Consequently, it would be worth here, I believe, revisiting this design for a new economy with regard to the public money system that is posed as an alternative to the debt money system of today's capitalist economy. The main features of the MuRatopian economy can be summarized from the excerpts below.

> However, the re-unification of (1) man and nature, (2) workers and capitalists, or employees and employers, (3) savers and investors, and (4) producers and consumers will not be realized simultaneously. Moreover, no necessity exists to do so. ....

> In any case, we see a new social design in the vision of the re-unification of (1), (2) and (3), and only a partial re-unification of (4). That is, human beings will begin to consider themselves as an inseparable part of nature and will try to live in harmony with nature according to nature's rhythm - the re-unification of (1). Both capitalist and working classes being abolished, all members of the society (and of the globe) will begin to "possess" (and share) their own properties and production units. As a result, the labor market as an exploitation market will eventually be eliminated together with the concept of wage and profit as a category, and Marx unfairness caused by the existence of a working class will also be gone forever - a re-unification of (2). Then, all members of the society (and of the globe) will begin to self-manage their own production units and will make decisions such as savings, investments and consumption by themselves in a co-operative and democratic manner. Let us call such people co-operatively working consumer-workers, in short, co-workers. Accordingly, co-workers will begin to self-manage their own funds (that is, basically they save to invest), and at least the financial capital markets which we observe in a capitalist economy will be gone forever - the re-unification of (3).
>
> We will call such a re-unified future economy *MuRatopian economy* where co-workers work co-operatively in communes, communities, local organizations, and global organizations in harmony with nature. The Japanese word *mura* literally means village. I have envisioned the future society in the spirit and practice of a Japanese village where village people live in a self-sufficient community, help each other co-operatively at the busiest time of harvest, and respect nature's way. The one character word *mura* may also be considered as consisting of two different characters: *Mu* and *Ra*. *Mu* implies "nothingness" or "emptiness" - the most fundamental concept of Zen Buddhism, and *Ra* means "being naked" or "having no possession". Accordingly, I have associated the implications of *Mu* (nothingness) and *Ra* (no possession) with *mura* (village), because I have further envisioned the mind of future society in the combination of these concepts. *-topia* is from the Greek *topos*, which means place. Hence, the word *MuRatopia* is now coined to describe our new social design.
>
> This is our future economy. (Yamaguchi, 1988, Pages 169-171)

In this design of the MuRatopian economy as a re-unification process of workers and capitalists, etc, the concept of *possession* plays an important role. What is the *possession*, then, that distinguish from the ownership in a capitalist economy? It consists of the three principles as the following excerpt indicates.

> A capitalist economy as a social institution presupposes a modern concept of private ownership. The essence of this concept is the exclusive right to dispose of a private property by its legal owner.

In other words, no other person can exercise such a right of disposal without the permission of the legal owner, even if the other person is actually in a state of possessing the property. Hence this concept allows the exclusive and absolute right of property disposal by its private owner *beyond time and space*. A capitalist economy would not function without this legal system of private ownership. For instance, an exchange of a commodity in a market presupposes its owner, because the exchange is nothing but a transfer of private ownership.

In comparison, possession refers to the exclusive right to dispose of a private property by those who are in a state of its actual management, and thus who are sharing it. In other words, possession is a private ownership which is *confined by time and space*. Private ownership only *here* and *now* - this is possession. In this sense if possession is imposed in private ownership, no legal owners of the property can exercise their right of disposal from outside or from past into future. For instance, no shareholders or capitalists can claim a dividend payment of the company they legally own unless they are indeed engaged in the actual production and management activities themselves. This is the essence of possession. And *possession* is the only institutional and legal requirement of property management which is imposed in the MuRatopian economy. To be more specific, for the case of production units this institutional requirement of possession consists of the following three principles:

Principle (1) Automatic possession of the production units at the time of participation.
When co-workers join MuRatopian organizations, they automatically become possessors of the production units and join self-management in a democratic manner. Moreover, no co-workers are dismissed against their will.

Principle (2) Automatic dispossession of the production units at the time of departure.
When co-workers leave MuRatopian organizations, they automatically dispossess the production units and lose control over self-management from outside. Dispossession also occurs at their death, and no one can inherit their possessions unless that person himself or herself joins the organizations.

Principle (3) Possession of the production units as a niche.
Everyone in the MuRatopian economy is entitled to freely create or seek the fittest niche or habitat in the form of possession, but no one is allowed to derive economic benefits from possession itself. In other words, sales of the production units are, under this principle, nothing but a change in the form of possession without payment, and thus the production units as physical stocks are continuously self-managed, accumulated or

> destroyed by new possessors. Hence, co-workers can only derive economic benefits from production and exchange of net flows (= consumption and investment goods), but not from exchange of stocks or the production units themselves (Yamaguchi, 1988, Pages 171-173).

The system structures of the MuRatopian economy has now become understandable to the reader. It is the economy that strives to re-unify the separated entities under the capitalist market economy. As an example, Figure 19.2 illustrates the state of the re-unified workers and capitalists and employers as co-workers.

With these system structures how does the MuRatopian economy work? In early 1980's no computer simulation method was available to me. Using my mental simulation power, I have claimed in (Yamaguchi, 1988, Chapter 10) that the following 14 issues could be solvable as system behaviors.

Economic Issues Solvable

(1) Unemployment
(2) Exploitation and Unfair Income Distribution
(3) Recession, Inflation and Stagflation
(4) Financial Tycoons
(5) Inhumane Incentives to Technological Innovation

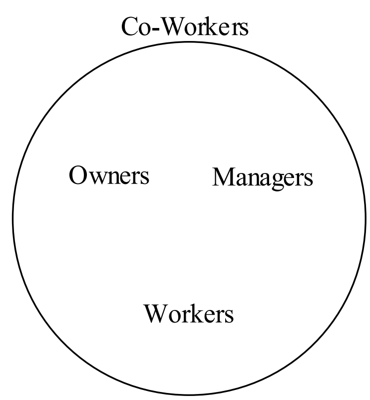

Figure 19.2: Re-unified Co-Workers

Social Issues Solvable

(6) Concentration and Congestion
(7) Violence and Crime
(8) Discrimination based on Hereditary Factors
such as Race, Color, Sex, Age, etc.
(9) Discrimination based on Posterior Factors
such as Religion, Belief, Culture, Language, etc.
(10) Alienation and Bureaucracy

Environmental Issues Solvable

(11) Destruction of The Eco-System

International Issues Solvable

(12) Poverty in The Developing Countries
(13) International Conflicts based on National Interest and Different Ideologies
(14) Nuclear Threats and Arms Race

Why Didn't the MuRatopian Economy Emerge?

The MuRatopian economy was proposed in the book Yamaguchi (1988) published in 1988 with an expectation that its new social design would gradually emerge as an alternative to the effete capitalist economy and socialist economy that collapsed in 1991. Since then more than a quarter of century has passed, yet 14 economic, social, environmental and international issues that have been claimed to be solvable still remain, and seem to be getting worse.

What went wrong with our new social design, then? It seems to have overlooked the following two features that have prevented its emergence.

(1) Developing countries such as BRICS (Brazil, Russia, India, China and South Africa) have started to catch up with the developed countries since 1990s. Being challenged by them with severe competitions, capitalist economies are forced to re-organize themselves by proclaiming a new capitalist vision of globalization. Under such a fanatic trend, an alternative vision of localization that the MuRatopian economy of re-unification has tried to establish has been pulled back behind the world economic stage in due course. Only recently, the financial and debt crises began to reveal a systematic failure of globalization under the current debt money system, making the alternative way ready to be implemented eventually.

(2) The debt money system has been so dominant as to command capitalist and former socialist economies as well as developing countries, so that we have been so far indoctrinated as if it is the only universal monetary system. Accordingly, monetary and financial instabilities, unemployment, and inflation/deflation have been caused by another reasons than the debt money system per se. Conversely, our macroeconomic simulations have revealed that these monetary and economic instabilities have been mainly caused by the current debt money system. In other words, the MuRatopian economy cannot solve these problems under the current debt money system. When the MuRatopian economy was designed in early 1980s, it had entirely overlooked the root cause of our socio-economic and environmental disasters.

19.4 The Green Village(MuRatopia) Economy

We cannot live without a hope; a hope that is supported by a promised dream. In mainstream economics, our promised dream has been the creation of a perfect market economy in which equilibrium is self-restored and resources are efficiently allocated as a state of Pareto optimum. If our economy is in disequilibrium such as recessions and unemployment, it is because of the existence of some imperfect conditions that retard the market equilibrium. Hence the removal of these imperfections becomes the first priority of macroeconomic public policies such as deregulation. In chapter 2, the price adjustment mechanism is shown to be not self-restoring and occasionally become chaotic; a counter-example against the mainstream equilibrium theory. In addition, chapter 7 has shown that even under the perfect price flexibility, the full capacity and/or aggregate demand equilibria failed to be attained.

This mainstream dream, though broken theoretically, has been further extended in the 1990s to include a promise of a perfect financial market under the so-called Efficient Market Hypothesis. Unfortunately, this promised dream was also completely broken by the recent financial crises in 2008 (which may be called the Second Great Depression). In this way the promised dream of the mainstream economics has become a completely broken promise on which we can no longer entrust our hope.

Under such circumstances, can an alternative hope be envisaged; an alternative hope that is robustly supported by a promised dream in which we can live a decent life that is sustainable and free from recessions and debt burdens. The economy that could support this dream has to be the one that meets criteria such as monetary and fiscal stability, full employment, debt-free government, equality in income distribution and sustainability.

The public money system discussed above is not enough in the sense that inequality still remains among shareholders and workers, leading to socio-economic instability. The MuRatopian economy is also not enough in the sense that it lacks public money system. Accordingly, the ideal system design of the future economy that provides such a promised dream must be, we believe, the integrated economy of these two; that is, the MuRatopian economic system of public money. Let us call it the "Green Village(MuRatopia) Economy". The word *green* symbolizes the *sustainability* supported by the public money system. We decided to keep "MuRatopia" as a newly re-defined place of village which is built on the public money system.

Hence, we conclude that the green village(MuRatopia) economy is the best design we can shape in order to meet the societal criteria that must include monetary and financial stability, full employment, debt-free government, equality in income distribution, and sustainability. Let us now discuss in detail some features of the system structures of this new economy.

System Structures of the Economy

The system structures of the new economy consists of the these two features: a public money system and possession.

Public Money System

The green village(MuRatopia) economy runs under the public money system. The system is well presented so far, and no explanation is needed concerning its functions.

Possession for the Re-Unifications of Markets

The current capitalist market economy is built on the legal concept of ownership, which has resulted in the creation of labor market between workers and capitalists, financial capital market between savers and investors, and commodity market between producers and consumers. During the 1990s, these market

Green Village(MuRatopia) Economy: Structures	
Economy	• Public Money System (against Debt Money System) • Possession (against Ownership)
Re-Unifications of Markets	→ Co-workers (Workers = Capitalists) → Self-investor (Savers = Investors) → Prosumers (Producers = Consumers) (⇒ Localization against Globalization)
Economic Policies	Public Money Financing Policy (against Keynesian Fiscal & Monetary Policies)
Green Village(MuRatopia) Economy: Behaviors	
Monetary & Financial Stability	Stable Money Stock Stable Price Level (No Inflation and Deflation) No Bank-run (against Deposits Insurance)
Employment	Co-Worker Employment (against Lay-offs)
Debt-free	Debt-free Government Less Private Debt
Equality	Income Equality (against Financiers' Interest Income, and Shareholders' Profits (Rent and Dividends))
Sustainability	Man and Nature re-unified

Table 19.3: The Green Village(MuRatopia) Economic System of Public Money

economies have been pushed to the extreme corner of globalization, or into the global market economy.

On the other hand, the green village(MuRatopia) economy is established on the concept of possession, as already introduced in the previous section, which is expected eventually to re-unify the separations generated under the market economies. First, workers are re-unified with capitalists and employers to become co-workers. Worker cooperatives and Employee Stock Ownership Plans (ESOPs) would be the examples of organizations operated and managed by co-workers. Second, savers are re-unified with investors to become self-investors so as to make their own investment out of their own savings. Third, producers are re-unified with consumers to produce custom-design products for consumers. They are called prosumers in Toffler (1981). Production of food and fresh vegetables that are locally produced and locally consumed could be a typical example.

In this way, the green village(MuRatopia) economy consisting of two features tends to create system structures in favor of *localization* or local markets vis-à-vis globalization or global markets under the current capitalist market economy.

Economic Policies

Economic policies of the green village(MuRatopia) economy will be the same as those under the public money system; that is, public money financing policy, and no further explanation of its functions may be needed.

System Behaviors of the Economy

Let us now investigate how the green village(MuRatopia) economy behaves or works in terms of monetary and financial stability, employment, government debt, equality in income distribution and sustainability.

Monetary and Financial Stability
The green village(Muratopia) economy runs under the public money system. Accordingly, monetary and financial stability will be attained in a similar fashion as discussed above under the macroeconomic systems of public money.

Employment
Workers are no longer forced to be laid off under the green village(MuRatopia) economy, because they now possess their own workplaces and become like family members of the organizations they belong to. Mondragon Cooperative in the Basque Country of northern Spain is one such example. Its workers kept their job security during the financial crises of 2008 and the following economic mess in Spain. This implies that employment of the green village(MuRatopia) economy is very resilient against economic instabilities.

Debt
Public money system of the green village(MuRatopia) economy enables the Public Money Administration to provide the interest-free money stock necessary for welfare and public policies at interest-free, so that government needs are no longer constrained by traditional tax and debt funding of its budget. Accordingly, government finance becomes completely debt-free, and fears of any public default is thoroughly eradicated.

Equality in Income Distribution
We have discerned two layers of inequality in income distribution caused by the present debt-based, rent-seeking institutional framework; that is, inequality between financiers and non-financiers, and inequality between capitalists and workers. The former inequality is eradicated by the introduction of the public money system, because money can no longer be created by the issuance of interest-bearing debt, so that financiers lose their main source of interest income. The latter inequality is removed by the introduction of the framework of possession, because dividends are no longer distributed among capitalists or shareholders, and instead are shared among co-workers.

The elimination of these two layers of inequality, however, does not imply that inequality among the co-workers are completely eliminated. On the contrary, there may still remain several levels of inequality in income distribution due to the different economic performances and productivities of co-workers. This type of inequality can not be completely removed, but can now be rationally justified as a result of economic activities, providing better incentives for hard work through economic efficiencies among co-workers.

Sustainability
Forced payments of interest accruing from heavy burdens of debt are thoroughly eliminated under the green village(MuRatopia) economy. This elimination, in turn, removes the driving forces of unnecessary economic growth to meet the payment of interest. Removal of forced economic growth, in turn, prevent the destruction of environment.

Moreover, co-workers of the green village(MuRatopia) economy become more conscious of their own workplaces as their own living spaces, which eventually energize their local economic activities and communities. Consequently, co-workers also become more conscious of the need of their future generations. This inclination goes wholly well with the following definition of sustainability which has been repeatedly quoted [2]:

> Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. (on Environment and Development, 1987, p.43).

Regrettably, many discussions on sustainability have been carried out in the literature without considering a role of both public money and its alternative economic system. In this sense, these arguments on sustainability are incomplete and short-sighted. Under such circumstances, it is posed that sustainability can be thoroughly attained under the green village(MuRatopia) economy.

Indicators for the Green Village(MuRatopia) Economy

GDP has been, as being used in this book, the most dominant indicator of macroeconomic behaviors. However, it has been heavily criticized recently, because it fails to measure human activities outside of markets such as household labors, and environmental destructions. To supplement or replace it, new economic indicators such as GNH (Gross National Happiness) and HDI (Human Development Index) have been suggested. Yet, those indicators are only applicable to measure system behaviors.

According to the discipline of system dynamics, system behaviors are already specified when system structure is designed. Consequently, the improvement of system behaviors can only be fulfilled with its structural changes. Otherwise, any effort to enhance system behaviors will turn out to be ineffective and unsuccessful in meeting its goals. In this sense, it becomes more essential to measure how system structures are being changed in order to affect system behaviors. With these ideas in mind, we would like to recommend the following two indicators to measure the structural changes from the current capitalist economic system of debt money to the green village(MuRatopia) economy.

[2]More detailed definition of sustainability is provided by the author on a basis of physical, social and ecological reproducibility; Chapter 3: Modeling long-term sustainability in (Quaddus and Siddique, 2004, pp. 29 - 59).

The first indicator is to measure how much of the current central bank is owned by the government and how high is the reserve ratio.

$$\text{Public Money Index} = \frac{\text{Public Ownership (\%)} + \text{Reserve Ratio (\%)}}{200\ (\%)} \tag{19.3}$$

For instance, in the case of the Public Money Administration, its public money index becomes (100% + 100%)/200% = 1. Compared with this, the Bank of England is 100% government-owned, yet its reserve ratio is said to be zero, then its public money index becomes (100% + 0%)/200% = 0.5. In the case of the Bank of Japan which is 55% owned by the government and its reserve ratio is around 1%, its public money index becomes (55% + 1%)/200% = 0.28. On the other hand, the Federal Reserve System (the American central bank) is said to be 100% privately owned, and its reserve ratio is around 10%. Then its public money index becomes (0% + 10%)/200% = 0.05.

The second indicator is to measure how co-workers are emerging.

$$\text{Co-worker Index} = \frac{\text{Co-Workers}}{\text{Total Labor Force}} \tag{19.4}$$

The increasing index of co-worker index implies that more workers are securing jobs at their workplaces, and living a better life, by reducing inequality. This index could be used as a representative of re-unification. Of course, the other indexes of re-unification could be introduced such as those of self-investment and prosumer. Further investigation of these indexes are left to the reader.

Imagine how fruitful our economy would be whenever people begin to compare these indexes instead of GDP as the appropriate measure of their economic performances. Imagine how joyful our life would be when it is being led by the hope that is supported by a promised dream of the green village(MuRatopia) economy.

Conclusion

This chapter first compared the system structures and behaviors between the public money system and debt money system, and argued that more than 99% would support the public money system in the face of the present systemic failure of the current debt money system. Yet, the public money system is not ideal, primarily due to the remaining inequality in income distribution among capitalists and workers in a capitalist economic system.

Then, our search for a better socio-economic system design continued by revisiting the MuRatopian economy that was presented in early 1980s as an alternative to the effete capitalist and socialist economies in light of the trend toward a coming information society. The economy, however, failed to emerge because of the neglect of the two features; emergence of the developing countries such as BRICS which have challenged the developed capitalist economies, and the role of public money.

Finally, these MuRatopian and public money economic systems are integrated to produce the best system design in terms of monetary and fiscal stability, full employment, debt-free government finance, equality in income distribution and sustainability the economy and environment. The economy is called the "Green Village(Muratopia) economy", and its system structures and behaviors are explored. Then two indicators for the economy are introduced, such as the public money index and co-worker index, to measure our promised dream toward the Green Village(MuRatopia) economy.

Chapter 20

A Transition to the Public Money System

This chapter [1] proposes a transition process from the debt money system to the public money system, which has been left unanalyzed in the previous chapter, though vehemently called for by those who wish to implement the alternative economic system. For this purpose, a simple macroeconomic model based on the accounting system dynamics is constructed. It turns out that this model can briefly handle main features of the debt money system, in 8 steps, that cause "booms and depressions", debt accumulation and failures of recent quantitative easing financial policy. It then offers a transition process to the public money system in 6 steps. These analyses are carried out by focusing on the behaviors of monetary base and money supply as their rationales are already laid out in our discussions so far.

20.1 Volatile Behaviors of Debt Money System

The current macroeconomic system, dubbed as the *debt money* system, is shown to be currently facing systemic failures of possible financial meltdown, defaults and hyper-inflation; that is, it is analyzed as a dead-end system in Chapter 13. As its alternative system that can overcome these systemic failures, the *public money* system is proposed as having the following three features:

- Governmental control over the issue of money
- Abolishment of credit creation with full (100%) reserve ratio
- Constant flow of money into circulation to sustain economic growth and welfare

[1] This chapter is based on the paper: From Debt Money to Public Money System – Modeling A Transition Process Simplified – in "Proceedings of the 32nd International Conference of the System Dynamics Society", Delft, Netherlands, July 20 - 24, 2014.

In Chapter 16, the comparative analyses of these two system structures and their behaviors are succinctly summarized in Tables 19.1 and 19.2. Yet, a transition process from the debt money system to the public money system is left unanalyzed, though vehemently called for by those who wish to implement the public money system. The purpose of this last chapter is, therefore, to present a transition process to the public money system of macroeconomy in order to get out of the current dead-end system.

In order to present a transition process, we have constructed a simple macroeconomic model, consisting of four sectors such as central bank, commercial banks, producers and government, on the basis of the analytical method of accounting system dynamics developed by the author [Companion Model: Transition.vpmx]. Consumer sector is not included here as inessential for the purpose of this chapter.

The model thus constructed turned out to be able to describe main features of the debt money system such as "booms and depressions", debt accumulation and failures of quantitative easing policy, etc., by focusing on the behaviors of monetary base and money supply. Accordingly, our analysis in this section starts with the presentation of these features of the debt money system in the following 8 steps.

(0) Initial Base Money into Circulation (t=0): M=180

Let us assume that our simple macroeconomy sets out with the initial base money of $180 billions[2] which is initially put into circulation. Figure 20.1 illustrates how the initial base money is booked both as the asset of the balance sheet of the central bank and as its liability of currency outstanding.

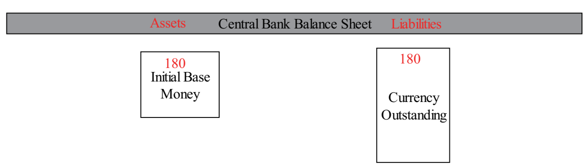

Figure 20.1: (0) Initial Base Money

This amount of initial base money could be assumed to be printed as convertible bank notes (or historically gold certificates) against gold asset held by the central bank (or goldsmiths), or printed as legal tender in exchange for the government securities as collateral asset. This initial base money is the only tangible real money we can touch and feel physically.

In this chapter money supply is simply defined as the sum of currency outstanding and deposits (including credits) under the debt money system, while it is defined as the sum of currency outstanding and demand deposits under the public money system, as displayed in Figure 20.2.

Money supply at this stage is thus depicted as M=180 in the subsection title.

[2]The unit of billions of dollar will be hereafter omitted.

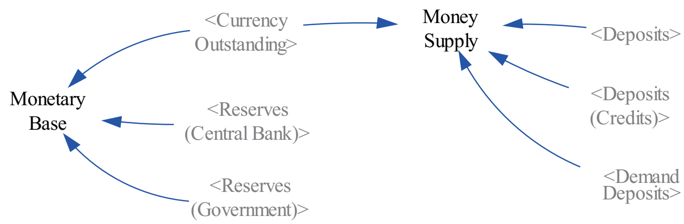

Figure 20.2: Definition of Money Supply

(1) Fractional Reserve Banking System (t=5): M=680

Now suppose a portion of initial base money, say \$100, is deposited as savings out of the currency in circulation, and commercial banks hold this full amount as their reserves with the central bank. Under the fractional reserve banking system, this amount allows the banks to create credits out of nothing according to the following formula:

$$\text{Credits (Banks)} = \frac{1-\beta}{\beta}\,\text{Reserves (Banks)} \tag{20.1}$$

where β is a required reserve ratio. It is the same as equation (5.23) in Chapter 5. The required reserve ratio in our economy here is assumed to be 10%. Then, the maximum amount of credits to be created by the banks becomes \$900 (= (1 - 0.1)/0.1 x \$100).

Under the debt money system, however, credits can be created only when someone in the economy come to borrow. Let us assume that producers come to borrow \$500 for their real investment at t = 5. Then, their deposit account is instantaneously opened up with \$500 being typed in by the computer keyboard of the banks, instead of \$500 being handed over directly to the producers in cash. In this way, \$500 is newly created, through the fractional reserve banking system, out of nothing to provide the investment activities. As a result, money supply in the economy now increases to M=680. Figures 20.4 and 20.12 illustrate these transaction processes. Numerical numbers (in reds, green etc,) that appear in the stock boxes of the Figures hereafter represent the amount of monetary values that exist at each step.

Due to this process of credit creation, the fractional reserve banking system has been historically justified by its proponents as an efficient system of providing enough funds to meet the need for growing economy. They pose that without the fractional reserve banking system our economy could not have developed as it has been today.

(2) Making Bubbles (t=10): M=1,080

Yet, this fractional banking system has been the root cause of "booms and depressions" as Irving Fisher and five co-authors of the "Program for Monetary Reform (1939)" claimed in its section 9:

> (9) Fractional reserves give our thousands of commercial banks the power to increase or decrease the volume of our circulating medium by increasing or decreasing bank loans and investments. The banks thus exercise what has always, and justly, been considered a prerogative of sovereign power. As each bank exercises this power independently without any centralized control, the resulting changes in the volume of the circulating medium are largely haphazard. This situation is a most important factor in booms and depressions (Fisher et al., 1939, p.19).

Under the fractional reserve banking system, bubbles could be easily created by making inessential (unproductive) loans to the financial and real estates sectors who are eager to borrow money whenever favorable loan conditions such as low interest rates are offered. Such aggressive loans have been beneficial to the banks as well for further streams of their interest incomes.

In our economy, the maximum loanable credits are $900, out of which $500 is already loaned to the producers for real investment. Let us now assume that the additional loans of $400 are made for financial investment such as stocks and real estates at t = 10. Figures 20.5 and 20.12 show how values of financial assets bubble to $400. Deposits of the banks increase to the maximum loanable amount of credits of $900, out of which banks can derive maximum amount of interest incomes. Money supply at this step increases to M=1,080.

(3) Bubbles Burst and Bank-runs (t=14): M=990

Bubbles always pop! As a result, financial assets of producers ($400) become valueless at t= 14, and their net assets suffer from the deficits of -$400, yet their accumulated debts remain as high as $900.

The immediate consequence of the burst of bubbles may be the bank-runs by depositors. In our economy, depositors are assumed to withdraw $10, and accordingly bank deposits are constrained to shrink by $90 (=(1 - 0.1)/0.1 x $10), and money supply to $990 from $1,080. Figures 20.6 and 20.12 show how financial assets collapse and bank-runs occur.

Irving Fisher observed this shrinkage of money supply as follows:

> The boom and depression since 1926 are largely epitomized by these three figures (in billions of dollars) – 26, 27, 20 – for the three years 1926, 1929, 1933.
>
> The changes in quantity were chiefly in the deposits. The three figures for the check-book money were, as stated, 22, 23, 15; those for the pocket-book money were 4, 4, 5. An essential part of this depression has been the shrinkage from the 23 to the 15 billions in check-book money, that is, the wiping out of 8 billions of dollars of the nation's chief circulating medium which we all need as a common highway for business.
>
> The shrinkage of 8 billions in the nation's check-book money reflects the increase of 1 billion (i.e. from 4 to 5) in pocket-book money. The

> public withdrew this billion of cash from the banks and the banks, to provide it, had to destroy the 8 billions of credit.
>
> This loss, or destruction, of 8 billions of check-book money has been *realized by few and seldom mentioned* (Italics are emphasized by the author). (Fisher, 1945, pp. 5,6)

Check-book money here is the same as demand deposits, and pocket-money implies currency outstanding (and in circulation). Thus, in a similar fashion, $90 in bank deposits is "destroyed" by the bank-runs of $10, which re-entered into the currency outstanding in our economy. Indeed, the fractional reserve banking system has become the root cause of booms and depressions.

Whenever bank-runs are triggered, banks as credit lenders are forced to withdraw deposits, causing credit crunch. This type of credit crunch is depicted as the loop of Lenders Credit Crunch in Figure 20.3. Depression of this type, however, has been avoided thanks to the introduction of deposit insurance by the governments in 1930s after the Great Depression.

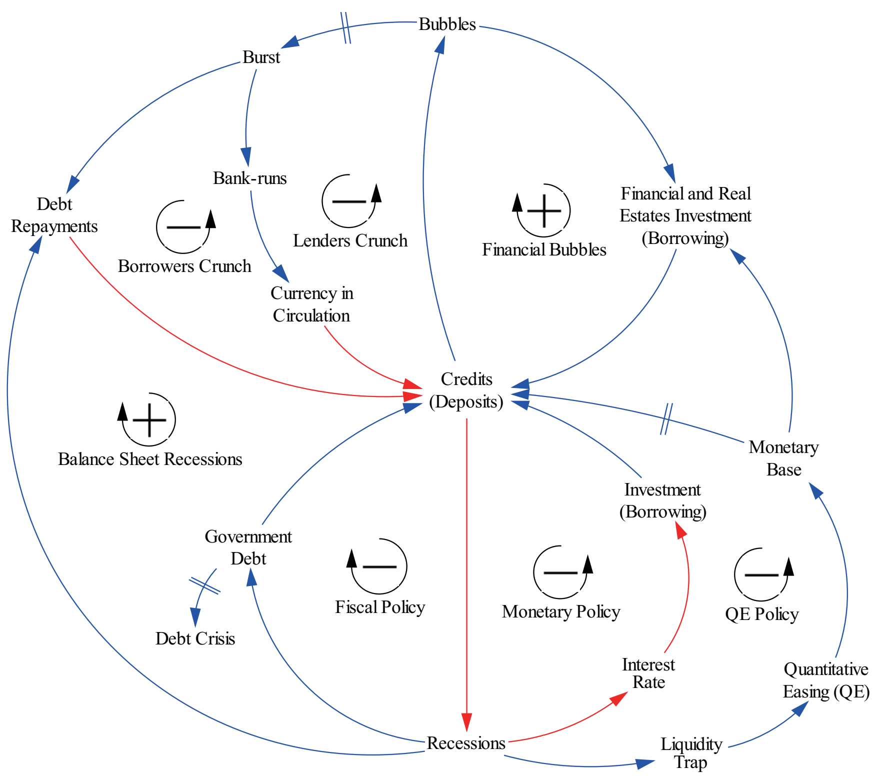

Figure 20.3: Bubbles and Recessions under the Debt Money System

(4) Credit Crunch (t=17): M=790

On the other hand, another type of depressions caused by the shrinkage of money supply or credit crunch has been observed recently by Richard Koo Koo (2009). He called this type of credit crunch "Balance Sheet Recessions." This type of credit crunch is depicted as the loop of Borrowers Credit Crunch in Figure 20.3. Whenever bubbles burst, negative net assets in the balance sheet become obstacles to the producers who want to continue their business activities. Accordingly, they are forced to repay their debt at all cost to restore their sound balance sheet. For instance, they may be forced to reimburse their debt partially, we assume, by feeding in \$200 out of their operating revenues at t = 17. This reimbursement reduces their net assets to -\$200 (= -\$400 + \$200), and their debt decreases to \$700 from \$ 900.

This repayment simultaneously reduces their bank deposits by \$200, and bank assets of loans to \$610. As a result, money supply of the economy reduces to \$790 from \$990; that is, M=790, and credit crunch of \$200 is triggered as illustrated by Figures 20.7 and 20.12.

Reduction of debt by producers is a favorable management to restore healthy state of the balance sheet at the microeconomic level, yet it causes credit crunch at the macroeconomic level collectively, which plummets GDP and triggers depressions and unemployment. In other words, debt money system of fractional reserve banking constitutes to be the root cause of "booms and depressions" since the Great Depression in 1929.

(5) Issuing Government Sequrities (t=20): M=1,190

In the wake of economic depressions caused by credit crunches, government is forced to bail out financially troubled producers by newly issuing securities; that is to say, it is forced to borrow from the banks. This is illustrated as the loop of Fiscal Policy in Figure 20.3. In our economy here we assume that the government issues securities of \$400 at t = 20. As a result, loan assets of the banks increases by \$400 and their deposits increase to \$1,010, as illustrated by Figures 20.8 and 20.12.

Under the debt money system, money supply only increases whenever someone comes to borrow from banks. This time the government comes to borrow, instead of the financially troubled producers. In this way, money supply has temporarily increased to, say, M=1,190.

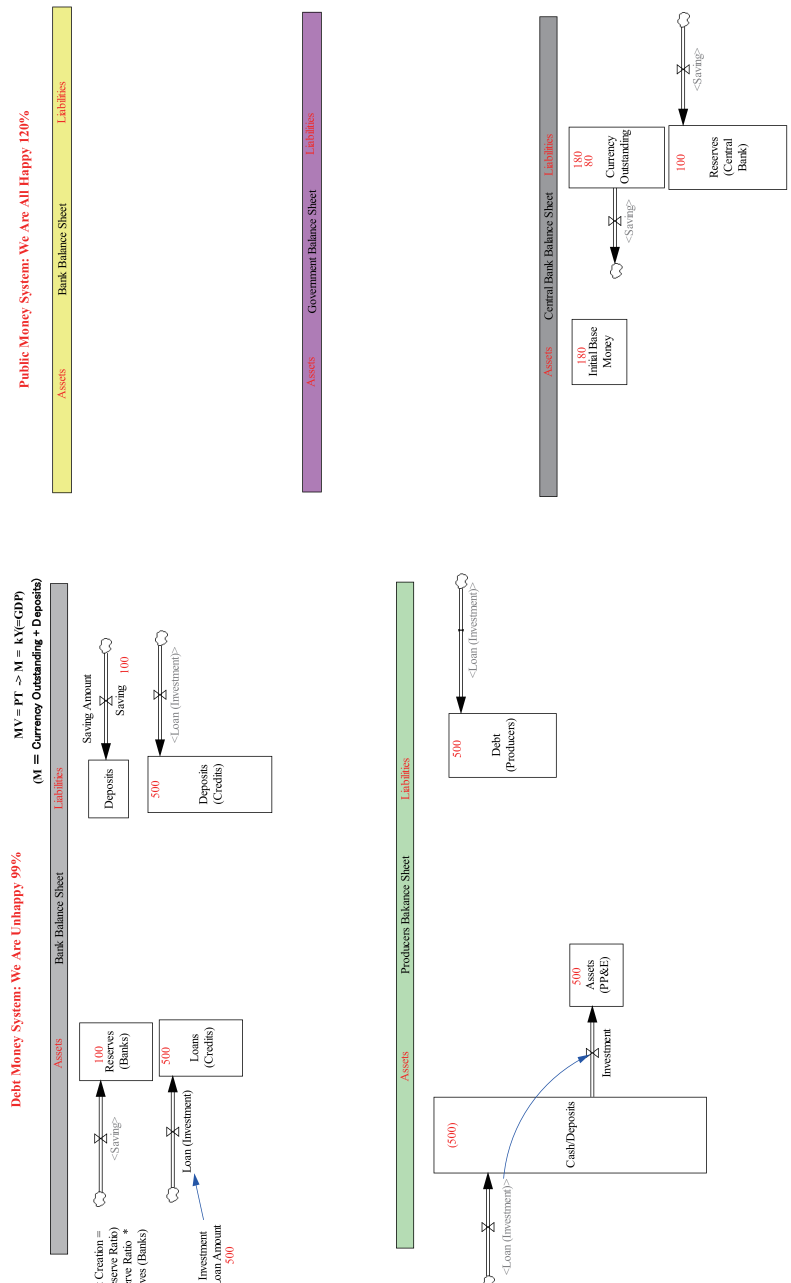

Figure 20.4: (1) Fractional Reserve Banking System

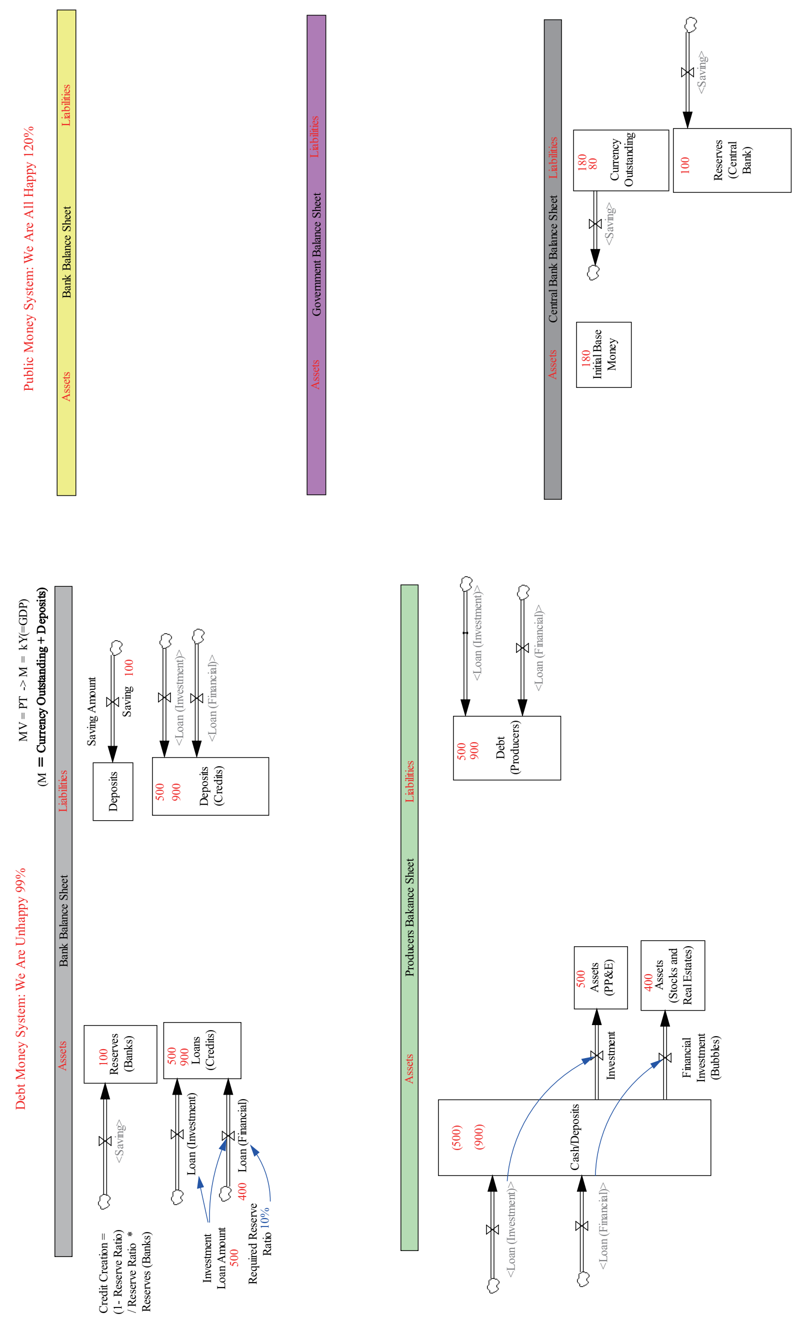

Figure 20.5: (2) Making Bubbles

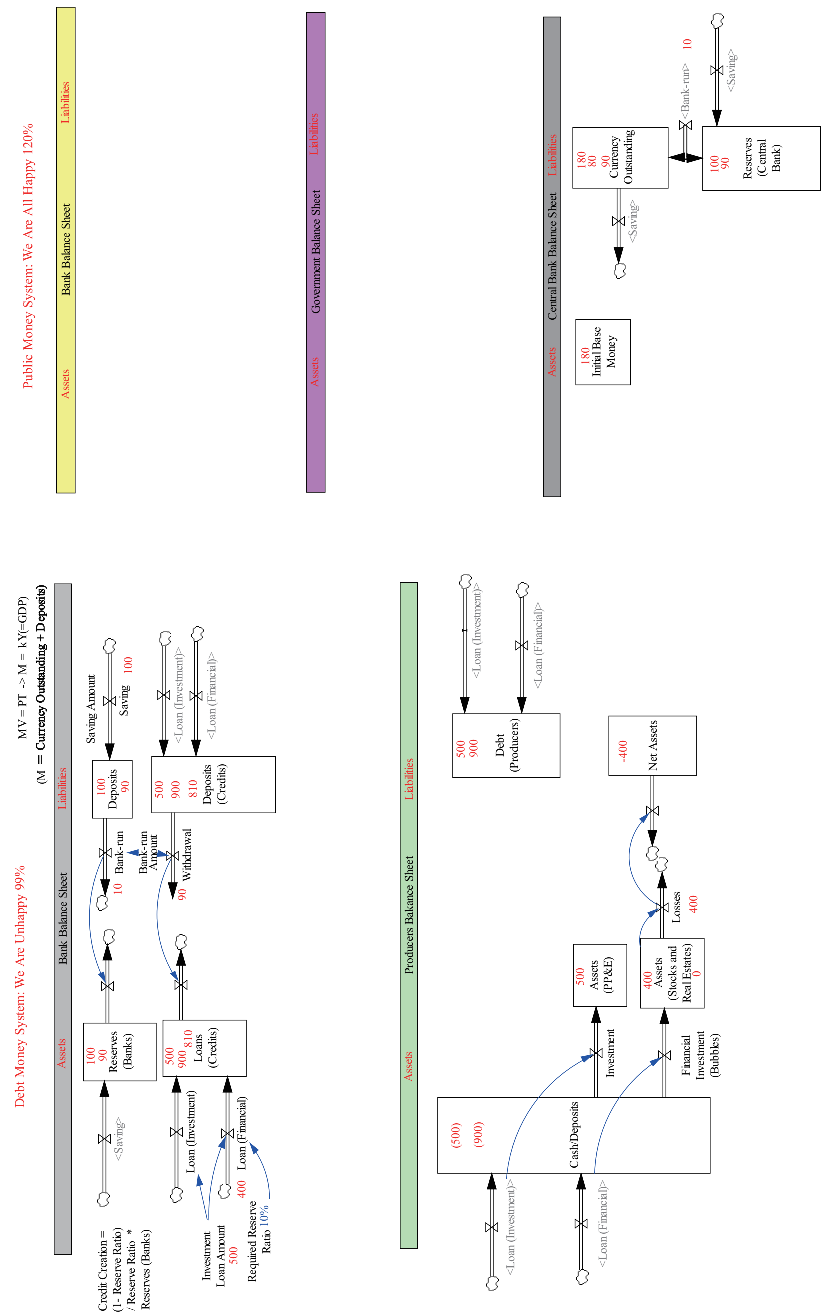

Figure 20.6: (3) Bubble Burst and Bank-runs

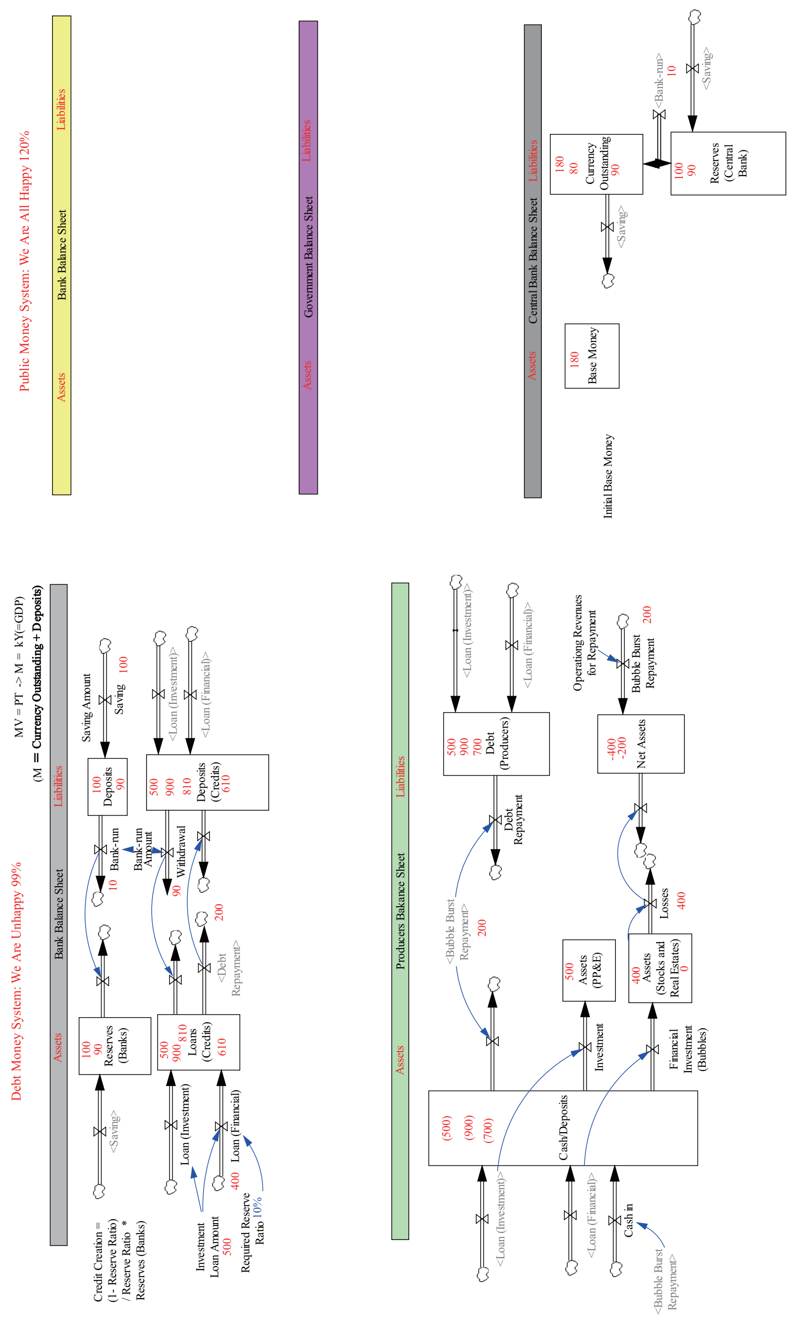

Figure 20.7: (4) Credit Crunch → Depressions

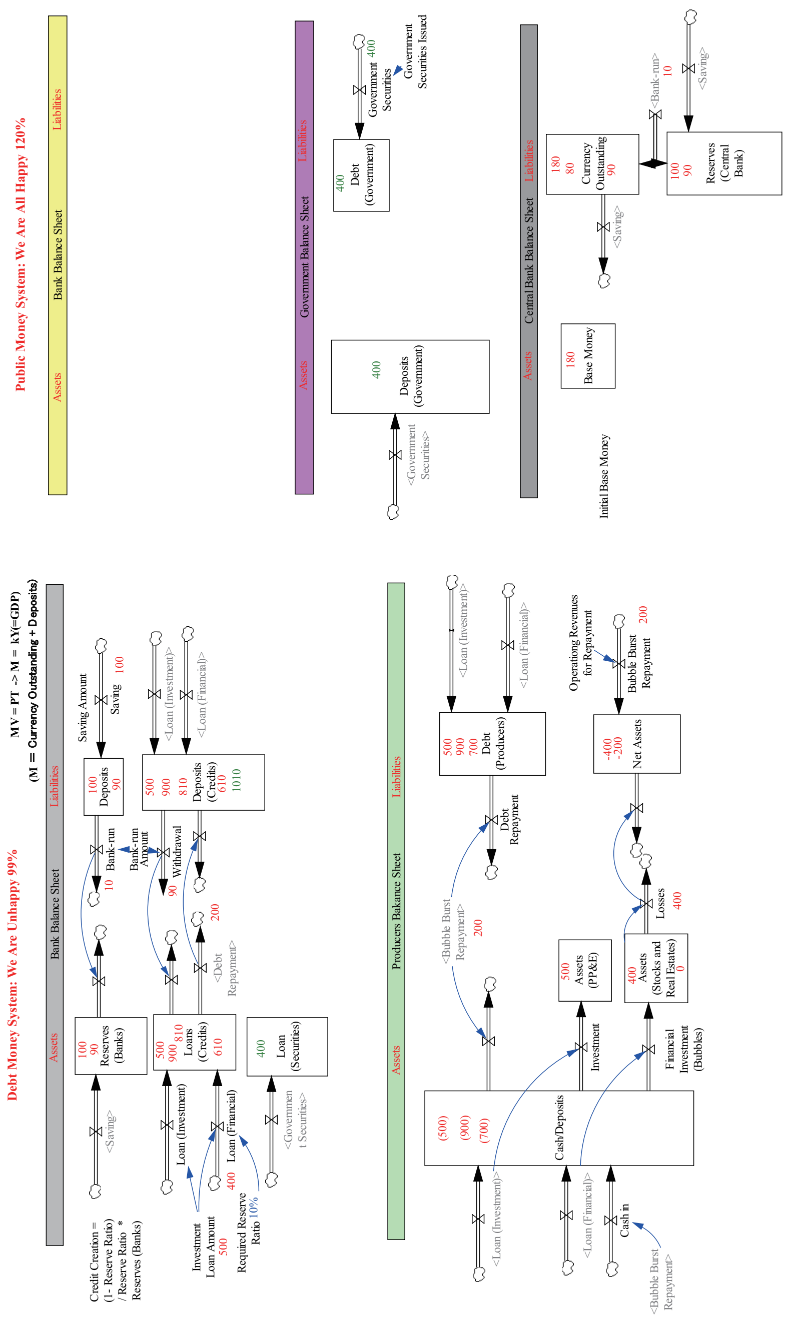

Figure 20.8: (5) Issuing Securities → Restore Money Supply

(6) Bailout → Debt Accumulation (t=22): M=790

The government is now forced to spend this newly-raised fund to bail out the financially troubled private sectors. Assume that producers receive the amount of \$400 as bailouts and use it to reimburse their debt at t = 22. Accordingly, their net assets now recover to \$200(=-\$200 + \$400) and their debt reduces to \$300.

This reimbursement simultaneously reduces the deposits of banks to the previous level of \$610, and money supply shrinks to the level before the issuance of securities by the government; that is, M=790, only leaving the government debt of \$400! Figures 20.9 and 20.12 show these behaviors.

Since money supply remains at the same level in spite of the huge amount of government debt expenditures, economy fails to be reactivated. This is exactly what happened to the Japanese economy between 1990 and 2010, causing long-term depressions of the so-called "Lost Two Decades". On the other hand, government debt continued to accumulate. This debt accumulation is exactly what has been happening among many OECD countries, specifically after the collapse of Lehman Brothers in 2008.

The accumulation of government debt under the fractional resereve banking system was warned as early as 1930s by the Irving Fisher, etc, as the following statement of section 17 demonstrates:

> (17a) Under the present fractional reserve system, the only way to provide the nation with circulating medium for its growing needs is to add continually to our Government's huge bonded debt (Fisher et al., 1939, pp.39,40).

(7) Collapse of Securities → Defaults

Accumulated debts of the government eventually cause difficulties of further borrowing by the government, which forces to raise interest rates, which sooner or later leads to the collapses of security prices, triggering bank insolvencies.

Simultaneously, these chaotic situations of possible financial meltdown make it difficult for the government to repay its accumulated debt, which means defaults of the government eventually. Figure 20.10 illustrates the case of bank insolvencies due to the deficit of net assets of banks (illustrated as a shaded stock). The reader may revisit the causal loop analysis of these situations in Figure 12.2 in Chapter 12.

(8) Financial Quantitative Easing (QE) (t=25): M=790

In this way, after the financial crises of Lehman shock in 2008, which we have called "the Second Great Depression", traditional fiscal and monetary policies of Keynesian economics have totally failed to function. The prolonged economic depression of the lost two decases in Japan is called the "Balance Sheet Recessions" by Richard Koo Koo (2009), as already pointed out in the step 4 above.

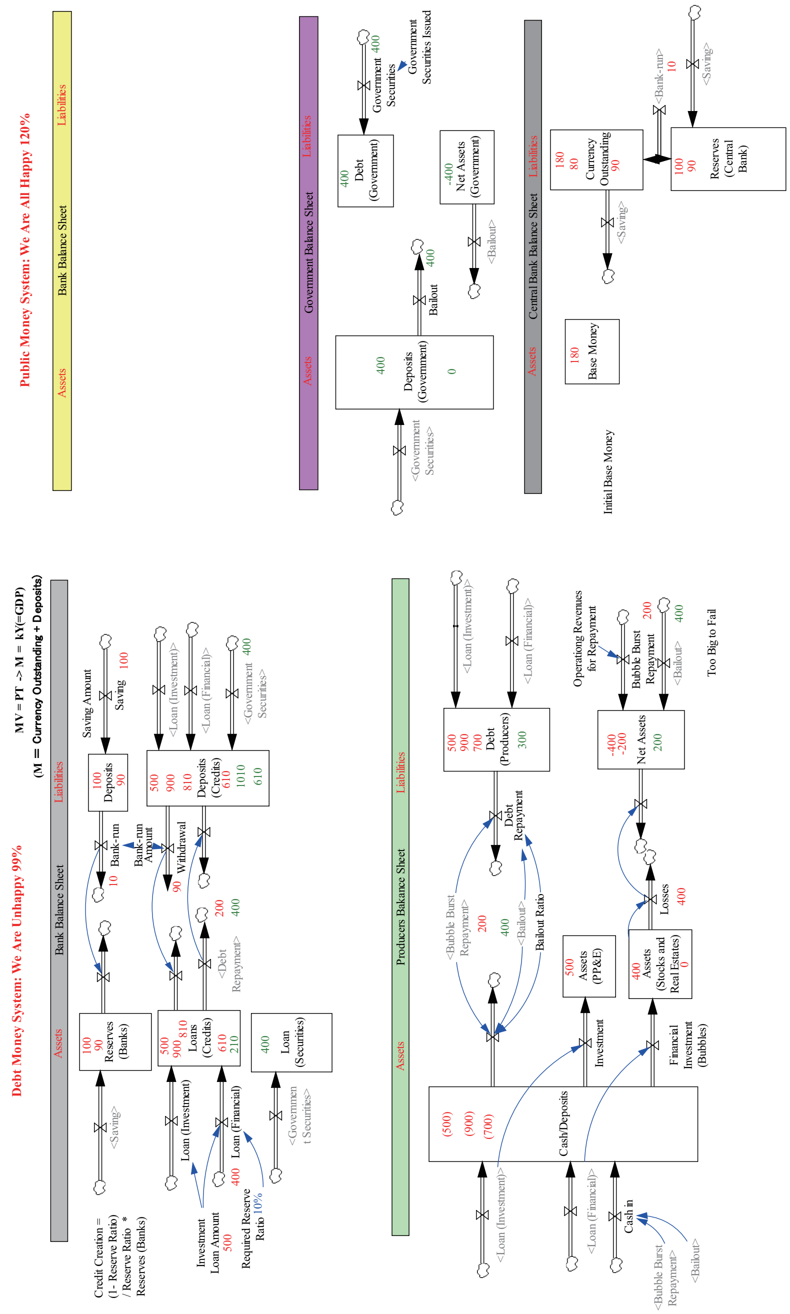

Figure 20.9: (6) Bailout → Accumulated Debt

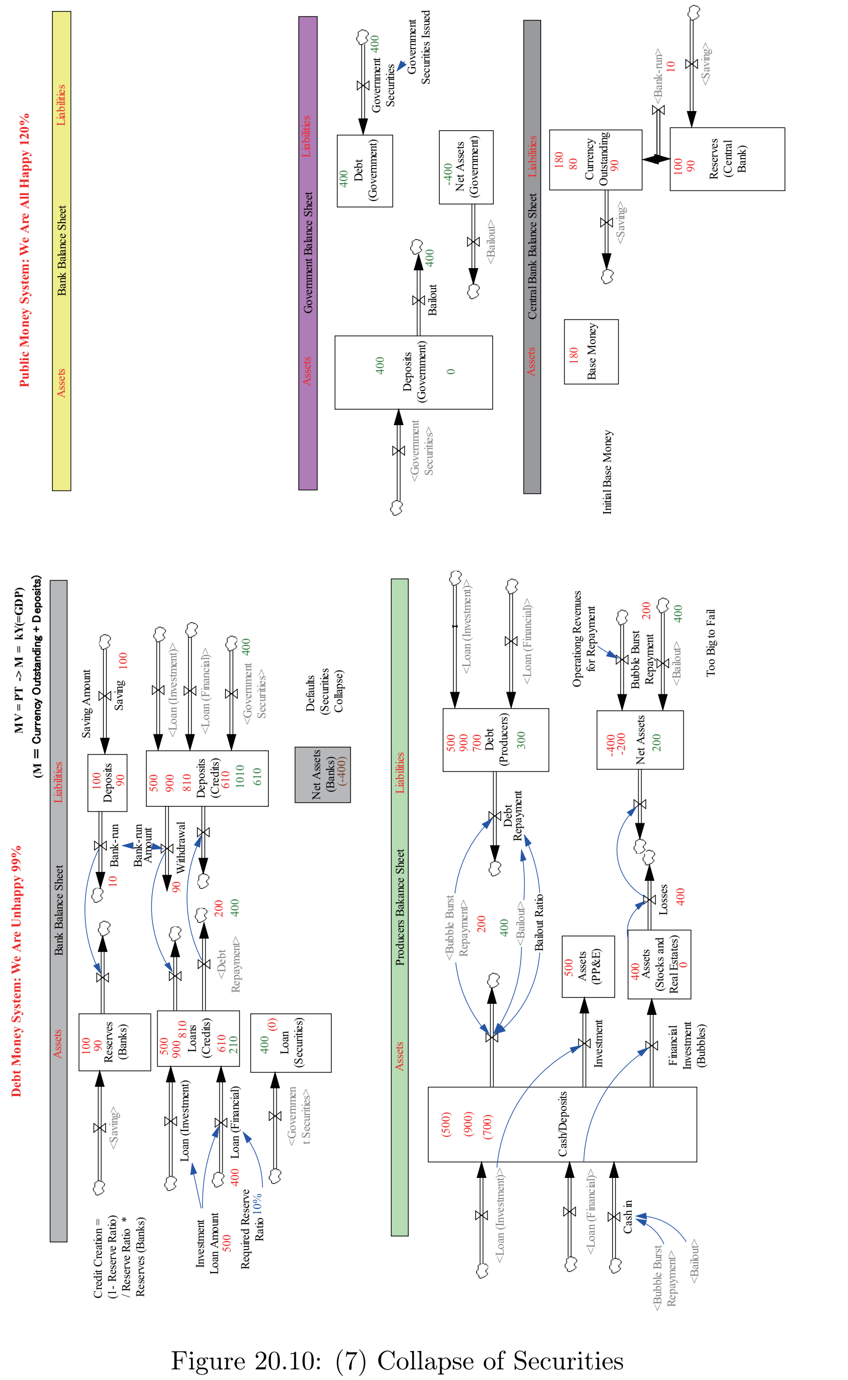

Figure 20.10: (7) Collapse of Securities

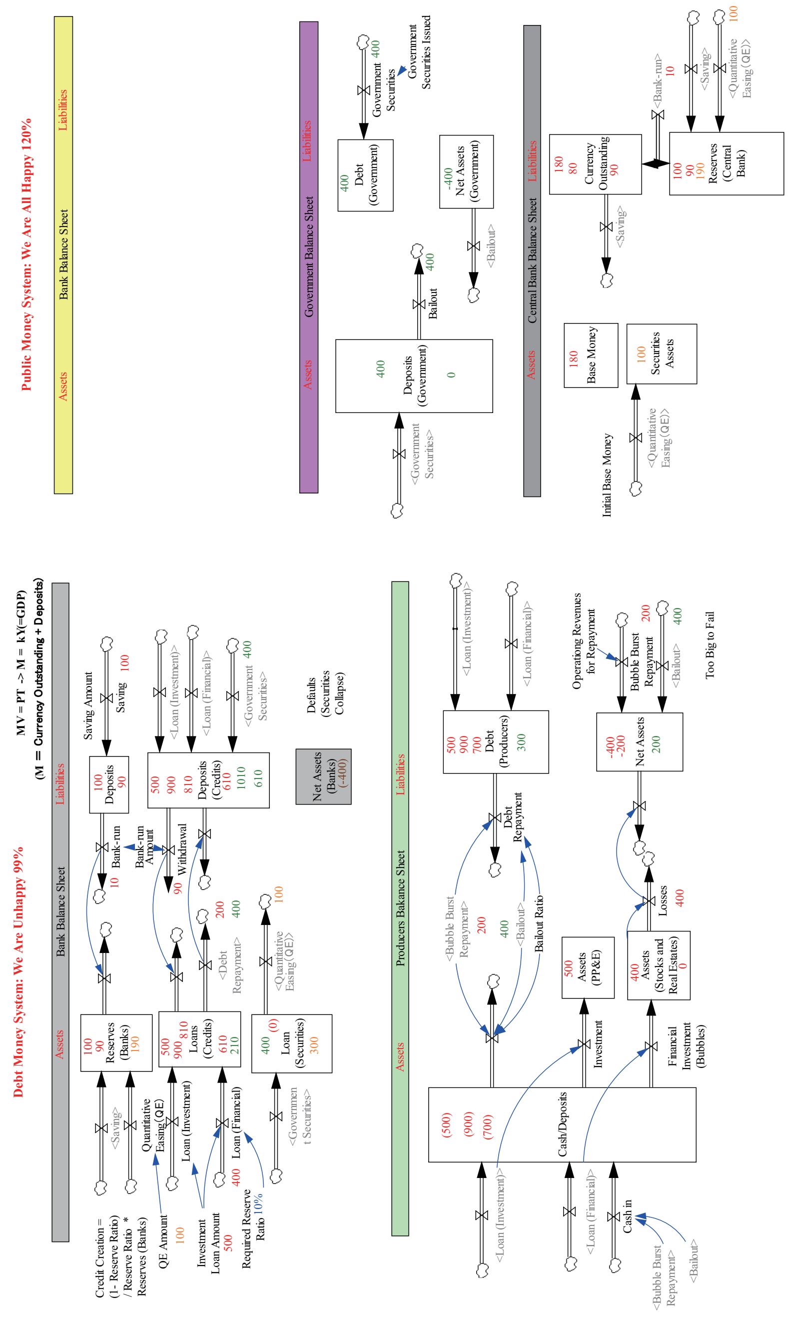

Figure 20.11: (8) Financial Quantitative Easing (QE)

Under the circumstances, the only policy left to the government is to ask the central bank to expand its monetary base through the purchase of government securities, with an expectation that the increased monetary base will increase banks' loans and money supply in due course. This policy is called "quantitative easing (QE)', which is illustrated as the loop of QE Policy in Figure 20.3.

In Figure 20.11, the central bank is shown to have purchased government securities of \$100, and banks' reserves increased by the same amount at t = 25. The purpose of this QE policy is the expectation of new credit creation up to the additional \$1,000 (= \$100/0.1).

Unfortunately, the quantitative easing failed to increase money supply, simply because banks become extremely reluctant to make loans to the financially troubled produces, and relatively healthy producers are forced to reimburse their accumulated debts out of their operating cash flow under the current economic recessions. This implies that the reinforcing loop of the Balance Sheet Recessions in Figure 20.3 dominates the balancing loop of QE Policy so that the increase in Monetary Base fails to expand Credits (Deposits). In this way, as illustrated in Figure 20.12, the expected QE policy has failed to stimulate the real economic activities such as consumption and investment demand, leaving the GDP in a stagnated state.

Unstable Money Supply under the Debt Money System

Behaviors of the debt money system are now investigated collectively in terms of monetary base and money supply. It is emphasized in this book that money sits all the time in the center of macroeconomic activities so that the availability of sufficient money stock is crucial to the sustained economic activities.

Figure 20.12 illustrates, under the fractional reserve banking system, how monetary base (line 1) creates it money supply (line 2) out of nothing from the step 0 through step 8; that is, t=0∼30. The behaviors of money supply thus created become very unstable.

Such fluctuations of money supply can be also caused by changing the economic values of the model sliders that are illustrated in Figure 20.13. Try to change the values of initial base money, saving amount, required reserve ratio, bank-run amount and operating revenues for repayment, and see how money supply fluctuates. This indicates that money supply under the debt money system can get easily fluctuated by these factors. Booms and depressions are frequently triggered by these changes in money supply, yet many of these changes are not under the control of the central bank and government.

On the other hand, changes in the values of government securities and QE amount also fail to increase money supply, which indicates the failures of the Keynesian fiscal and monetary policies. Indeed, the current debt money system is dead-end in the sense that unstable money supply cannot be well controlled.

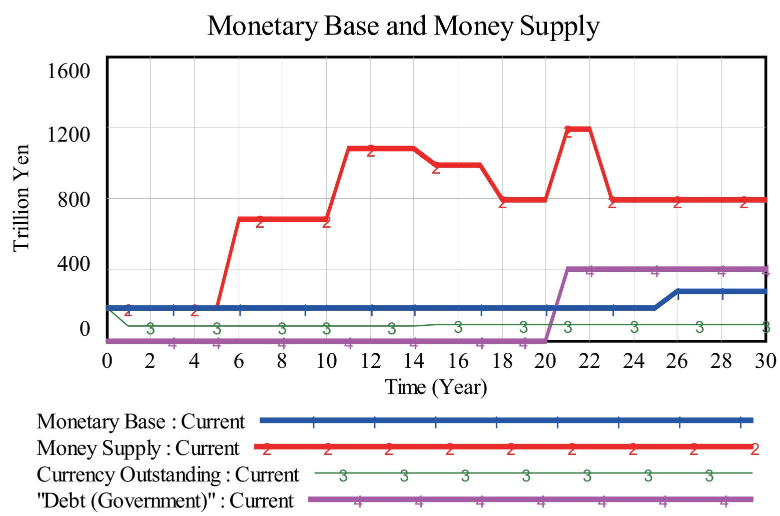

Figure 20.12: Monetary Instability under the Debt Money System

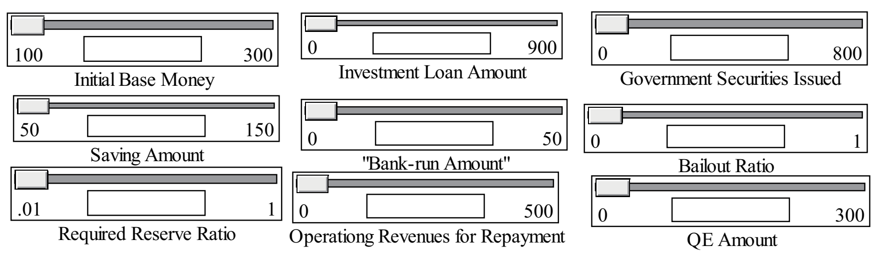

Figure 20.13: Parameters under the Debt Money System

Unstable Money Multiplier

Let us further investigate the unstable nature of money supply in terms of money multiplier since money supply is calculated by the equation (5.20) in Chapter 5, which is replicated here as

$$\text{Money Supply (Base)} = m * \text{Monetary Base} \tag{20.2}$$

where money multiplier (m) is defined by the equation (5.14) as

$$\text{Money Multiplier } (m) = \frac{\alpha + 1}{\alpha + \beta} \ . \tag{20.3}$$

Currency ratio (α) and reserve ratio (β) are a little bit differently defined here from Chapter 5, according to our model definitions in Figure 20.14, as follows[3]:

[3]At time = 0, the amount of deposits and deposits (credits) are zero, and division by zero needs be avoided. Accordingly, these ratios are set to be 1 without losing generality.

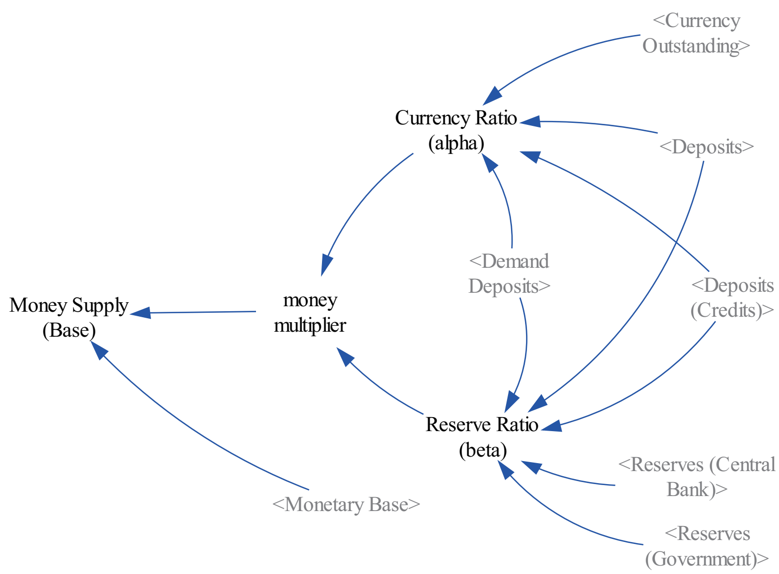

Figure 20.14: Definition of Money Multiplier

$$\text{Currency Ratio } (\alpha) = \frac{\text{Currency Outstanding}}{\text{Deposits} + \text{Deposits (Credits)}} \tag{20.4}$$

$$\text{Reserve Ratio } (\beta) = \frac{\text{Reserves (Central Bank)}}{\text{Deposits} + \text{Deposits (Credits)}} \tag{20.5}$$

Values of Money Supply (Base) thus obtained are confirmed to be the same as those of Money Supply in Figure 20.12, that is, Money Supply = Money Supply (Base). Behaviors of money multiplier, currency ratio and reserve ratio are shown in Figure 20.15 as lines 1, 2 and 3, respectively. Since monetary base is constant until t = 25, instability of money supply has been caused by the instability of money multiplier. The instability of money multiplier is in turn caused by the instability of currency ratio and reserve ratio as Figure 20.15 demonstrates.

What causes their instability, then? Currency ratio is affected by the consumers' attitudes to save or hold money in cash, which are in turn affected by the (expected) interest rate, stability of bank management, etc. An extreme case is a bank-run of consumers as depositors when bubbles pop. On the other hand, reserve ratio is influenced by the bankers' stances to make loans or withdraw them, or producers' perspectives to borrow money. As already explained in steps 2 through 4 above, these attitudes of consumers, producers and bankers cause instability of money multipliers and money supply, triggering economic instability in due course.

When QE is introduced at t= 25, monetary base increases from 180 to 280, yet, reserve ratio also soars from 0.128 to 0.271 at t = 26. And, money multiplier

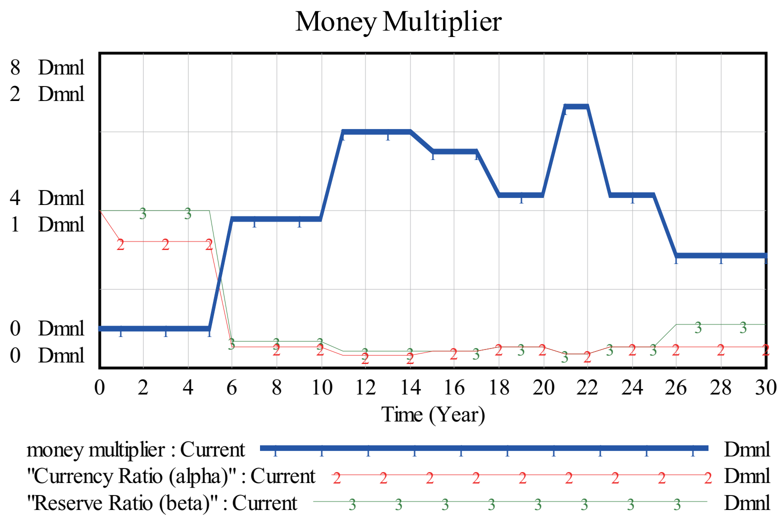

Figure 20.15: Instability of Money Multiplier

decreases from 4.39 to 2.82. Hence the increase in monetary base is canceled out by the decrease in reserve ratio and money multiplier so that money supply stays constant at 790 (= 2.82 * 280) as illustrated in Figure 20.12

It is now clear that the stability of money supply is beyond the control of the central bank and government, and hard to be obtained under the debt money system. It has to be replaced with more stable and sustainable public money system as analyzed in Chapter 14.

20.2 A Transition to the Public Money System

(T1) Public Money Conversion (t=31): Base Money=88

We are now in a position to explore a transition process to the public money system from the current dead-end debt money system. As already pointed out in section 1, three conditions have to be met to attain the public money system. First condition is the following:

- Governmental control over the issue of money.

To meet this condition, privately-owned central bank has to be legally converted to the publicly-owned organization, which we have called the Public Money Administration (PMA). The PMA is, then, able to create public money, consisting of coins and public notes as legal tender. This legal step has to be performed in a democratic manner through our legal process of establishing a new monetary law we propose such as the Public Money Act, for instance.

As pointed out in the footnote of Chapter 12, on Dec. 17, 2010, a bill based on the American Monetary Act was introduced to the US House Committee on

Financial Services as H.R. 6550 by the congressman Dennis Kucinich. This bill is called "The National Emergency Employment Defense Act of 2010 (NEED Act)". The bill was re-submitted on Sept. 21, 2011 as H.R. 2990 by the congressman Dennis Kucinich. This NEED Act is exactly to implement the public money system in the United States.

To promote a smooth conversion of the currency outstanding to the public money upon the implementation of the Public Money Act, it becomes more effective, we pose, if a favorable exchange rate between the current debt money and the public money is offered such that

$$\$10 \text{ (Debt Money)} = \$11 \text{ (Public Money)}. \tag{20.6}$$

10% increase in the amount of base money would not only encourage the currency conversion faster but also stimulate the discouraged consumption and reactivate the economy. Figure 20.16 illustrates the conversion process of currency outstanding so that its original amount of $80 (before the bank-runs) increases to $88.

(T2) Securities as Reserves Collateral (t=31): M(p)=588

Next transition step is to implement the second condition of the public money system:

- Abolishment of credit creation with full (100%) reserve ratio,

and attain 100% money according to the Irving Fisher Fisher (1945). He vehemently proposed this process as follows:

> Let the Government, through an especially created "Currency Commission," *turn into cash* enough of the assets of every commercial bank to increase the cash reserve of each bank up to 100% of its checking deposits. In other words, let the Government, through the Currency Commission, issue this money, and with it, buy some of the bonds, notes, or other assets of the bank or lend it to the banks on those assets as security[4]. Then all check-book money would have actual money – pocket-book money – behind it. (Fisher, 1945, p.9)

Since this process may turn out to be a source of confusion, let us explain this transition process in three steps; that is, T2, T3 and T4. Let us being with the step T2 here. For the implementation of 100% reserves, it is essential at this stage to classify deposits into two types of deposits: demand (and checking account) deposits and time deposits. Demand deposits were called "check-book money" by Irving Fisher. Under the full reserve ratio, banks are only required to hold demand deposits fully and are not allowed to make loans out of them. That is, demand deposits are owned by the depositors and banks only keep

[4] In practice, this could be mostly "credit" on the books of the Commission, as very little tangible money would be called for – less even than at present, so long as the Currency Commission stood ready to supply it on request.

them safely on behalf of the depositors for the convenience of their transaction payments.

On the other hand, time deposits are trusted with the banks, which in turn invest them on risky projects for higher returns. In this way, time deposits become the main source of loans for banks, and time depositors share the returns from the investment as well as losses.

Hence, 100% reserves only imply the 100% reserves of demand deposits, In our economy, let us assume that among the deposits of \$700, \$500 are demand deposits and \$200 are time deposits, while the current bank reserves are \$200. (We have started with the public money supply of M(p)=588; that is, demand deposits of \$500 and currency outstanding of \$88). Under the situation, if 100% reserves are required in the transition process to the public money system, banks have to raise additional \$300 to attain 100% reserves. In reality, almost all banks will have to face similar situations when the public money system is implemented.

There are two paths that meet this 100% reserves as Irving Fisher, etc. proposed in the quotation above. The first path is to "let the Government issue this money, and with it, buy some of the bonds, notes, or other asets of the bank"; that is, to allow the banks to convert government securities they hold to the required reserves. The second path is to "let the Government issue this money, and lend it to the banks"; that is, to allow the banks to borrow public money unconditionally from the PMA at zero interest for unlimited period until they can reimburse the debt out of their financial assets such as loans, government securities, corporate stocks and bonds (since most of these financial assets are purchased by banks as financial investment through their credit creation processes out of nothing).

The first path will reduce liability burdens to the banks, compared with the second path. Accordingly, we recommend the first path, because in reality banks hold enough government securities to cover their demand deposits. For instance, Japanese banks as a whole hold government securities of about 500 trillion yen, while their demand deposits are around the same amount. Therefore, they need not borrow money from the PMA. In our economy, banks hold \$300 of government securities, which are now converted to the reserve assets as illustrated in Figure 20.17. Then, the securities assets of the central bank (now the PMA) becomes \$400. This transition can be easily carried out without causing any troubles.

Moreover, banks can get benefits from this conversion of government securities to the collateral of full reserves, because they can avoid possible collapse of security values to be triggered by financial and debt crises in the future; that is to say, once their securities are converted, their values can remain frozen against the risk of defaults in the future. At the same time, interest incomes from the securities are guaranteed by the PMA until they become due.

In this way financial sector is stabilized as Irving Fisher claims:

> I have come to believe that the plan, "properly worked out and applied, is incomparably the best proposal ever offered for speedily

> and permanently solving the problem of depressions; for it would remove the chief cause of both booms and depressions, namely the instability of demand deposits, tied as they are now, to bank loans." (Fisher, 1945, p.xviii)

(T3) Temporal Increase in Base Money (t=33): M(p)=588

As the second step, the PMA now newly issues public money of $400, which is put into the net assets of the government balance sheet as well as its deposits assets. Simultaneously, the Public Money assets of the PMA is increased by the same amount, which is also balanced by the Government Reserves as its liability. Accordingly, monetary base temporarily increases to $988, yet public money supply stay the same at M(p)=588, as illustrated in Figures 20.18 and 20.22.

(T4) Debt Liquidation (t=35): M(p)=588

Government now spends the deposits of $400 to liquidate its debt of $400 as the third step. In the PMA's balance sheet, Securities Asset is cleared, which is in turn balanced by the same amount of reduction from the Government Reserves as illustrated in Figure 20.19. Accordingly, monetary base reduces to the original amount of $588, and again coincides with the public money supply of M(p)=588 as illustrated in Figure 20.22. Hence, the liquidation of government debts by printing public money electronically does not increase money supply, simply because the public money banks have received electronically stay as their bank reserves at the PMA. Therefore, no inflation is triggered at all under the liquidation of the government debt!

This liquidation process of the government debt is explained by Irving Fisher, etc. as follows.

> (17b) As already noted, a by-product of the 100% reserve system would be that it would enable the Government gradually to reduce its debt, through purchases of Government bonds by the Monetary Authority as new money was needed to take care of expanding business (Fisher et al., 1939, p.41).

(T5) Time Deposits Conversion (t=37): M(p)=588

In this way, through the three steps of T2 through T4 demand deposits of $500 are fully backed by the 100% reserves in our economy. As the next step, the conversion of time deposits of $200 can be easily done by simply regarding them as the time deposits of public money without further transactional changes as illustrated in Figure 20.20. This conversion surely does not change public money supply.

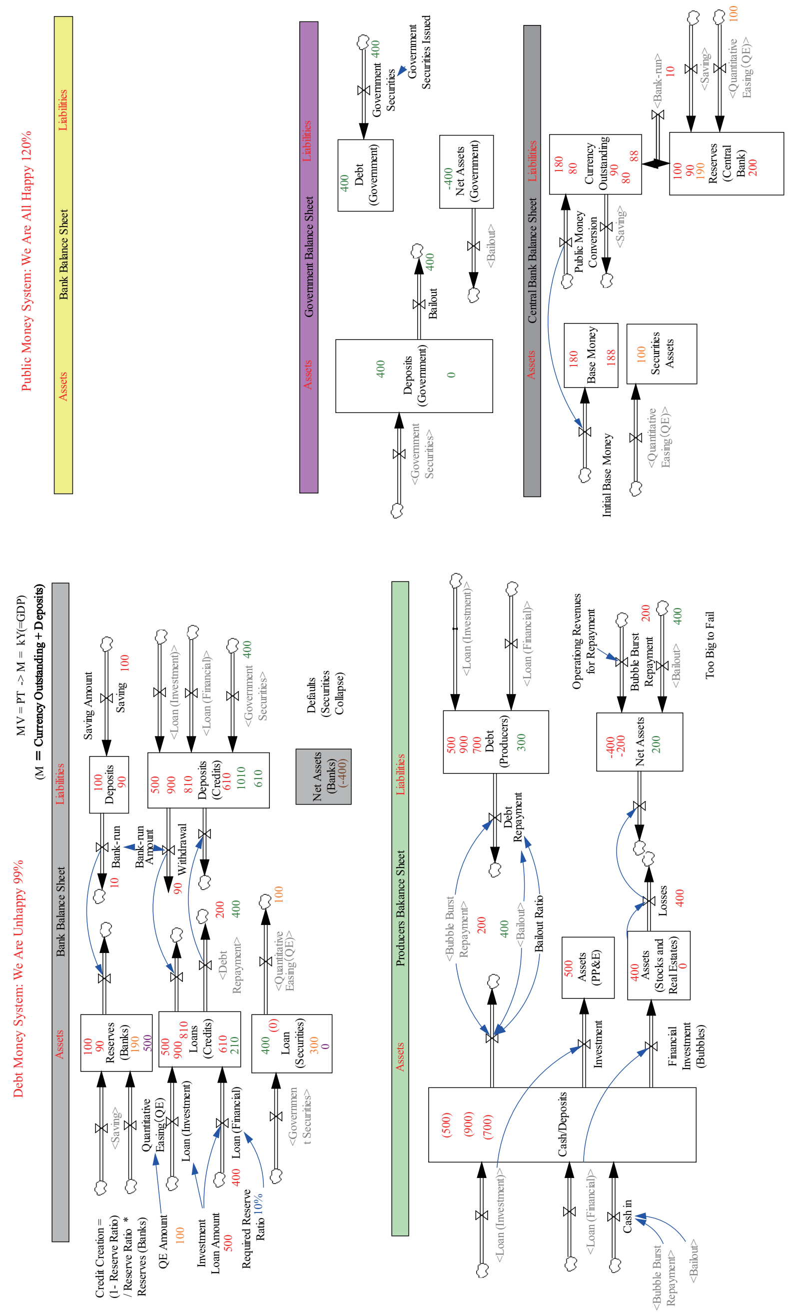

Figure 20.16: (T1) Conversion to the Public Money

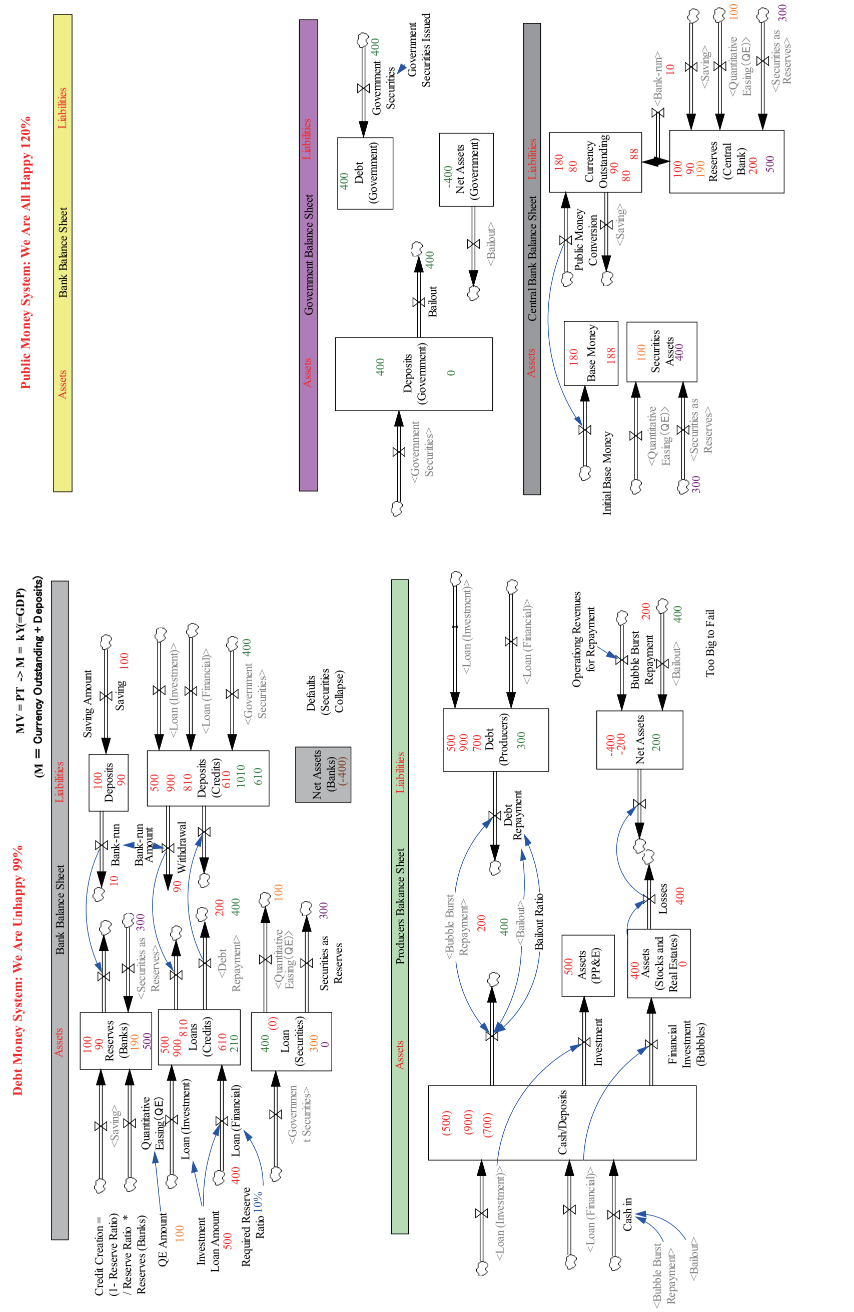

Figure 20.17: (T2) Securities as Reserves Collateral

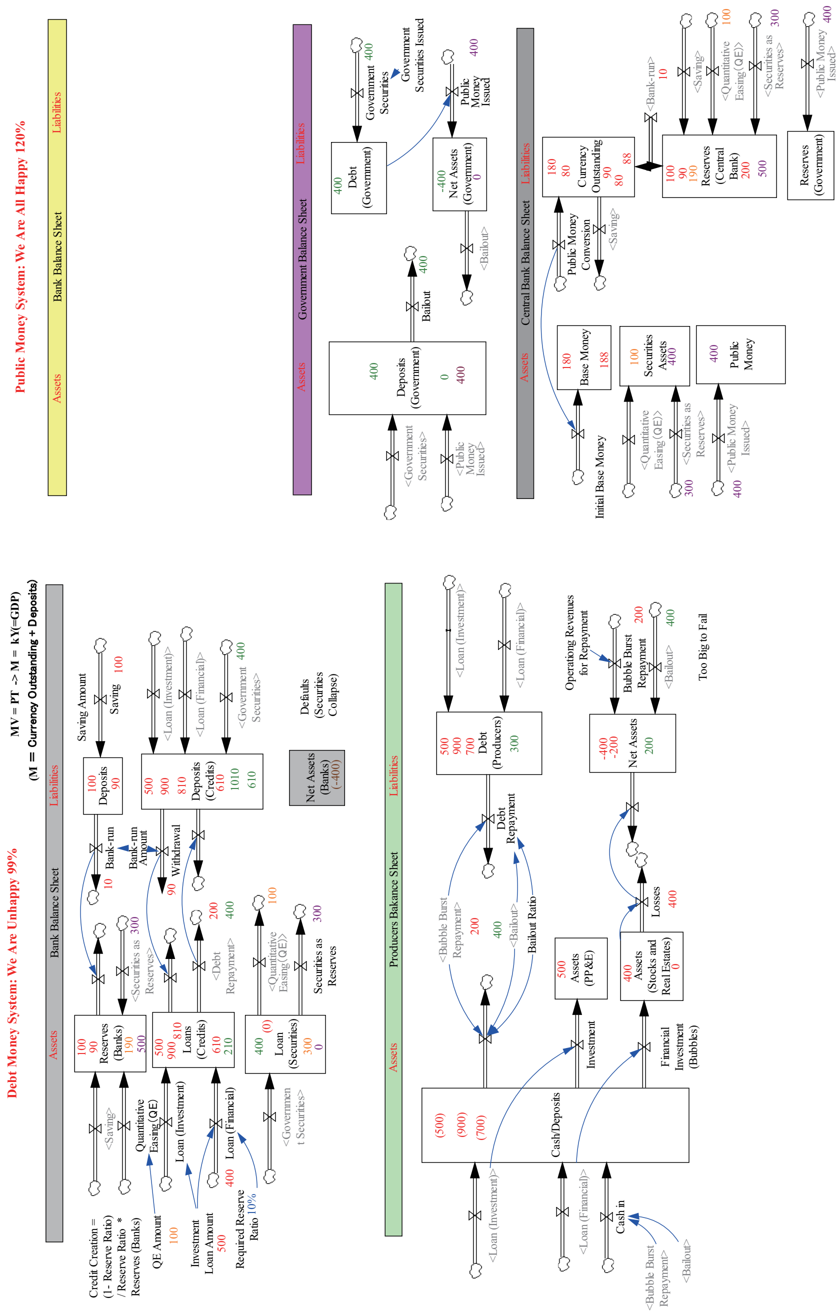

Figure 20.18: (T3) Public Money Issued

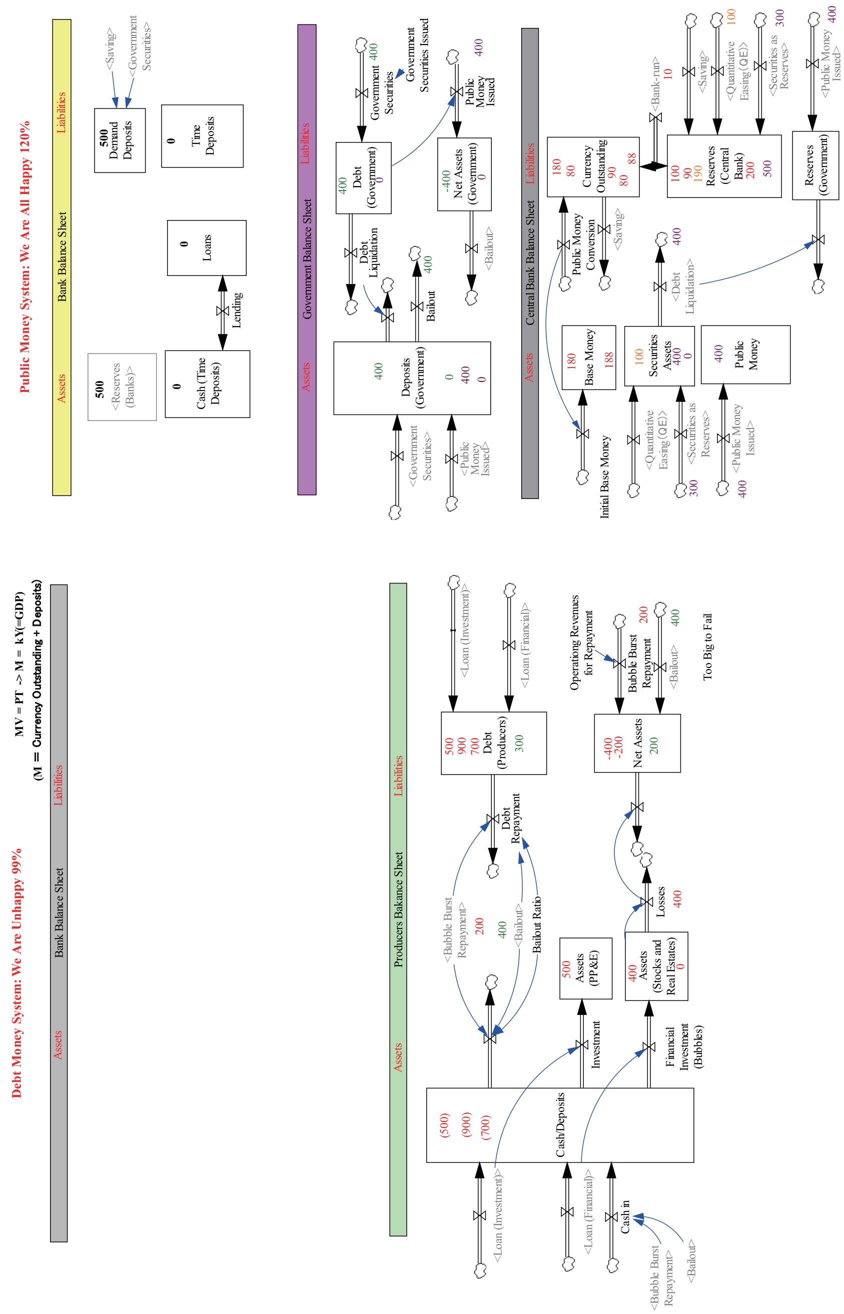

Figure 20.19: (T4) Debt Liquidation: Money Supply Unchanged

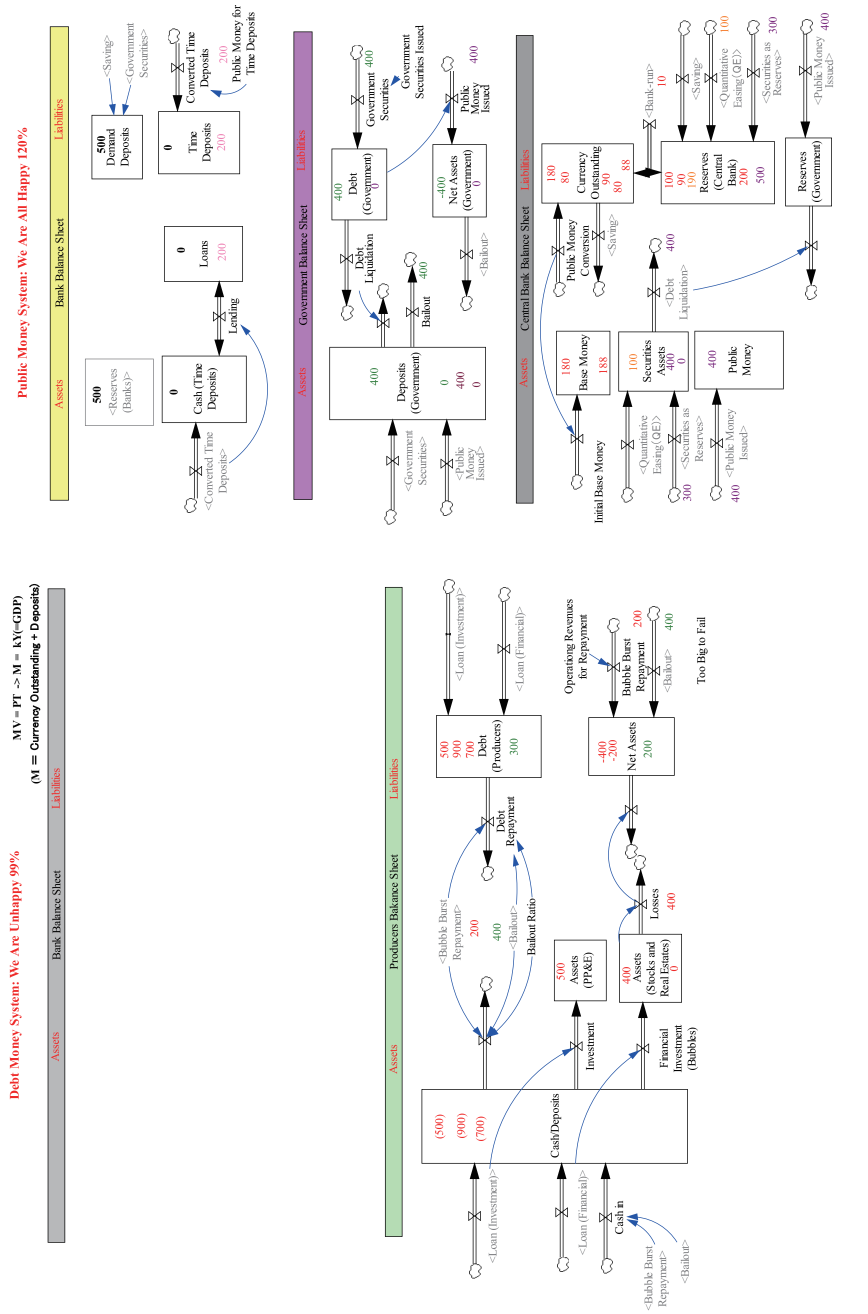

Figure 20.20: (T5) Public Money Converted to Time Deposits

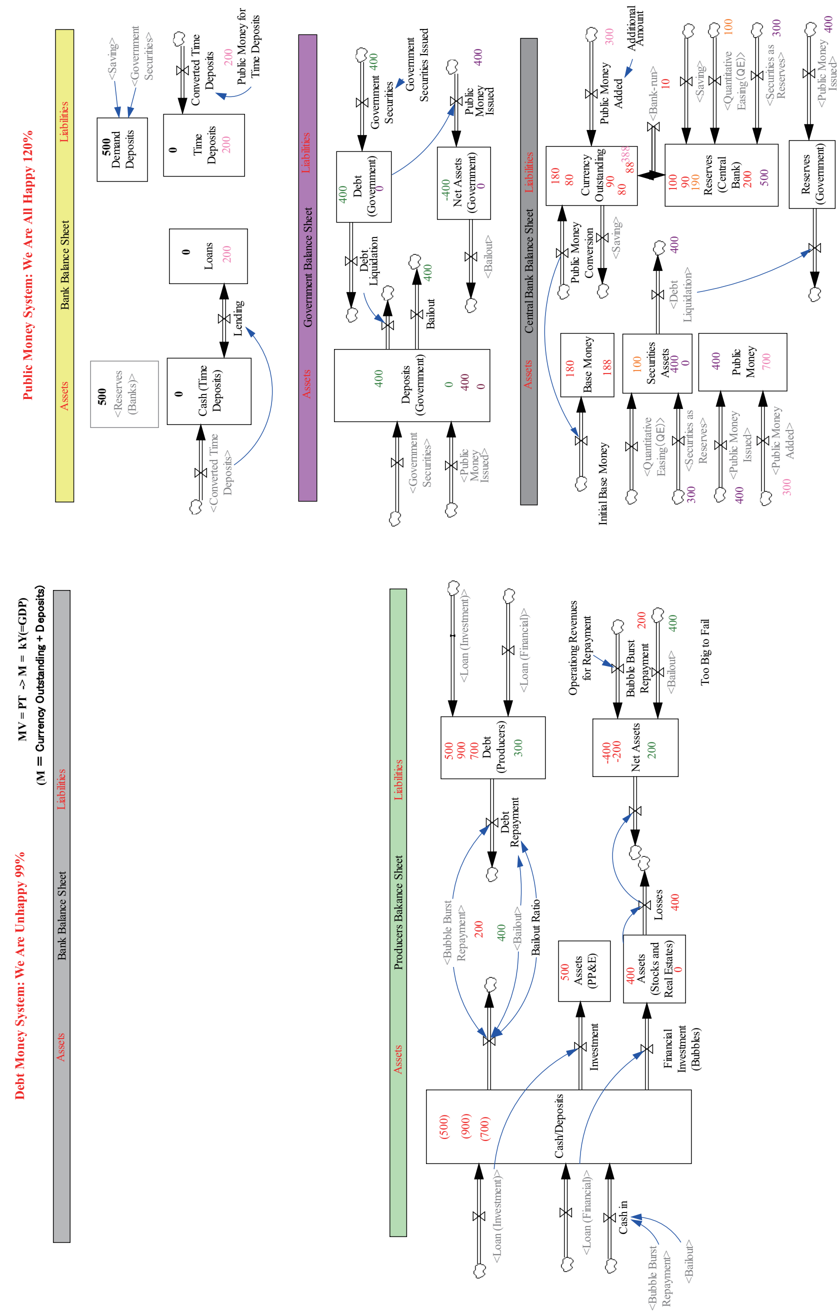

Figure 20.21: (T6) Public Money Added into Circulation for Welfare and Growth

Under the public money system, loans are made out of time deposits (cash), and repayments of loans implies the increase in cash assets. Accordingly, no credit crunches occur under the public money system. The public money, once put into circulation, stays in the economy, causing no bubbles and recessions.

(T6) Public Money Added to Circulation (t=40): M(p)=888

The third condition of the public money system is the following:

- Constant flow of money into circulation to sustain economic growth and welfare.

Public money can be further put into circulation according to the need for economic growth and government expenditure for welfare, etc. Let us assume that the additional amount of $300 is put into circulation. This amount is first put into Deposits and Net Assets accounts of the Government, and Public Money and Reserves(Government) accounts of the PMA as in the process of (T3). Then, whenever government spends it out of its Deposits (and Net Assets), it is simultaneously put into the Currency Outstanding account out of the Reserves(Government) according to the PMA's double bookkeeping rule.

Figure 20.21 only illustrates the final process of putting the additional amount of public money into circulation under the PMA balance sheet. Figure 20.22 shows that the public money supply is increased to P(p)=888 [5].

Stable Money Supply under the Public Money System

We have now successfully presented a transition process from the debt money system to the public money system in 6 steps. Figure 20.22 illustrates this transition process in terms of the changes in money supply.

Let us review the entire process over 50 years (time unit of year used in the model does not necessarily apply to the actual length of year).

Debt Money System (t=0∼30) This is the period of booms and depressions, caused by the fractional reserve banking system; that is, monetary base (line 1) is utilized to create unstable money supply (line 2) out of nothing, generating volatile money supply.

Transition Period (t=31∼37) This is the period of transition from the current debt money system to the public money system; that is, bank credits are converted to the 100% money, and government debt (line 4) is liquidated without causing inflation and chaos!

Public Money System (t=38∼50) This is the period of monetary stability; that is, stable public money supply (line 1 = line 2) is attained by unifying monetary base (line 1) and money supply (line 2) under the public money system.

[5] To be precise, if time deposits are further added to this public money supply, we have M(p)1=888 and M(p)2=1,088, respectively. On the other hand, M1 and M2 have not been distinguished in our debt money system so that M1=M2=790.

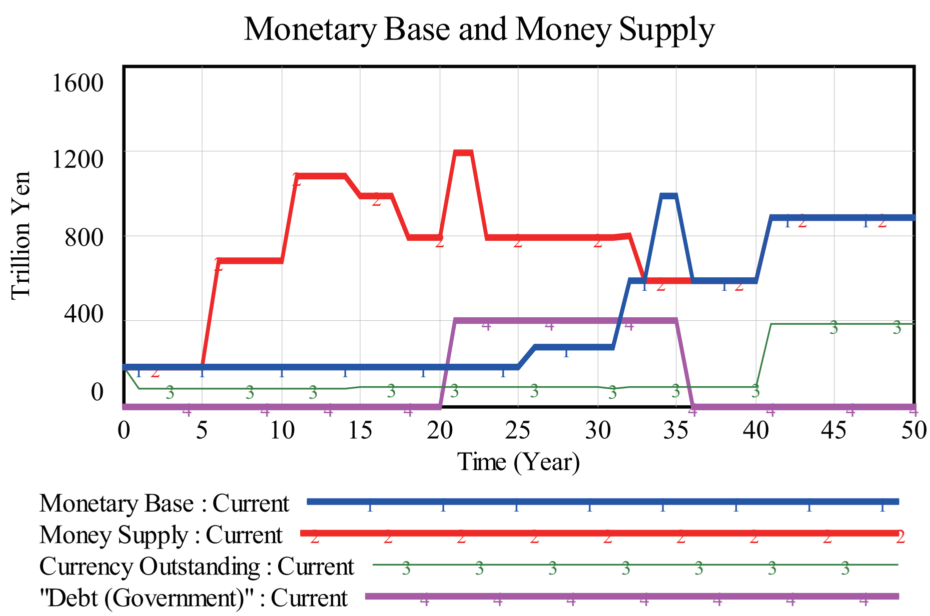

Figure 20.22: From Debt Money to Public Money System

As the reader can easily identify in Figure 20.22, under the public money system monetary base (line 1) and money supply (line 2) do no longer get split under the public money system, and money supply becomes all the time equal to monetary base.

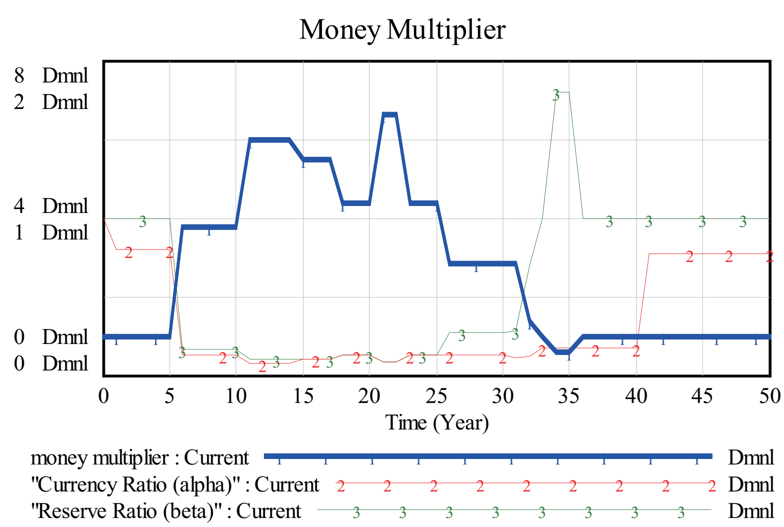

Figure 20.23: Money Multiplier from Debt Money to Public Money System

To understand this in detail, let us examine the behavior of money multiplier. Under the public money system, currency ratio and reserve ratio are defined as follows:

$$\text{Currency Ratio } (\alpha) = \frac{\text{Currency Outstanding}}{\text{Demand Deposits}} \tag{20.7}$$

$$\text{Reserve Ratio } (\beta) = \frac{\text{Reserves (Central Bank)} + \text{Reserves (Government)}}{\text{Demand Deposits}} \tag{20.8}$$

Figure 20.23 shows that except the transition period of t = 34 and 35, the reserve ratio (β) becomes 1, and, from the equation (20.3), money multiplier also becomes $m = 1$ [6]. Accordingly, money supply becomes equal to monetary base and gets very stable. Moreover, it never gets affected by the volatile behaviors of the currency ratio, as in the case of the debt money system. In other words, volatile behaviors of consumers to hold cash does not cause credit crunches and trigger recessions. Public money system has realized stable money supply, followed by stable economic behaviors.

However, this does not imply that the public money system fully secure monetary and financial stability and becomes free from "booms and depressions". Yet, as demonstrated in Chapter 13, monetary and financial instabilities, if triggered, can be better managed by simply applying public money policies under the public money system than traditional Keynesian monetary and fiscal policies under the current debt money system.

Figure 20.24 illustrates how monetary stabilization is attained in a very simple but effective way, compared with the complicated loops, under the debt money system in Figure 20.3, such as credit crunches of lenders and borrowers, balance sheet recessions, monetary and fiscal policies and QE policy.

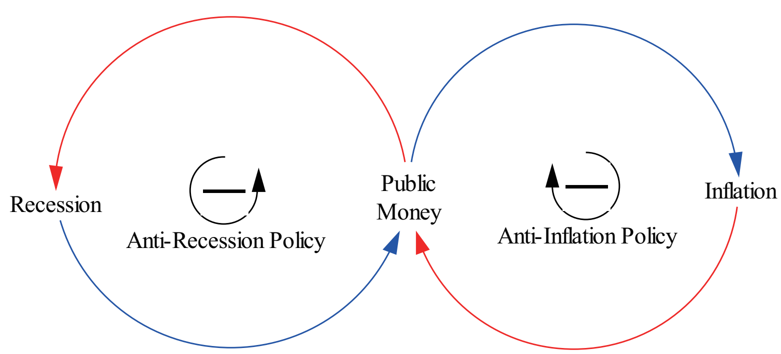

Figure 20.24: Monetary Stabilization under the Public Money System

In addition, other advantages obtained from the behaviors of the public money system and summarized in Chapter 15 such as full employment, debt-free

[6] Notice that in the Figure multiplier is illustrated with a scale of 8, while reserve ratio is illustrated with a scale of 1.

government, income equality and sustainability, provide another rationales for our advancing this transition process urgently toward the public money system, without losing time to create a better world.

Let me here stop my long off-road journey since the early 1980s. I truly thank the reader who have traveled on this long journey with me. Please keep on moving forward to the peak of our HOPE.

Conclusion

This final chapter tries to propose a transition process from the debt money system to the public money system. For this purpose, a simple macroeconomic model is constructed on the basis of accounting system dynamics in order to focus on the comparative behaviors of money supply.

This simple macroeconomic model turned out to be powerful enough to convince why our current debt money system has become a dead-end systemic failure. Specifically, booms and depressions, accumulation of government debts, and failures of quantitative easing are systematically explained to be caused by the privately-owned central bank and the fractional reserve banking system that creates credits out of nothing; that is, the current debt money system itself. Indeed, fractional reserve banking system has been, for centuries, the root cause of many socio-economic instabilities and disasters such as unemployment, inequality, wars, and environmental destruction, though not analyzed here.

Then, a transition process to the public money system is explained in 6 steps. It is shown that this transition process can be carried out peacefully without causing inflation and systemic chaos. It is our hope that under the public money system we will be finally freed from the calamities of debt money system, and be able to establish peaceful societies for the welfare of humanity, present and future. This completes the author's long journey for a better world in this book.

Part VII

Electronic Public Money

Chapter 21

Electronic Public Money

This chapter[1] explores the futures of money in the age of blockchain technology, and propose our view that Electronic Public Money (hereafter called EPM) issued by blockchain and distributed ledger technologies as crypto public money will be money of the futures.

Under the current debt money system, large amount of money stock is created by commercial bank loans at interest due to fractional reserve banking. The prolonged global recession since 2008 prompted a discussion again, following the Great Depression in 1930's, that this debt money system does not fulfill its function due to its structural defects, systematizing banking crisis, government debt accumulation, income inequality and environmental destruction. An alternative system of public money is proposed to solve the inherent problems of the debt money system in Part IV: Macroeconomic Systems of Public Money (Chapters 12 through 16) . In the mean time, the proposal and implementation of Bitcoin (Nakamoto, a, 2008) inspired various blockchain-based money, including the proposal of electronic public money (EPM) system (Yamaguchi and Yamaguchi, 2017b, 2017). An expanded classification of money presented below in this chapter categorizes blockchain-based money into four types: Crypto-coin, Central Bank Cryptocurrency, Crypto-token and EPM. It is then analyzed that all blockchain-based money except EPM still suffer from the structural defects of the debt money system due to their dependence on it. A need for development of new EPM protocol is emphasized along with its core design configuration.

[1]This chapter is based on my two joint papers with Yokei Yamaguchi. The first paper is titled "Peer-to-Peer Public Money System – Focusing on Payments" (Yamaguchi and Yamaguchi, 2017b, 2017), which was presented at the 2nd Asia-Pacific Conference of the System Dynamics Society, National University of Singapore, Feb. 20, 2017. The second paper is titled "Public Money, Debt Money and Blockchain-based Money Classified – EPM as Money of the Futures" (Yamaguchi and Yamaguchi, 2017a, 2017). which was presented at the 13th Annual AMI (American Monetary Institute) Monetary Reform Conference in Chicago, Sept. 16, 2017. The second paper is dedicated to the memory of Stephen Zarlenga, director of the American Monetary Institute, who passed away on April 25, 2017 at his home in Chicago. Without his vision on monetary reform and guidance through his work (Zarlenga, 2002, 2002), our present research on the public money system would not have gotten started.

21.1 The Year 2008

Current monetary system is based on a fractional reserve banking system. This is a system where bank deposits, which constitute large amount of money stock, are created when commercial banks grant loans at interest, or purchase existing financial assets from non-banking sectors. In short, the amount of nation's money is tied with investment activity of private commercial banks. Since every aspect of our lives has come to rely on bank deposits created as interest-bearing debts, the present economic system is alternatively called the *debt money system*.

The year 2008 became an epoch-making year for this debt money system. First, the financial crisis and global recession reconfirmed, following the Great Depression in 1929, that the debt money system embodies structural design failures, systematizing monetary and financial instabilities. Secondly, two papers were published in that year which provided foundations for rethinking the debt money system: a paper on the accounting system dynamics macroeconomic model by this author (Yamaguchi, 2008, 2008), which later became a theoretical foundation of the proposal of Public Money System (Yamaguchi, 2011, 2011), and a paper on Bitcoin by Nakamoto (Nakamoto, a, 2008), which provided technological breakthrough in designing peer-to-peer transaction system through blockchain technology.

ASD Macroeconomic Model

I have proposed the Principle of Accounting System Dynamics (ASD) in (Yamaguchi, 2003, 2003), a new computer simulation modeling method that combines Accounting System and System Dynamics; the integration of a robust double-entry bookkeeping foundation of social science and dynamical foundation of differential equation in natural science. By applying this analytical method, I have developed a series of macroeconomic modeling step-by-step; (Yamaguchi, 2005, 2005), (Yamaguchi, 2006, 2006), (Yamaguchi, 2007, 2007). Then at the 26th international conference of the system dynamics society held in Athens, Greece, July 20-24, 2008, I have presented a complete accounting system dynamics (ASD) open macroeconomic model as cited above.

Less than two months after the presentation of the paper, the financial crisis took place. Being deeply distressed by this economic disaster, I have begun to search for a new economic system which will be free from the detrimental effects of the debt money system; (Yamaguchi, 2009, 2009), (Yamaguchi, 2010, 2010), (Yamaguchi, 2011, 2011), (Yamaguchi, 2012, 2012), (Yamaguchi, 2014, 2014), (Yamaguchi and Yamaguchi, 2015, 2015), (Yamaguchi and Yamguchi, 2016, 2016). My research has been led by the so-called Chicago Plan of monetary reform (Fisher et al., 1939, 1939), which has been briefly covered in Part IV of the previous chapters. Accordingly, the public money system is proposed in this book as the alternative monetary system that addresses four systemic problems of the present debt money system: 1. Monetary and financial instability, 2. Government debt crisis, 3. Income inequality, and 4. Environmental destruction. Particularly, it has been emphasized that these problems are symptoms (system behaviors), not the causes (system structure), of the debt money system, and that, accordingly, re-designing the underlying structure is essential to genuinely overcome these issues. The alternative system design of public money is further developed in the context of Japan (Yamaguchi, 2015, 2015). The upper part of Figure 21.1 briefly illustrates how the proposal of the public money system has evolved since the year 2008.

Figure 21.1: Proposals for Public Money System and Bitcoin in the Year 2008

Bitcoin

On October 31st of 2008, less than two months after the collapse of Lehman Brothers, Satoshi Nakamoto, a pseudonymous author, submitted a 9 page-long paper in a mailing list of cryptography: "Bitcoin: A Peer-to-Peer Electronic Cash System" (Nakamoto, a, 2008). Then, in January of 2009, the source code, later known as the Bitcoin reference code, was made open-source. On Jan. 3rd, 2009, the genesis block, the very first block of ever-extending blockchain for Bitcoin transactions, was successfully mined on the internet, breaking the dawn of unprecedented experiment of global peer-to-peer transaction system. The essence of Bitcoin is summarized in the first sentence of the original paper:

> A purely peer-to-peer version of electronic cash would allow online payments to be sent directly from one party to another without going through a financial institution (Nakamoto, a, 2008).

Bitcoin achieved the first decentralized transaction system on the internet that has practically avoided the so-called "double-spending problem" by combining the existing technologies of cryptography, the innovative idea of blockchain, and proof-of-work (PoW) consensus algorithm in distributed computing system. Since then applications of blockchain technology opened up a possibility for designing a new type of decentralized infrastructures and organizations. The lower part of Figure 21.1 briefly illustrates how the blockchain technology has been evolving since the year 2008.

Blockchain for Genuine Monetary Reform

We are currently observing hundreds of new blockchain applications being proposed and developed across industries. As illustrated in the lower part of Figure 21.1, however, all blockchain applications are built upon the vulnerable structure of the debt money system, which was identified to cause monetary and financial instability by Irving Fisher in (Fisher, 1945, 1935) and (Fisher et al., 1939, 1939), and government debt crises by our joint papaer in (Yamaguchi and Yamguchi, 2016, 2016). Main benefits of the technological applications will be lost when the underlying monetary system remains unfixed and fails to fulfill its functions. What is now needed is to reform the basic structure of the current debt money system through blockchain technology.

21.2 Money Creation Revisited

21.2.1 Public Money and Debt Money

Our first step in rethinking the current debt money system begins by looking at different nature of money by analyzing how money is issued. This analysis is already done in Chapter 5. Accordingly, we make a quick revisit of the chapter so long as needed for the explanation in this chapter. Table 21.1, partially adopted from Table 5.2 in Chapter 5, classifies different types of money into two categories; public money and debt money. Public money is issued by the consent of the public as interest-free money, while debt money is issued by private parties as interest-bearing debt.

21.2.2 Money as Legal Tender

Table 21.1 then introduces the definition of money as legal tender. Money is nothing but information of value which can be exchanged for goods and services, and the stability of its purchasing power must be maintained over a period of time. As such, it does not concern how it is represented on what kind of media, be it tangible or intangible, except that its unit of measure is defined by law (legal tender) as observed by Aristotle (384-322 BC) in ancient Greece as follows:

> and this is why it has the name *nomisma* - because **it exists not by nature, but by law (*nomos*)** and it is in our power to change

Classification of Money

Front: Issuance	Public Money	Debt Money (at interest)	
Back: Fiat Status	Money as Legal Tender		Functional-Money
Non-metal Commodities	Shell, Cloth (Silk) Woods, Stones, etc		
Metal Coinage	Non-precious Metal Coins Gold, Silver & Copper Coins		Metal Ingots (such as Gold)
Paper Notes	Public Money Notes by PM Admin.	Goldsmith Certificates Central Bank Notes	
Digital Cards & Accounts	Digital Public Money (PM)	Central Bank Reserves (Central Bank Digital Currency: CBDC)	Bank Deposits (Credits by Loans)

Table 21.1: Public Money vs Debt Money

it and make it useless (Zarlenga, 2002, p.34).

Contrary to his recognition, money has historically been explained in terms of its physical properties, even though it has changed its form of media from physical to an abstract one along with rapid development in information technology. As an example, money in Japan consists of government coins, Bank of Japan notes and reserves (which are essentially electronic digits in the ledgers of Bank of Japan's database), all of which have no intrinsic values.

Today, as one can see from Table 21.1, almost all of medium of exchange used in daily transactions are deposits expressed in the form of electronic digits at commercial banks' database.

Unfortunately, however, Adam Smith (1723-1790), known as the father of economics, reversed the definition of *money as legal tender* as follows:

> By the money price of goods it is to be observed, I understand always, *the quantity of pure gold and silver* for which they are sold, without any regard to denomination of the coin (Zarlenga, 2002, p.313).

In this way, Adam Smith defined *money as commodity.* This erroneous logical step by the father of economics seemed to be widely used until this day. Advancing this idea axiomatically, many macroeconomics textbooks define money as an entity that meets the following three functions; (1) unit of account, (2) medium of exchange and (3) store of value. According to this axiom, gold and silver could be best qualified as ideal money because, *by nature*, their physical properties perfectly meet the three functions of money. This reversed definition has been a root cause of the confusion on the definition of money even among professional economists, and the public who are heavily influenced by them.

21.2.3 Bank Deposits as Functional-Money

Let us now look at three different measurements of money used in modern economy. Money used in our daily transactions is called money stock. It is defined as

$$\text{Money Stock} = \text{Currency} + \text{(Commercial Bank) Deposits} \tag{21.1}$$

Money stock thus defined is the total amount of money available in the economy as medium of exchange, regulating transactions and economic activities. The word *currency* appears for the first time in this measurement of monetary aggregates. It is strictly defined (such as in Japan and other nations) as

$$\text{Currency} = \text{Coins} + \text{(Central Bank) Notes} \tag{21.2}$$

Therefore, currency is the same as "cash", and by definition it is *legal tender* in the sense that no one can reject to receive it for payments.

Under the current fractional reserve banking system, there is another type of money called (central bank) reserves, which are mainly used for final settlements between commercial banks. Reserves are legal tender held by commercial banks and other non-banking financial institutions at central bank. With currency and reserves, base money or monetary base is defined as follows:

$$\text{Base Money} = \text{Currency} + \text{(Central Bank) Reserves} \tag{21.3}$$

How about commercial bank deposits? Are they also *money as legal tender*? According to Masaaki Shirakawa, a former governor of the Bank of Japan, the answer is negative.

> Contrary to the central bank notes, creditors can refuse to accept bank deposits as the payments of debt obligations because of credit risks associated with bankruptcies of debtors' banks. However, in normal times, bank deposits **function as money** because of creditors' confidence that bank deposits can be converted to central bank notes (Shirakawa, 2008, p.13) (translated by the joint authors).

Deposits are neither money as *legal tender* nor *currency* in this sense. That is why they are classified as *functional-money* in Table 21.1 even though they are widely accepted as the chief means of payment due to its convertibility with currency (legal tender). Let us emphasize again that deposits are nothing but *functional-money* created or destroyed by commercial banks under the fractional reserve banking system. This distinction of money from functional-money is the first step in rethinking the basic structure of the present debt money system.

21.3 Debt Money System Revisited

21.3.1 The Origin: Fractional Reserve Banking

The history of fractional reserve banking practices can at least be traced all the way back to the Venetian bankers in the middle of the 14th century (Fisher et al., 1939, 1939). Since then the age of free banking followed, in which commercial banks issued their own bank notes against deposits of precious metals such as gold and silver. For various historical contexts and political reasons, fragmented private banking systems began to be centralized through central banking system around the 17th century. No later by 19th century, gold standard system began to be established. In order to maintain the gold standard as international monetary system by assuring the fixed gold unit against national currencies under the growing economy, central banks needed to take deflationary policy action (raise interest rates) as a result of a shortage in world's gold reserves.[2] Industrialized nations in the west suffered from the deflation, and transfer of large amount of gold for settling international trades became impractical particularly during the war time. Eventually, nations were forced to abolish 'gold currency'. Finally, after the unilateral cancellation of the direct convertibility of the United States dollar to gold in 1971, the international monetary system abolished gold as a basis of money. This transition into fiat currency system under the fractional reserve banking, from another perspective, was a completion of the present *Debt Money System* in which money stock would no longer be limited by physical amount of gold and silver.

21.3.2 Structure of Debt Money System

Since the financial crisis in 2008, enormous amount of regulations and supervisory mechanisms have been implemented. However, they made the existing regulatory system more complex at best, if not any. In essence, the basic structure of debt money system remained the same before and after the crisis. Structure of the debt money system is summarized in the last column of Table 21.2, which is slightly modified from the original Table 19.1 in Chapter 15. It is a system in which base money is issued by central banks which are privately-owned in many nations, and deposits are supplied into the economy as interest-bearing debts through commercial banks' loans.

	Public Money System (Proposed)	**Debt Money System** (Current)
Money Issuer Its Owner	Public Money Administration The government (Public)	Central Bank & Commercial Banks
Required Reserves	100% (for Demand Deposits)	Fractional
Role of Banks	Intermediaries of Money	Creators of Deposits
Money Stock	Base Money = Money Stock (Financial system unaffected)	Base Money: by Central Bank Deposits: by Bank Loans
Issuance of Money	Interest-free	Interest-bearing Debt
Economic Policies	Public Money Policy (Direct Public Money Injection)	Monetary Policy: Central Bank Fiscal Policy: Government

Table 21.2: System Structures of Public Money and Debt Money

[2] The central banks were accustomed to maintain a reserve of upwards of forty per cent in gold or gold exchange behind their note issuances (Fisher et al., 1939, 1939).

21.3.3 System Behaviors: Four Built-in Failures

Behaviors of the debt money system are summarized in the last column of Table 21.3, which is slightly modified from the original Table 19.2 in Chapter 15. Debt money system has been observed to cause boom and bust, which in turn trigger monetary and financial instabilities, followed by accumulation of government debt caused by capital injection necessary to save the banking system and to implement fiscal stimulus policy. Over time, this system structure inevitably brings income inequality between a handful of financiers and the remaining non-financiers, leading to an extreme concentration of wealth. Furthermore, the debt-based monetary system forces economic growth that puts eco-systems under enormous stress, leading to environmental destruction. Accordingly, the debt money system is concluded to entail built-in system design failures of monetary and financial instability, accumulation of government debt, income inequality and environmental destruction as analyzed in Chapter 15 and (Yamaguchi and Yamguchi, 2016, 2016).

It is emphasized that these problems are system behaviors (symptoms) largely driven by the underlying structure of the debt money system. Thus they can be only fixed by re-designing the structure which directs how the system would behave. Let us re-examine these four system design failures in more detail below.

	Public Money System (Proposed)	**Debt Money System** (Current)
Monetary Stability	Stable Supply of Money Stable Price Level	Excessive Credit Creation & Crunches Inflation & Deflation
Financial Stability	No Bank-runs	Business Cycles, Banking Crisis (Booms and Depressions)
Employment	Full Employment	Involuntary Unemployment
Government Debt	No Government Debt	Built-in Debt Accumulation → Recession & Unemployment
Inequality	Income Inequality between Workers and Capitalists	Income Inequality between Financiers and Non-financiers
Sustainability	Sustainability is Possible	Debt Accumulation (Private and Public) → Forced Growth → Environmental Destruction

Table 21.3: System Behaviors of Public Money and Debt Money

1. Monetary and Financial Instability

Instability of Money Stock

Let us first consider monetary and financial instability since it is one of the most important criteria and the main purpose of system re-design. Under the debt money system, new deposits are created when commercial banks make loans, while, conversely, existing deposits are destroyed when loans are repaid. This way, money stock on which we all rely as chief mediums of exchange, is *endoge-*

nously created and destroyed. This leads to inherent instability of money stock (supply) especially during the period of booms and busts as money creation is tied to lending business of commercial banks.[3] Instability of money stock under the fractional reserve banking system was observed in the U.S during the Great Depression and is documented by Fisher (Fisher, 1945, 1935). In a recent cases of Japanese asset price bubble and burst during late 1980's and early 1990's, money stock continued to increase unlike the case of the Great Depression, because the government continued to borrow money this time, instead of debt-repaying private sectors, by issuing government bonds, which in turn has led to an acceleration of the government debt accumulation (Yamaguchi and Yamaguchi, 2015, 2015).

Financial System Crisis

Inevitable results of booms and busts are credit defaults, bankruptcies, foreclosures and bank runs, followed by higher rate of unemployment and long term recession. Financial crises are systematized by the underlying system structure of fractional reserve banking such that rational economic behaviors of repaying loans by private sectors during the economic downturn precipitate recession by further destroying money stock. The occurrence of this paradoxical phenommenon is identified as *fallacy of composition*.

2. Government Debt Accumulation

Under the debt money system, government is obliged to finance through taxation. For the amount of fiscal deficits, it has to rely on borrowings from private sector, mainly from banks and non-bank financial institutions (and indirectly from the central bank through open market purchases). Under such system, the government debt could grow at an exponential rate caused by a reinforcing loop of compounding interests. When private sectors stop borrowing from banks during economic recessions, the government instead has no choice but to borrow for implementing fiscal stimulus in order to maintain the level of aggregate demand, leading to further increase in its outstanding debts. These accumulated debts will surely trigger another type of economic crisis; debt crisis. In system dynamics, whenever an event is observed repeatedly and becomes a pattern, there must be a underlying system structure producing such a pattern of the event. Following this analytic approach, Parts II and III of this book explored system structure of the present system and identified it as a *debt-end* system. In short, the current debt-based system is far from a sustainable path and, sooner or later, destined to crash if no structural change is to be taken.

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[3] The simulation experiment using simple ASD model in (Yamaguchi and Yamguchi, 2016, 2016) shows that compound changes in currency ratio and capricious behavior of banks' lending ratio amplify instability of money stock, although base money remains entirely constant and stable.

3. Income Inequality between Financiers and Non-Financiers

As we have seen above, commercial banks and central bank collectively administer both payment system and money creation under the present system. Since almost all money exists in the form of debt, interest has to be paid as long as money exists. To be more specific, banking institutions earn vast amount of interest by creating and lending money to other non-banking private sectors and the government. This way, the current system works like a gigantic vacuum machine of national income, transferring large amount of income from non-financiers to financiers.

More specifically, when borrowers take loans at interest, interest payments go out of their equity and flow into the equity of banks as retained earnings. When buyers use credit cards and pay back by installments, they have to pay higher interest because they are getting loans from nonbank intermediaries who are essentially getting loans from banks as credit facility. Simultaneously, sellers or merchants have to pay card fees to nonbank intermediaries for the services they received from them.

In this way, equities of buyers and sellers (non-financiers) move to equities of nonbank intermediaries and banks (financiers). To sum, income redistribution is forcefully done from non-financiers to financiers under the current system. This is another type of income inequality under the current debt money system by way of transaction fees in addition to the one we have seen above.

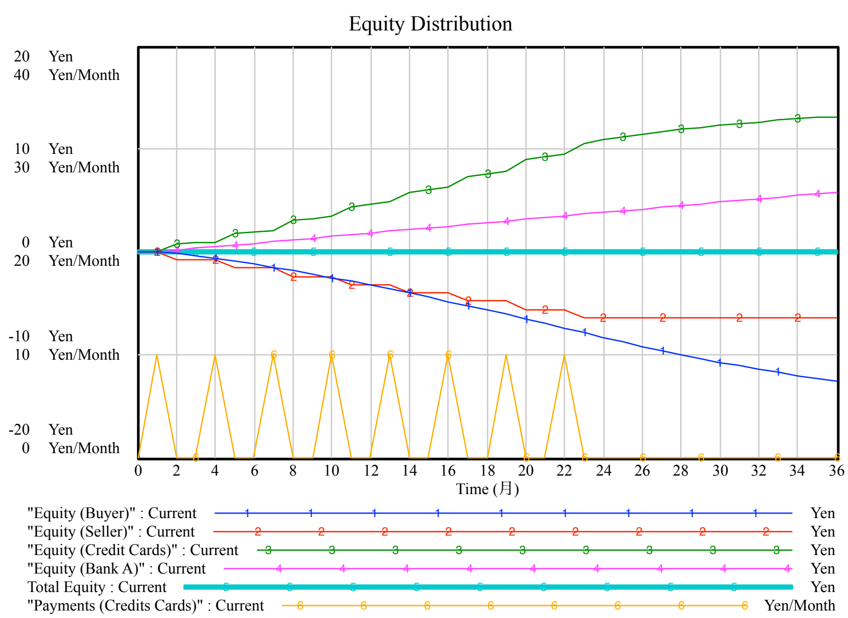

Figure 21.2: Income Inequality between Financiers and Non-financiers

Figure 21.2 is produced by running "the payment system model through nonbank intermediaries and multiple banks", illustrated in Figure 21.10 of the next section. It shows how equities flow from non-financiers (lines 1 and 2) to financiers (lines 3 and 4) when buyers purchase goods and services of 10 (thousand) yen every 3 months for two years (line 6).

In short, the current system of debt money is structured in such a way that it concentrates wealth into a handful of interest-earning financiers. Income inequalities is, indeed, an inevitable result of the system structure of debt money.

4. Environmental Destruction

More serious system design failure for our sustainable futures lies in the environmental destruction. Under the debt money system, borrowers are under enormous stress to repay loans at interest. Perpetual pressure to keep paying interests and pay back the principal incentivize borrowers (debtors) to minimize costs, discarding social investments for environmental protection. In other words, the system structure of debt money reverses systematic efforts for environmental protection and imposes behavioral structure of forced economic growth at the price of eco-system.

21.4 Payments under Debt Money System

It is essential for exploring money of the futures to understand how payments have been made under the debt money system. In this section we will investigate current payment methods in detail. Payments are made with currency (cash) and demand deposits.

Hence, they are divided into two categories; payments with cash and payments with deposits. Payments with deposits are further broken down into the one that goes through banks and the other that goes through nonbank financial institutions.

Figure 21.3 illustrates overview of all payment methods, including Bitcoin[4], under the current debt money system. Figure 21.4 enlarges the overview figure and focuses on 6 payment methods under debt money system; that is, payments with cash (① and ②), payments through banks (③ and ④), and payments through nonbanks (⑤ and ⑥). Let us now take a look at the in detail, respectivey.

21.4.1 With Cash and Electronic Cash

① Payments with Cash

Money Stock consists of cash and deposits. In Japan, Currency in Circulation (cash) constitutes only as much as 15% and the remaining 85% are deposits. Let us first explore how cash is used for transactions. Figure 21.5 is a simple Accounting System Dynamics model of transaction with cash. Cash moves from buyers to sellers, while goods and services co-flow in an opposite direction.

[4]Payments with Bitcoin is discussed in the sub-section 21.6.2 below

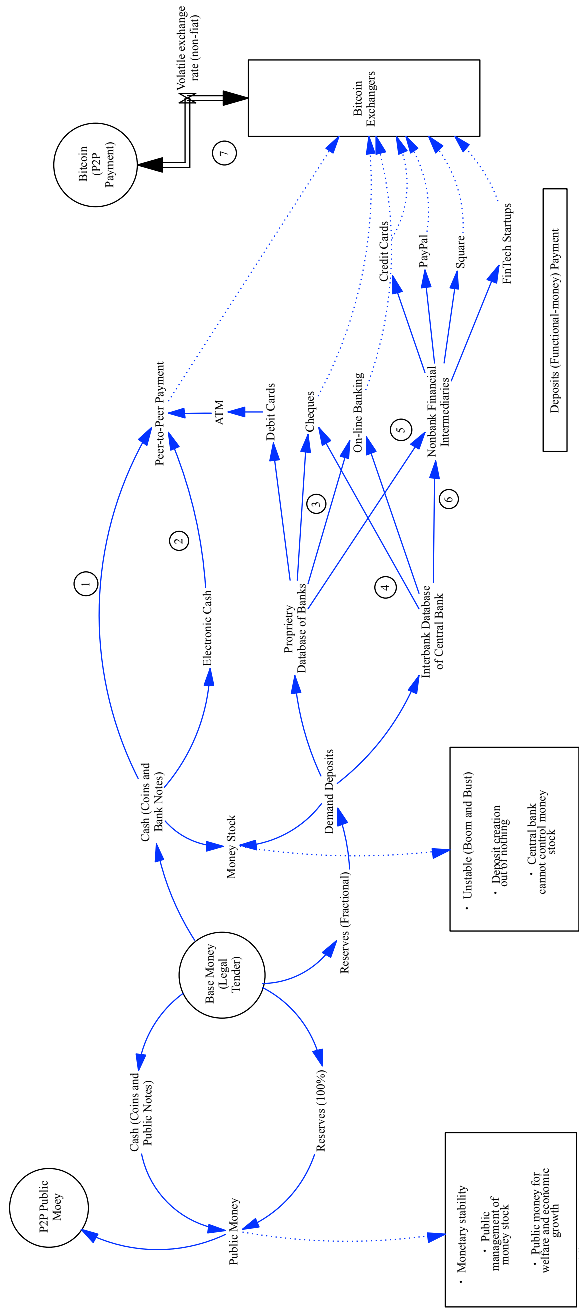

Figure 21.3: Overview of Payment System under Public and Debt Money

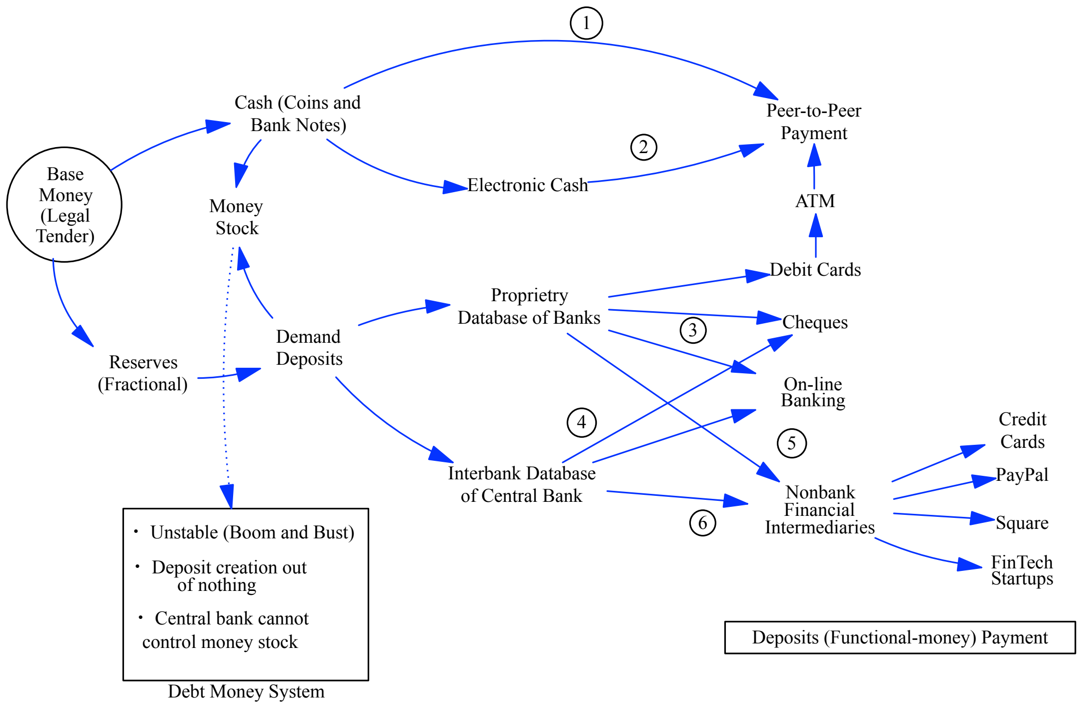

Figure 21.4: Overview of Payment Methods under Debt Money System

② Payments with Electronic Cash

Cash can be substituted by electronic cash. Electronic digits are stored in electronic cards as prepaid money in exchange for currency (coins and bank notes), and used for transactions. As payments with electronic cash become more convenient, this type of payment is getting widely used. Figure 21.6 presents a simulation model of this payment method.

21.4.2 With Deposits through Banks as Intermediaries

③ Payments through Banks

Deposits (as functional-money) are created out of nothing as electronic digits in the database of banks. They are used for payments by transferring them between the accounts of buyers and sellers of a single bank or in multiple banks, which are then settled through their inter-bank database at the central bank.

Traditionally, most payments are done through cheques, and recently by on-line banking. If buyers and sellers reserve their checking accounts in the same bank, their transactions can be easily done through the proprietary database of the same bank. This payment is modeled in Figure 21.7.

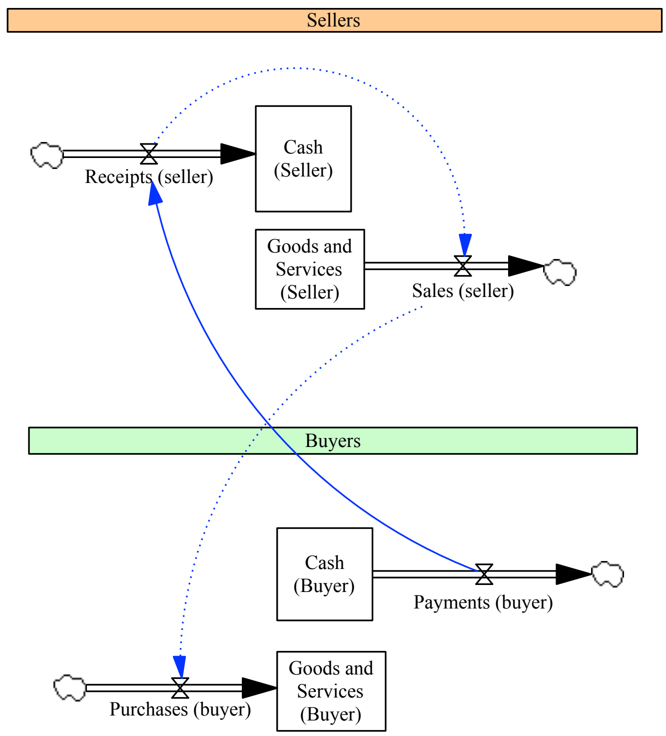

Figure 21.5: Payment System ① with Cash: Peer-to-Peer

④ Payments Settled at Clearing System of Central Bank

If buyers and sellers have their checking accounts at different banks, their transactions have to be cleared through the inter-bank payment system and settled through the central bank reserves. This payment is modeled in Figure 21.8.

21.4.3 With Deposits: Non-banks as Intermediaries

⑤ Payments through Non-banks and Banks

Recent innovations in FinTech are advancing the area of payments with deposits; that is, payments by smart phones such as iPhone and laptops. Some well-known examples are PayPal, ApplePay, Square Reader(NFC) and Square Stand. Traditional service charge for credit card is between 5% and 8%. Square now offers only 3.25% for similar services. All other credit cards are forced to reduce their service charges of 4% - 5% to around 3%. In this way FinTech revolution is advancing the efficiency of credit card payments.

When buyers and sellers as well as nonbank intermediaries such as credit

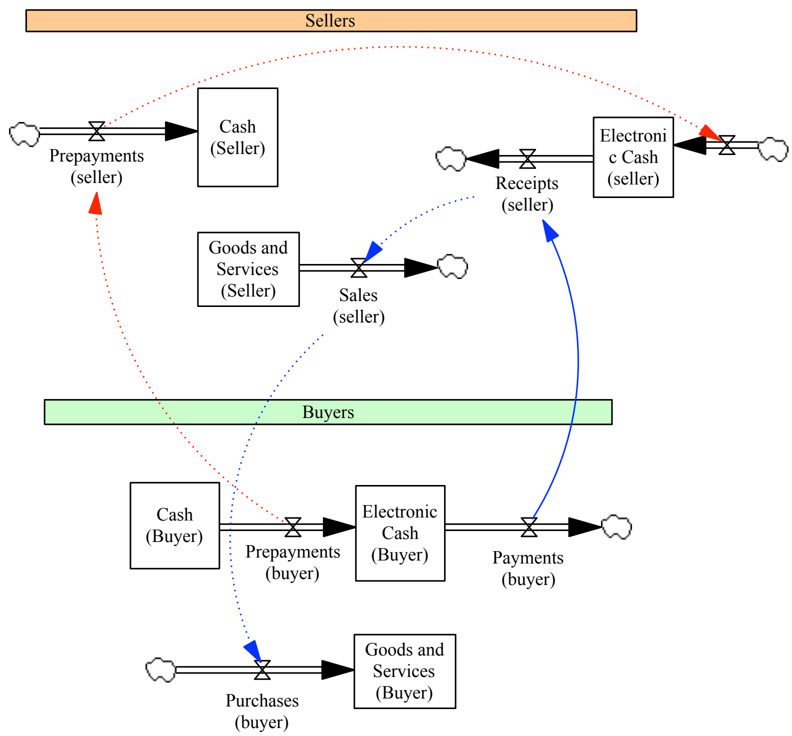

Figure 21.6: Payment System ② with Electronic Cash

card companies have their checking and deposits accounts within the same bank, their transactions are done through the proprietary database of the same bank. This payment is illustrated in Figure 21.9.

⑥ Payments through Non-banks and Central Bank

When buyers, sellers and nonbank intermediaries such as credit card companies keep their checking and deposits accounts at different banks, their transactions are cleared through the inter-bank database at the central bank. This payment model is exhibited in Figure 21.10.

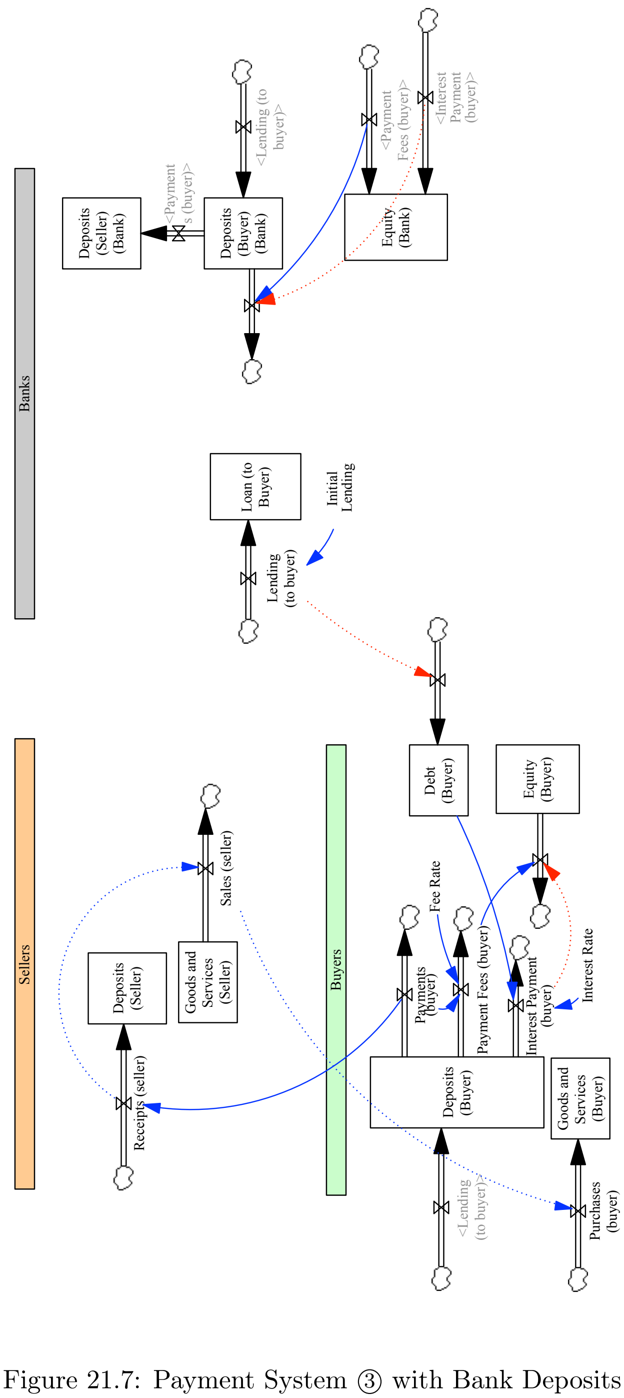

Figure 21.7: Payment System ③ with Bank Deposits

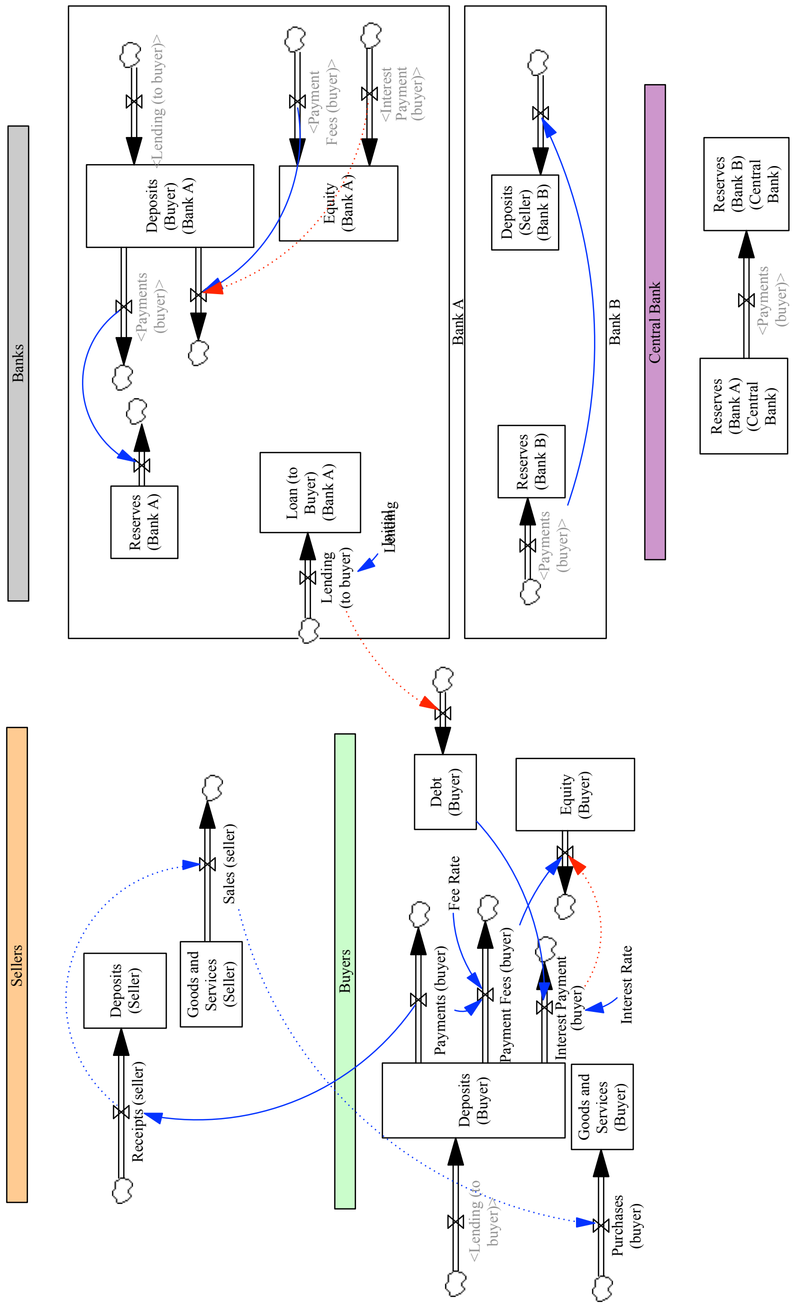

Figure 21.8: Payment System ④ with Multiple Bank Deposits

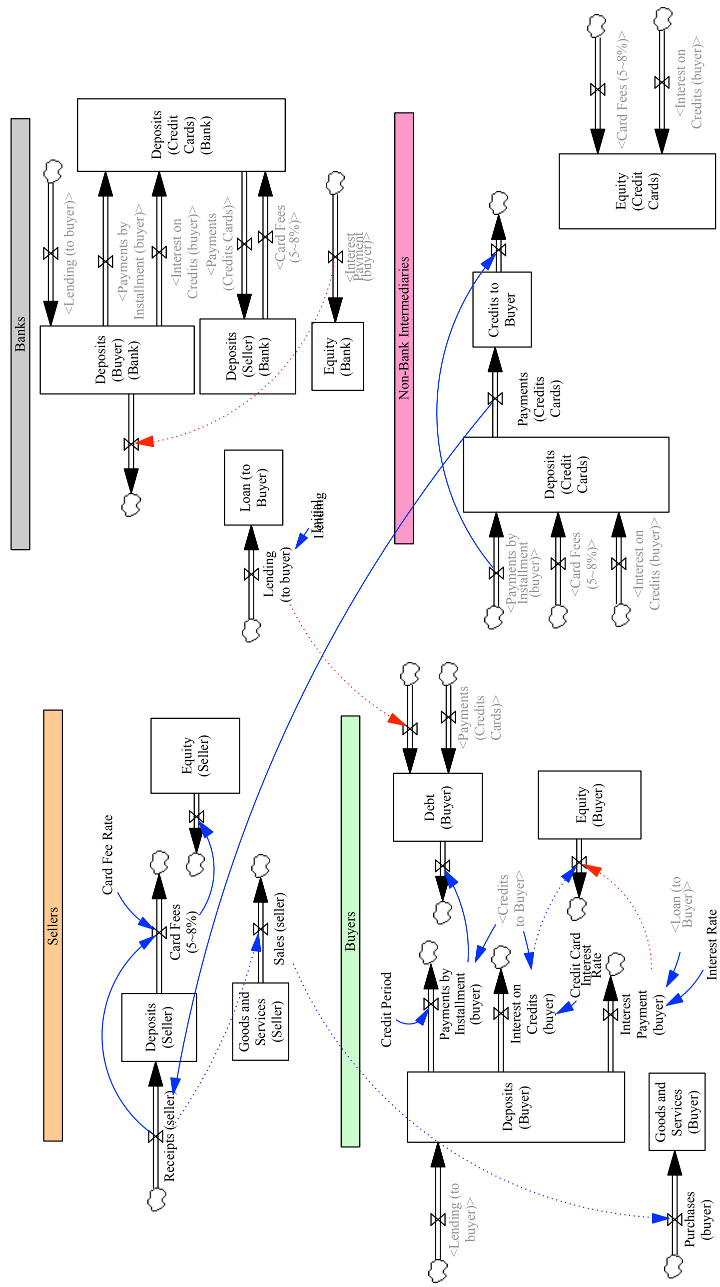

Figure 21.9: Payment System ⑤ through Nonbank Intermediaries (Credit Cards)

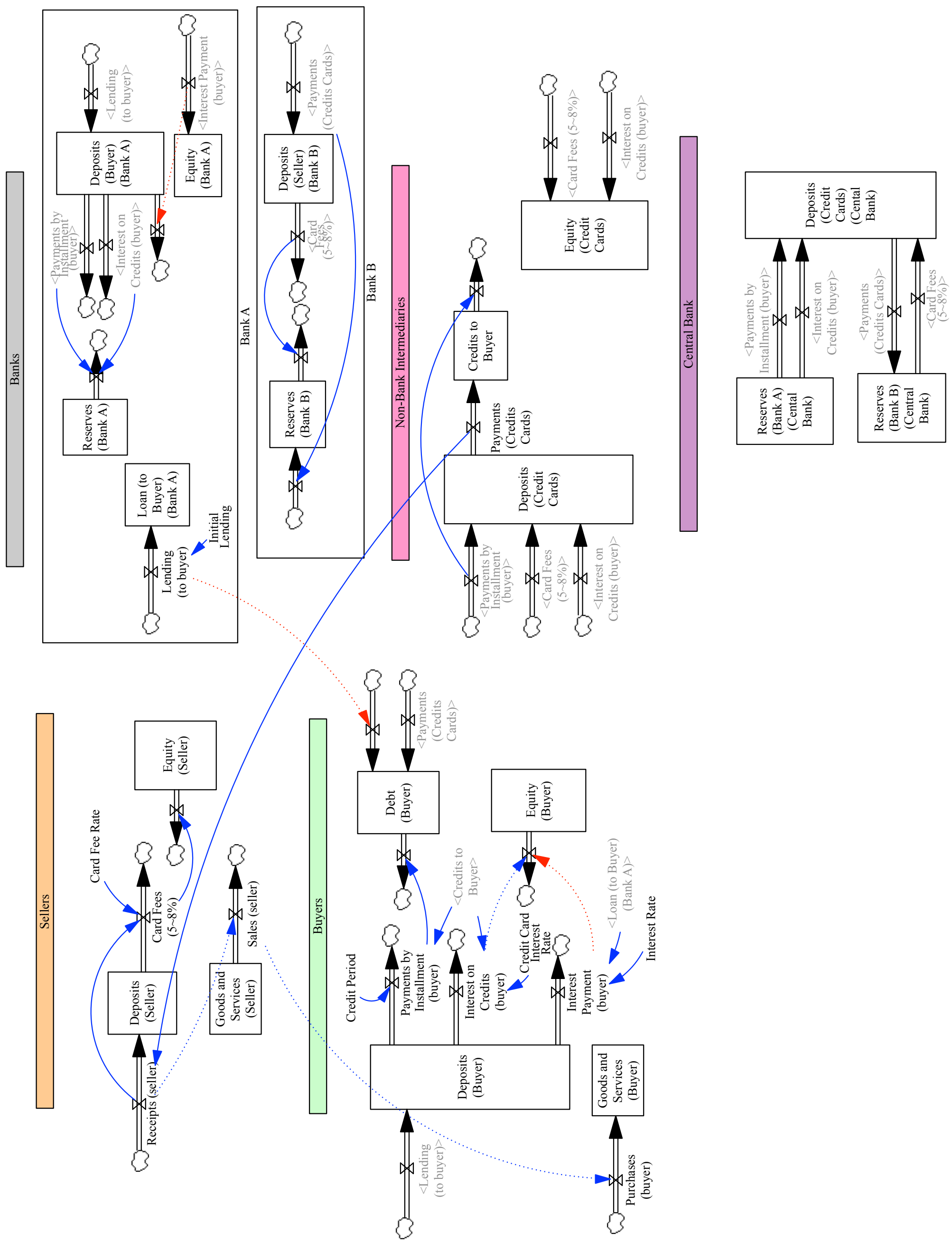

Figure 21.10: Payment System ⑥ through Nonbank Intermediaries and Multiple Banks

21.5 Public Money System Revisited

21.5.1 The Origin: Chicago Plan and 100% Money

In this section we make a quick revisit of Part IV: Macroeconomic System of Public Money and my Japanese book: Public Monney (Yamaguchi, 2015, 2015). The Great Depression in 1929 was the first major economic disaster caused by the system design failures of the debt money (fractional reserve banking). Having recognized this, eight economists at the University of Chicago[5] proposed an alternative system design called "The Chicago Plan for Banking Reform" in 1933 based on the original idea put forward by Frederick Soddy in 1926, who won the Nobel prize in chemistry in 1921. Their proposal was handed over to the President Franklin D. Roosevelt on March 16, 1933 through Henry A. Wallace, then Secretary of Agriculture. Unfortunately, however, it failed to be implemented as political oppositions, especially from bankers who retain the profitable system, were substantial (Phillips, 1995, 1995). Instead, the Banking Act of 1933 known as Glass-Steagall Act, which was less restrictive to bankers, was enacted on June 16, 1933 by FDR.[6] Then, the Chicago Plan was vehemently carried on by Irving Fisher from Yale University (Fisher, 1945, 1935) and his group of five economists[7] as "A PROGRAM FOR MONETARY REFORM" (Fisher et al., 1939, 1939), and later by Milton Friedman (Friedman, 1948, 1948), (Friedman, 1992, 1960). Gradually, the Chicago Plan and similar sort of proposals began to be neglected and made *a taboo subejct* (Turner, 2013, 2013) as an alternative economic policy discussion.[8]

The monetary reform thus proposed as the Chicago Plan simply aimed to introduce 100% required reserve ratio for demand deposits such that

$$\text{Money Stock} = \text{Base Money} \tag{21.4}$$

Under this full reserve (100% money) system, all demand deposits (functional-money) will be all backed by base money, legal tender. This way, money stock, being defined by currency and demand deposits, becomes equal to base money.

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[5] They are: G.V. Cox, Aaron Director, Paul Douglas, A.G. Hart, F.H. Knight, L.W. Mints, Henry Schulz, and H.C. Simons.

[6] The Act was repealed in 1999 by the President Bill Clinton, and replaced with the Glamm-Leach-Billey Act also known as the Financial Service Modernization Act of 1999, which was criticized of having ultimately led to the financial crisis in 2008,

[7] They are: Paul H. Douglas, University of Chicago; Frank D. Graham, Princeton University; Earl J. Hamilton, Duke University; Willford I. King, New York University; and Charles R. Whittlesey, Princeton University.

[8] As a recent case, Congressman Dennis John Kucinich, a member of the U.S. Representative from Ohio between 1997-2013, put forward the American Monetary Act in 2011, which is an equivalent of the Chicago Plan.

> On 26 July 2011, Kucinich invited Professor Kaoru Yamaguchi from the University of California at Berkeley and Doshisha University in Japan, to give a congressional monetary briefing on this idea. ... Any version of the Chicago Plan will be fought to the death by the banking system because it threatens both its power base and its business model. (Lietaer et al., 2012, 2012, pp.129-130)

Based on the Chicago Plan, we have proposed *Public Money System* in Part IV of this book as an alternative system design to overcome structural flaws of the debt money system.

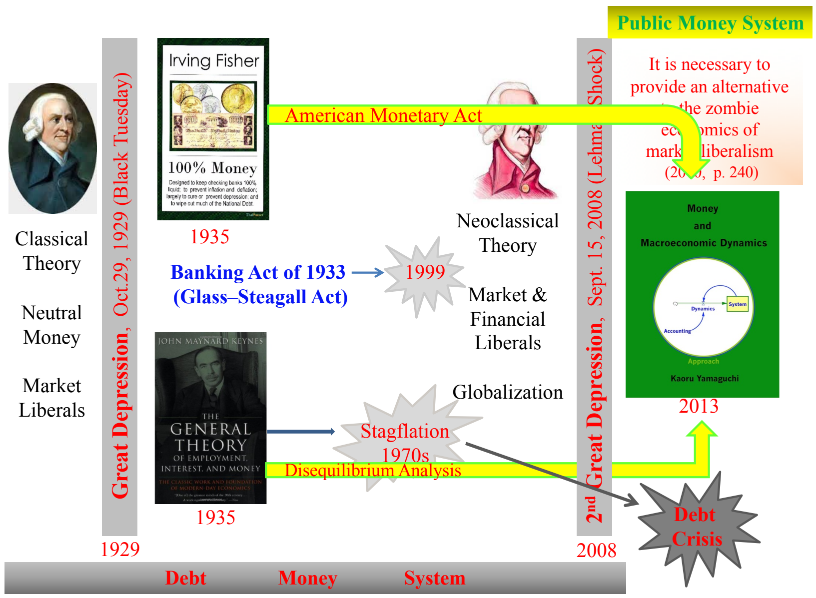

Figure 21.11: From Debt Money to Public Money System

Figure 21.11 illustrates how two great economists learned important lessons independently from the Great Depression in 1930's; that is, 100% Money by Irving Fisher (Fisher, 1945, 1935) and The General Theory of Employment, Interest and Money by John M. Keynes (Keynes, 1936, 1935). It also shows that a new macroeconomic theory of public money system developed with Accounting System Dynamics (ASD) modeling approach (**?**, 2013, First Edition) is an integration of the above two lessons proposed in 1935 in the wake of the Great Depression in 1930's.

21.5.2 Structure of Public Money System

Money exists by law as discussed in Section 2. Accordingly, money must be issued as decreed by law (legal tender). And a reliable monetary system must provide stability of its purchasing power. System structure of public money is summarized in the second column of Table 21.2 shown above. Its gists are as follows:

- Public money is issued at interest-free by the Public Money Administration (PMA) as equity of the nation, not by commercial banks as interest-bearing debt.

- 100% required reserve ratio is held for demand deposits.
- Public money is put into circulation to sustain economic growth and welfare.

Banks as Intermediaries of Public Money

By requiring banks to keep 100% reserve ratio for demand deposits and to follow appropriate accounting journal entries for bank-lending transaction, banks become genuine intermediaries of existing money under the public money system. Separation of money creation and private lending business is thus achieved.[9]

Loanable funds of banks come from three sources: (1) their own money (retained earnings), (2) time (savings) deposits and (3) loans repaid. Especially time deposits are savings of the economy and become a main source of loanable funds for commercial banking sector, connecting savers and borrowers in the economy. As a result, main source of income for commercial banking institutions consists of (a) earned interest income from lending business and (b) service fees for providing payment and custody service. In this way a robust and stable foundation of banking system will be established.

This business model of banks, which is what normal textbooks regard them to be, provides them with economic incentives to put weights on real investments that would result in stable returns rather than on zero-sum financial gambling. Consequently, banks under the public money system seek for real investment opportunities in more productive markets, making the whole financial sector more competitive and efficient. Thus, interest rates are determined in the financial market competitively. In this respect, the Public Money Administration will be free from monetary policy of manipulating interest rates through market operations as presently done by the central banks of the debt money system.

Issuance of Public Money

Who should issue money, then, in place of the privately-owned central banks and commercial banks? Issuance of money or legal tender is the prerogative of the *public*. Thus, we propose that the issuer has to be a *public* organization, politically independent from the influences of the government and vested interest groups. Secondly, it must be a sole entity under the publicly-elected legislative branch of the government regulated by the constitution, such as the Congress in the United States, the Parliament in the United Kingdom and the Diet in Japan. Such an organization is commonly referred to as the *Public Money Administration* (PMA) in Part IV of this book.

[9] Concerning the role of government in the process of money creation, Frank. H. Knight, one of the original proponents of the Chicago Plan in 1933 and of the founding members of the Chicago School of Economics, stated:

> No violation of the basic principles of extreme *laissez faire* theory would be involved in separating the monetary system from the vicissitudes of speculative private business. (Knight, 1933, 1933)

To make this alternative system design workable while avoiding political pressures and fiscal dominance, the following two conditions must be strictly met:

C1. The Public Money Administration plays a role of *supply side* of public money, while the executive branch of the government (Department of Treasury in the U.S, Ministry of Finance in Japan, etc.) plays a role of its *demand side*. The amount of public money is determined by the interplay of demand and supply sides.

C2. Transparency of both information and decision processes of public money issuance has to be fully guaranteed to the public.

To implement the conditions of C1 and C2, an organizational structure of demand and supply side of public money administration is proposed in (Yamaguchi, 2015, 2015) as illustrated in Figure 21.12 as a case example in Japan. According to the proposal, the PMA is established under the direct supervision of the Diet as an politically independent organization from the influences of other branches of the government, politicians, lobbyists as well as special interest groups.

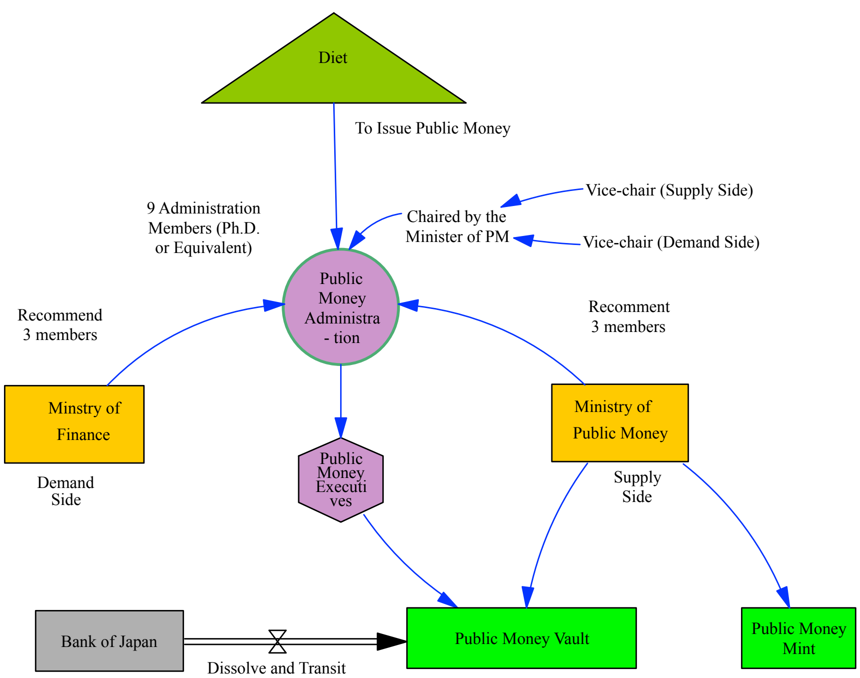

Figure 21.12: Organizational Structure of the Public Money Administration (Japan)

Public Money Policy and Fiscal Policy

Government needs to collect taxes for providing public services to the people. However, tax increase necessary for fiscal spendings during economic recession could dampen the aggregate demand and prolong or worsen the recession. Under the situation, the demand side of the PMA, say, Ministry of Finance, demands for additional amount of money to finance the fiscal deficits. Under the public money system, the demand side of the PMA needs to publicly disclose all fiscal information to justify their demand for additional money issuance. In this way both the supply and demand sides of the PMA interplay one another and perform a "check and balance" mechanism to keep fiscal (and governmental) dominance away from money issuance.

One may still wonder what happens if both sides of the PMA are corrupted, and large amount of money is issued in a short period of time? To guarantee the price stability even under such possibility, a third condition must be clearly stated as in the article 8 of the Public Money Act proposed in (Yamaguchi, 2015, 2015):

C3. Minister of Public Money Administration shall resign, without exception, whenever price level fluctuates beyond ± 2 % in 3 consecutive months, compared with a corresponding period of previous year.

Choice of price index such as Consumer Price Index (CPI), the range of price fluctuation and its period shall be determined nation by nation on the basis of domestic economic conditions in accordance with monetary and financial environment of her neighboring nations.

Spending policies of public money may be outlined in the following categories:

Human Development Public investment in education and research (tuition-free higher education etc.) as human development program for future investment.

Infrastructures Investment for constructing 21st century infrastructures such as IT networks, green energies, and green transportation system.

Social Welfare Universal medical and healthcare program and other social welfare programs.

It should be noted that the Public Money Administration is an entity exclusively responsible for the management of money stock, and nothing else. Thus, under the public money system, the nation's financial system remains the same except the detachment of money creation from commercial lending businesses.

21.5.3 System Behaviors: Four Failures Getting Fixed

Second column of Table 21.3 above summarizes the behaviors of the public money system. Under the public money system, four major system design failures in the debt money system are shown to be removed; that is, (1) monetary and financial instability, (2) accumulated government debts, (3) income inequality between financiers and non-financiers, and (4) environmental destruction.

1. Monetary and Financial Stability

Stability of Money Stock

Let us first examine the failure of monetary and financial stability. Whenever 100% required reserve ratio is introduced, money stock becomes equal to base money, meaning that all money in the economy is issued as public equity by the PMA (one of the government branches), and every commercial bank deposit becomes money (legal tender), as opposed to functional-money under the current system. Accordingly, instability in money stock is stabilized, and it would no longer be affected by the changes in liquidity preferences of depositors, capricious lending behaviors of banks, and debt repayments by borrowers (Yamaguchi and Yamguchi, 2016, 2016).

Financial Stability

Under the public money system, bank runs no longer occur as each unit of demand deposits at each banking institution is fully reserved all the time. This leads to a robust banking system, and abolishment of too-big-too-fail policy.

2. Liquidation of Government Debt

Concerning the system behavior of government debt accumulation, the government now becomes debt-free as its securities are getting paid off with public money whenever they become due (Yamaguchi, 2010, 2010), (Yamaguchi, 2011, 2011), (Yamaguchi, 2012, 2012). Government securities may be used as substitution by commercial banks for attaining 100% reserve ratio during the transition process as discussed in Chapter 16. Consequently, the executive branch of the government (MoF in Japan, and Dept. of the Treasury in the U.S.) becomes free-hand to pursue its public policies without being constrained by the burden of national debts and interest payments.

3. Income Inequality

Income inequality between financiers and non-financiers is reduced by the amount of interests previously concentrated to banking sector through public and private debts. Hence, income inequalities between financiers and non-financiers will be substantially removed over time. However, it should be remarked that no system structure is introduced, as discussed in Chapter 15, to reduce income inequality between workers and stockholders (or capitalists) under the public money system.

4. Improvement of Environmental Protection

Under the present system, banks ultimately decide where to invest and to which industry necessary funds are supplied. The system structure of public money introduces a number of economic incentive loops towards green businesses. One of them, which we believe is significant, is for commercial banks to take depositors' opinion (social aspect of lending business) into account since they will become intermediaries of money between savers and borrowers under the proposed system. In other words, socially responsible investments become more accessible. In this way, the structural cause of forced economic growth at the price of environmental destruction is removed in the public money system.

21.5.4 Transition Steps to the Public Money System

The current debt money system is transitioned to the public money system in the following two steps;

Step 1 Enact, say, the Public Money Act (Yamaguchi, 2015, 2015), thereby replacing the existing laws that authorize a fractional reserve banking system with 100% reserve requirement system.

Step 2 The Public Money Act dissolves the current central bank such as Bank of Japan, and incorporates it into the newly established Public Money Vault administered by the PMA.

Public money system discussed so far in this section did not consider any application of blockchain technology when it was first proposed in (Yamaguchi, 2011, 2011). With our present proposal of electronic public money (EPM) system as in (Yamaguchi and Yamaguchi, 2017b, 2017), the public money system discussed in this section will be referred to as the original public money system in comparison to the EPM.

21.5.5 Payments under Public Money System

Income Inequality caused by transactions fees still remains

Under the public money system, monetary stability is restored and government debts are liquidated (Yamaguchi, 2010, 2010), (**?**, 2013) (Yamaguchi and Yamguchi, 2016, 2016). Yet, payment methods do not change drastically; that is, payment methods ① through ⑥ discussed in Section 21.4 remain the same. In other words, income inequality between bankers and non-bankers are reduced by the amount of interests previously concentrated to bankers through government debts and private debts, since deposits (and debts) are no longer created by banks out of nothing.

Yet, nonbank financiers continue to charge transaction fees so that income inequality between financiers and non-financiers by way of transaction fees still remains as before.

What is needed to reduce the remaining income inequality in the public money system is the introduction of peer-to-peer transaction design, which becomes available through the distributed ledger technology first introduced in Bitcoin (Nakamoto, a, 2008).

21.6 Bitcoin and Blockchain Technology

21.6.1 System Structure of Bitcoin

Before we explore the EPM as money of the futures in the following sections, let us overview Bitcoin here as the first application of blockchain technology. Bitcoin has provided a new method to make peer-to-peer payments electronically across national borders. As described by Andreas (Antonopoulos, 2017, 2017, p.2), Bitcoin consists of:

- A decentralized peer-to-peer network (the Bitcoin protocol)
- A public transaction ledger (the blockchain)
- A set of rules for independent transaction validation and currency issuance (consensus rules)
- A mechanism for reaching global decentralized consensus on the valid blockchain (Proof-of-Work algorithm)

To avoid a trusted party in coin generation, the Bitcoin protocol is designed such that miners gain new amount of Bitcoin as a reward for successfully creating a new candidate block containing Bitcoin transactions, and being confirmed by other network peers. Each block is generated every 10 minutes on average. The maximum amount of Bitcoin supply is predetermined at 21,000,000 BTC that will be attained approximately by the year 2140. A rate of new Bitcoin generation per block is decreased by half in every 210,000 blocks (or 4 years approximately) and each block contained 50 new BTCs for the first four years. Anyone who wish to use Bitcoin can either try to mine new Bitcoin or purchase it at exchangers who facilitate potential buyers and sellers. However, the difficulty of Bitcoin's mining have increased so high that ordinary users with normal computing machine cannot expect to win against other professional miners in the network.

21.6.2 Payments with Bitcoin

⑦ Payments with Bitcoin

It is pointed out in Section 21.2 that bitcoin is neither legal tender nor currency by all means; that is, it must be functional-money just like the present-day bank deposits. Accordingly, if we want to use bitcoin in broader economy, it must be exchanged for currency, or deposits. This aspect of Bitcoin as transaction medium is briefly illustrated in Figure 21.13 as overview of payments with Bitcoin. Therefore, it is better to be called digital (or crypto) ingot, similar to gold ingot. Gold ingots have been historically used to clear trade balances, and are traded as investment commodities nowadays. In this sense, it is appropriate to interpret Bitcoin as digital ingot, which plays a role of functional-money, similar to bank deposits that could be legally refused to accept as a means of transaction payments. Indeed, Figure 21.13 demonstrates how it is constrained as a means of exchange. Figure 21.3 in Section 21.4 illustrates overview of all payment systems we have discussed so far; that it, ① through ⑦.

Figure 21.14 presents its detailed payment system. Even though Bitcoin payments are peer-to-peer and in this sense the same as cash payments in Figure 21.5, it requires additional Bitcoin exchangers, similar to gold traders.

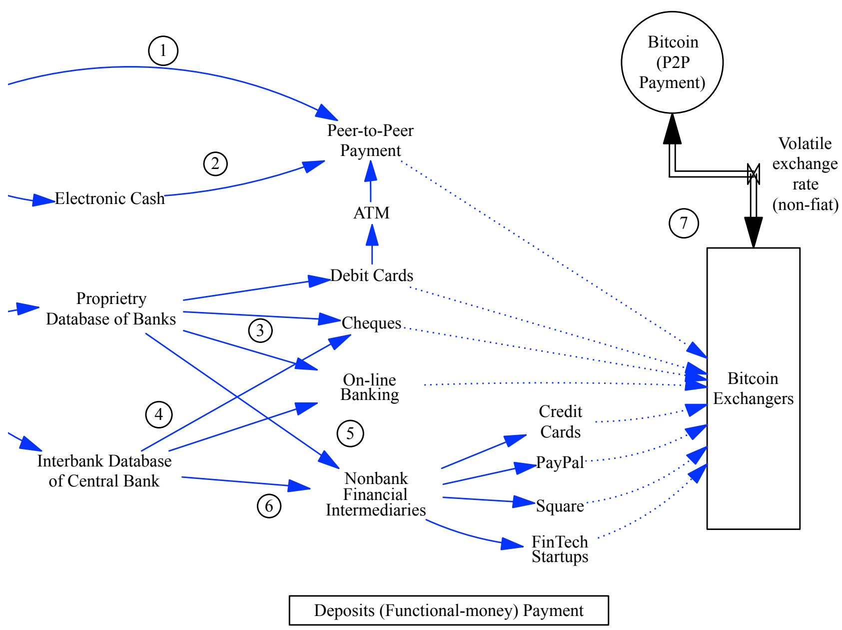

Figure 21.13: Overview of Debt Money and Bitcoin Payments

21.6.3 How Bitcoin Transactions Work?

Distributed Public Ledger

Until the introduction of Bitcoin, the only payment method with digital currency is by electronic cash stored in prepaid cards or other substitutes as illustrated in Figure 21.6. This was due to the difficulty of avoiding the so-called *double-spending* problem and *Byzantine Generals Problem* in the field of distributed computing. Bitcoin practically provided a breakthrough to these challenges with a brilliant idea of public ledger through proof of work.

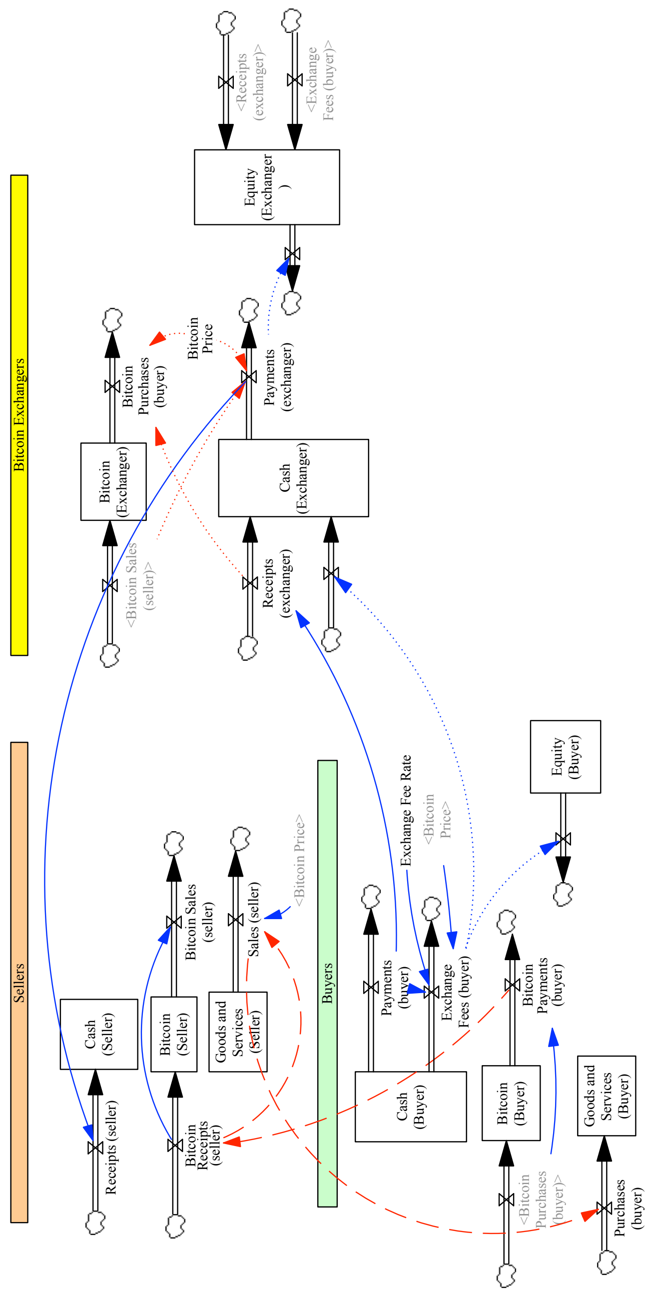

Figure 21.14: Payment System with Bitcoin: Peer-to-Peer

Let us examine how it works in terms of system dynamics modeling framework. In system dynamics, cash flow of peer-to-peer transaction can be easily captured by stock-flow diagram as in Figure 21.15. Dynamic equations of this stock-flow diagram can be written as follows:

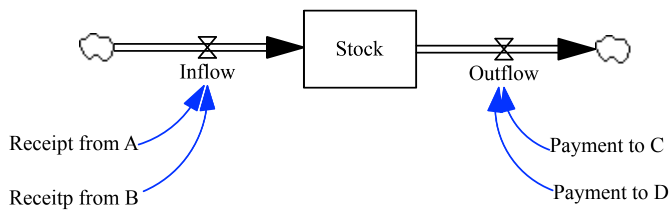

Figure 21.15: Stock-Flow Presentation of Transaction Ledger

$$\begin{aligned} \text{Inflow}_t &= \text{Receipt from A}_t + \text{Receipt from B}_t \\ \text{Outflow}_t &= \text{Payment to C}_t + \text{Payment to D}_t \\ \text{Stock}_{t+1} &= \text{Stock}_t + \text{Inflow}_t - \text{Outflow}_t, \quad t = 0,\ 1,\ 2, \cdots \end{aligned} \tag{21.5}$$

Without losing generality, these equations of stock-flow relation are broken down and re-arranged into an accounting ledger of inputs and outputs relation at a discrete time $t = 0, 1, 2, \cdots$ such that

$$\text{Inputs}_t \begin{cases} \text{Stock(unspent)}_t \\ \text{Receipt from A}_t \\ \text{Receipt from B}_t \end{cases} \implies \text{Outputs}_t \begin{cases} \text{Payment to C}_t \\ \text{Payment to D}_t \\ \text{Stock(unspent)}_{t+1} \end{cases} \tag{21.6}$$

This is how the stock-flow relation in system dynamics is transformed into transaction ledger. In Bitcoin network, new transactions are first propagated across the network and stored in transaction pools of Full Bitcoin nodes located world-wide. Verified transactions are collected and put into a *block* every 10 minutes on average. The so-called miner who has solved the mathematical problem (finding a nonce) first is given the right to create a candidate block and propagate it to the network, generating a specified amount of new Bitcoin as a reward. Once it is validated by participating nodes, the new block is then added on top of the previous chain of blocks called *blockchain*.

As new block is added in this way, validity of the transactions in the latest block is reinforced by having the subsequent blocks built upon the previous block. No centralized authority of trusted third parties such as banks is needed in such system design. This vividly contrasts with privacy model and payments system under the debt money system described above, in which every transaction in our economy has to be executed through the centralized and trusted third parties.

This decentralized peer-to-peer networks of trust realized by blockchain technology are transforming the payment methods in finance. A fundamental difference between the debt money system and Bitcoin is that any records of transaction are maintained by centralized institutions in the debt money system, whereas in Bitcoin they are shared as a global public ledger.

21.7 Challenges facing Bitcoin

Currently, Bitcoin faces fundamental challenges if it were to serve as a robust monetary system; that is, the fixed supply and volatility of its value.

a. Fixed Amount of Bitcoin Supply

The fixed amount of supply pushes up the Bitcoin prices as gold price used to be in the face of increasing demands, imposing deflationary pressure. The system design of fixed supply worked well during the infant phase of Bitcoin, because that attracted more Bitcoin users as its value went up as intended by Satoshi Nakamoto (unidentified) explained in the following internet post[10] :

> As the number of users grows, the value per coin increases. It has the potential for a positive feedback loop; as users increase, the value goes up, which could attract more users to take advantage of the increasing value (Nakamoto, b, 2009).

The increasing value keeps incentivizing miners to invest more in hashing race, making the network more resistant to double-spending attacks. However, this fixed supply reminds us of the structural limitation under the international monetary system based on gold standard, which eventually forced the collapse of dollar-to-gold convertibility in 1971. In other words, as long as its supply is limited, Bitcoin continues to face similar challenges before serving as a sound means of exchange under a growing economy.

b. Volatility of Bitcoin Price

The increasing value has made Bitcoin an investment target, like gold, rather than a means of payment. The volatility of its purchasing power, thus, makes it unsuitable as a means of real transaction of goods and services.

[10]However, Satoshi Nakamoto, the original developer of Bitcoin, suggests that it is technically possible to make Bitcoin as a stable means of exchange if we could find a trusted party who is able to actively manage the supply of money. This is indeed a promising insight in designing peer-to-peer public money systems in the next section.

c. Technical Shortcomings

In addition to these economic problems, Bitcoin faces technical shortcomings arising from the specific technical approach it has adopted in its mechanism design. To incentivize minings in proof-of-work approach, coin generation and block construction (transaction validation) are intertwined, concentrating the important functions of the monetary system into miners. Specifically, system design of Bitcoin results in: (1) high energy costs due to massive computations, (2) risk of validator concentration of power into a few large-scale mining pools, and (3) ambiguity in forming a unique blockchain (forking) and limited scalability. To overcome these shortcomings, entirely new approaches have been proposed such as *Algorand* (Algorithmic Randomness) by Micali (Micali, 2016, 2016), and *Elixxir* (Scalable Digital Sovereignty) by Chaum (Chaum, 2018, 2018).

Current Blockchain Applications as Patchworks

In retrospect Bitcoin was the first application of blockchain technology. More precisely, the overall system design of Bitcoin and the underlying technology were inseparable. However, it is recognized that the idea of blockchain can be applied independent from Bitcoin through utilization of different consensus algorithms other than proof-of-work, and a recent focus has been more on the business application of blockchain technology rather than Bitcoin itself. Blockchain is technically evolving into Distributed Ledger Technology (DLT). Many applications of blockchain technology have been mushrooming not only as Alt(ernative) coins but also as "virtually everything of value and importance to humankind $\cdots$ that can be expressed in code (Tapscott and Tapscott, 2016, page 7)".

However, as pointed out in Section 21.1, the blockchain technology is currently applied to improve financial services of the debt money system by minimizing operating costs of the existing financial institutions.

As long as current blockchain applications continue to be developed on top of the debt money system, they could become nothing more than *blockchain patchworks* since they were not designed to address fundamental problems of the underlying debt money system as depicted in Figure 21.16.

21.8 Electronic Public Money System

21.8.1 Integrated Public Money and Blockchain

The public money system revisited in Section 21.5 is shown to fix system design failures of the debt money system revisited in Section 21.3. Yet its implementation has been difficult since its birth (Yamaguchi, 2011, 2011) because its predecessor, the Chicago Plan in 1933, has been made "taboo" in economics as discussed in Subsection 21.5.1. In Section 21.6, we examined Nakamoto's approach in designing a new electronic payment system that relies on cryptographic proofs in transaction validation and (computational) mining for new

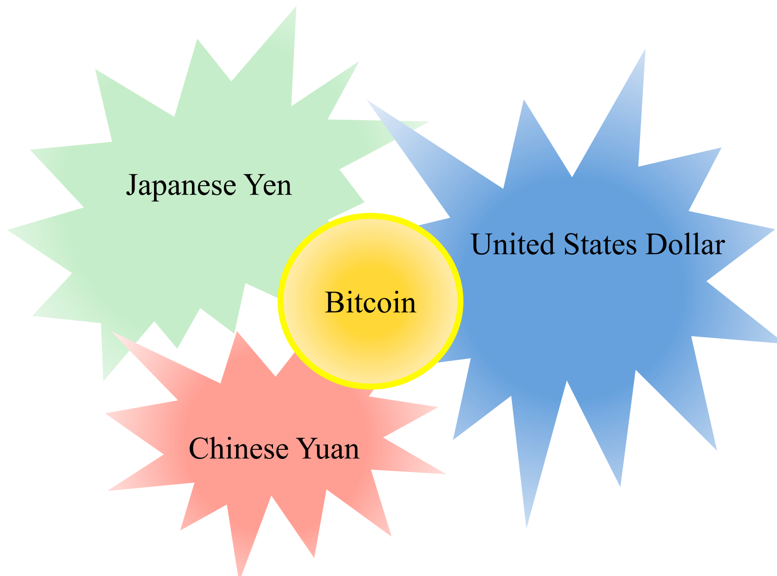

Figure 21.16: Collapsing Debt Money Systems

Bitcoin generation. Yet, the absence of any trusted party to manage the supply of Bitcoin, thus its purchasing power, has led to challenges for Bitcoin to serve as an alternative monetary system to the debt money system.

Under these circumstances, blockchain technology appeared all of sudden as if it were a *savior* toward the public money system, because it could bring back, from a completely different angle of information technology, the old but greatly relevant issue of monetary reform out of the *taboo subject*. The practical use and implementation possibility of blockchain technology for nation's payments system are becoming increasingly hot subject. More specifically, blockchain could be built into a system design of public money to save the current debt money system from its complete meltdown. Such an integrated system design proposal is called *Electronic Public Money (EPM) System* by Yamaguchi and Yamaguchi (Yamaguchi and Yamaguchi, 2017b, 2017).

Figure 21.17 illustrates how two separate developments of concepts since the year 2008, Chicago Plan and Blockchain Revolution, are integrated into a unified design of Electronic Public Money (EPM) system.

21.8.2 Structure of EPM System

The essence of the public money system is the separation of money creation process from commercial lending and investment activities, both of which are done by private banking sector under the current debt money system. This separation of two important functions of monetary system holds true in EPM system design. Thus, as in the original public money system, structure of EPM

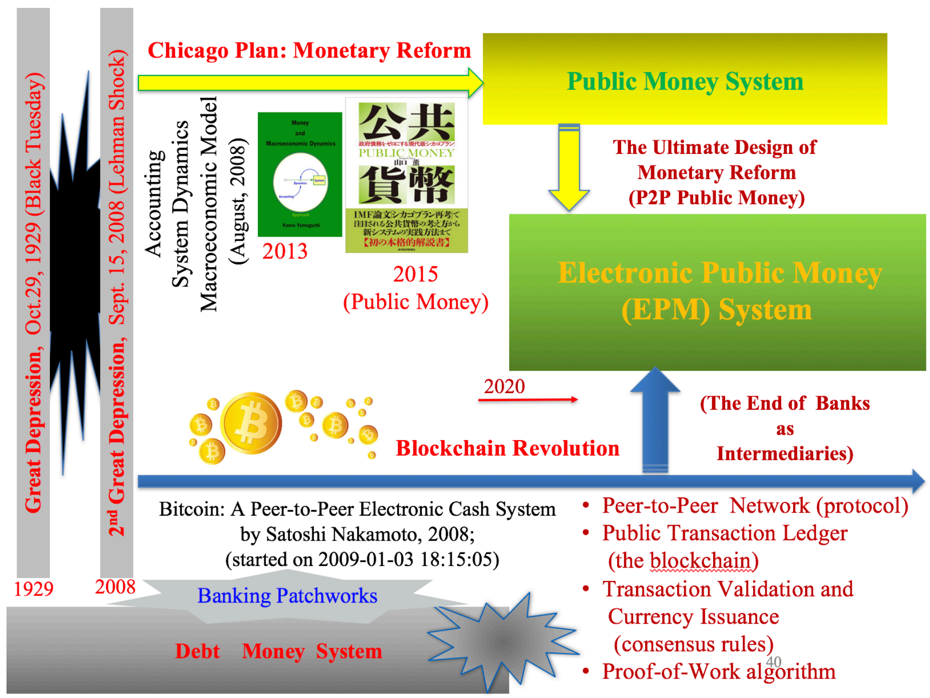

Figure 21.17: Unified System Design of Electronic Public Money

system is featured as follows.

- Electronic public money (EPM) as legal tender is issued at interest-free by the Public Money Administration (PMA) as public equity.
- EPM is put into circulation to sustain economic growth and welfare at interest-free.

It is worth remarking here that the second structural feature of the public money system explained in Section 21.5.2 is missing; that is, "100% required reserve ratio is held for demand deposits". Under the EPM system, payments can be done directly between peer-to-peer parties with electronic cash. Under such system, payments by deposit transfer become less and less needed. Consequently, bank deposits are expected to gradually lose its dominance as chief means of payment, making the second feature of the public money system less irrelevant over time. Even so, nation's financial system will remain the same in a foreseeable future under the EPM system as in the original public money system until a full transition to the EPM system is completed. Accordingly, it is fair to say that, as long as demand deposits exist,

- Commercial banks are required to hold money against every demand deposits (100% required reserve ratio).

As a result, money in the EPM system consists of coins, notes (replacing former central bank notes) and electronic public money (EPM) all issued by the PMA.

Issuance of Electronic Public Money

In order to facilitate economic growth and welfare, EPM is issued by the (supply side of) Public Money Administration, which plays the ultimate role of *a trusted party* as in the original PM system. The PMA is a public institution established under the direct supervision of the legislative branch of the government, and is responsible for managing the amount of EPM stock (supply) as discussed in Section 21.5.2. This vividly contrasts with Bitcoin whose total amount of supply is predetermined to avoid any trusted (third) party in generation of new coins, or the debt money system where deposits are endogenously created and destroyed by commercial bank loans so that money stock cannot be directly controlled even by the central bank.

Public Money Policy and Fiscal Policy

Money stock is managed by the PMA in the EPM system as public money policy. In case of fiscal deficits, *a uniform tax* (a new tax scheme proposed as *public service fees* in Remark 1 below) is increased to meet budgetary balance. This public service policy is conducted by the Ministry of Finance (MoF) in Japan, for instance, in consultation with the PMA. Increasing the tax during economic recession, however, could worsen the recession. In such a case, the PMA could issue additional money (EPM), which will be put into circulation through expansionary fiscal policy. Recall, however, that the fiscal dominance over issuance of money is avoided since any final decisions on the new issuance of money are determined independently of the fiscal needs as explicated in Section 21.5.2.

21.8.3 System Behaviors of EPM Systems

EPM system fixes the four design failures of debt money system as the original public money system is expected to address. As listed below, behaviors of the public money system discussed in Section 21.5.3 are similarly observed under the electronic public money system such as monetary and financial stability, liquidation of government debt, income equality, and environmental protection. Income inequality will be more drastically eliminated because various payment methods will be simplified into peer-to-peer (P2P) payment methods under the EPM system[11]. Hence, system behaviors will be summarized as follows.

a. Stabilization of monetary system and its increased resiliency to the internal and external financial shocks

[11] This point will be further discussed in the last Section 21.10.

b. Liquidation of government debt within each EPM region.[12]

c. Elimination of income inequality between financiers and non-financiers.

d. Environmental protection within each EPM region.

Additionally, we consider that a world-wide network of EPM systems would attain, for example, the following cross-national behaviors.

e. Acceleration of cross-boarder capital flows into socially responsible investments, and environmental projects.

f. Expansion of peer-to-peer micro-lending investments, thereby stimulating community projects and small or medium-sized business opportunities.

g. Reduction of over-indebtedness and social unrests in favor of a sustainable growth path within each EPM region.

21.9 Blockchain-based Money Classified

21.9.1 Classification of Money after the Year 2008

For identifying money of the futures, we are now in a position to classify money, specifically blockchain-based money, To begin with, we broadly define blockchain-based money as (crypto-)money created by blockchain technology that are transacted on blockchain-based payment system. This includes Bitcoin and all other types of 'cryptocurrencies'. Since the emergence of Bitcoin in 2008, more than 1,000 different blockchain-based money have been said to be created as Altcoins (alternative coins). Bitcoin was originally referred to as "peer-to-peer electronic cash" by Nakamoto (Nakamoto, a, 2008). Then all these blockchain-based money began to be called digital currency, virtual currency, digital money, digital cash and cryptocurrency without much care in their usage. Unfortunately, many confusions seem to have emerged as to the usage of the words such as *money* and *currency* in cryptocurrency space. As we have classified different types of money between public money and debt money, and between legal tender and functional-money in Table 21.1, the same classification should be applied to blockchain-based money.

According to our analysis, all Altcoins are similar to Bitcoin as far as their functional aspect as medium of exchange is concerned. Therefore, they should be classified as functional-money because they are not legal tender. On the other hand, the concept of electronic public money (EPM) has been introduced as an another type of blockchain-based money. These two types are positioned in the functional-money and public money columns, respectively, in our extended

[12] As shown in Figure 21.19 below, EPM regions based on different currency are expected to emerge.

classification of Table 21.4 below. Yet, debt money (as legal tender) column between the two still remains blank.

Only recently, as if remaining blank spaces in the classification table are being filled in, other types of blockchain-based money have been proposed and experimented. They are central bank cryptocurrency (CBCC) and crypto-tokens. As a result, four different types of blockchain-based money are newly added into our classification table of money: Crypto-coin, CBCC, Crypto-token, and EPM as shown in the extended Table 21.4. Let us now explore these blockchain-based money in more detail.

Classification of Money (after the Year 2008)

Front: Issuance	Public Money	Debt Money (at interest)	
Back: Fiat Status	Money as Legal Tender		Functional-Money
Non-metal Commodities	Shell, Cloth (Silk) Woods, Stones, etc		
Metal Coinage	Non-precious Metal Coins Gold, Silver & Copper Coins		Metal Ingots (such as Gold)
Paper Notes	Public Money Notes by PM Admin.	Goldsmith Certificates Central Bank Notes	
Digital Accounts & Cards	Public Money Deposits	Central Bank Reserves	Bank Deposits (Credits by Loans)
(After 2008)	< **EPM** >	< CBDC >	< Crypto-Coins >
Digital Tokens (Blockchains & Distributed Ledgers, etc.)	Electronic Public Money issued by PM Admin. (Peer-to-Peer PM)	Central Bank Digital Currency (issued as Base Money)	Bitcoin and approx. 1,000 Altcoins
		< Crypto-token (as Notes)	(as Deposits) >
		· M_1-backed Bank token: MUFG coin (Japan)	
		· M_1-backed Non-Bank token: Zen token (Japan)	
		· M_0-backed EPM token (cash)	

Table 21.4: Classification of Digital token-based Public and Debt Money

21.9.2 Crypto-Coins

Bitcoin as Functional-Money

Crypto-coins, consisting of Bitcoin and Altcoins,[13] are what is often referred to as cryptocurrencies. Before Bitcoin, electronic money (digits) stored in digital cards and other substitutes issued in exchange for *currency* (cash) were the only digital cash or e-cash.[14] From our strict definition of currency and money

[13]Crypto-coins could further be classified into permission or permission-less (public) types, depending on whether a validating node is required a permission to join the network. Permission-type crypto-coins allow more functionality such as higher transaction throughputs. For the purpose of this chapter, however, the distinction between these two may not be needed.

[14]Debit cards and credit cards such as Visa are not digital cash. They are payment instruments used in exchange for deposits at banks through card-issuing companies (non-bank payment service providers) by transfer of bank deposits.

discussed in Section 21.2, Bitcoin must be distinguished from legal tender or currency because we can refuse to accept it in payments. In this sense, it is more appropriate to regard it as "digital ingot" or "crypto ingot" generated by miners similar to gold ingot, which can only be accepted as long as both parties in transaction agree. Accordingly, Bitcoin is categorized as functional-money in the classification of money in Table 21.4, since it functions as money similar to bank deposits under the debt money system. Other crypto-coins (Altcoins), though each crypto-coin may consider different security models and consensus algorithms, are also not legal tender, and only play a role as functional-money under the debt money system.

Readers may now wonder why these crypto-coins are classified under the umbrella of debt money? For example, a new amount of Bitcoin is generated so long as a new candidate block is successfully constructed and validated by other network peers. There is no debt or any form of lending activity is involved in the process. The same principle also applies to Altcoins in general. However, as discussed in Section 21.6, the use of Bitcoin and Altcoins is very limited, and they function not as alternative monetary systems, but as supplementary payment methods under the debt money system. Hence, they are classified under debt money in the sense that they serve as "functional money under the debt money system".

The World's Top 10 Crypto-coins

Their fixed amount of supply caused by the absence of value adjustment mechanism brings about volatility of values. Many crypto-coins are observed to share the same structural challenges as Bitcoin as discussed in Section 21.6, and have been regarded as high-risk and high-return investment products. Accordingly, almost all Altcoins that we know of today are classified as functional-money. Table 21.5 lists top 10 crypto-coins, as of Sept. 2, 2017, according to their

Top 10 Crypto-coins (as of Sept. 2, 2017)

Rank	Name	Market Capitalization	Price
1	Bitcoin	$76,561,792,510	$4629.09
2	Ethereum	$33,622,114,919	$356.22
3	Bitcoin Cash	$9,769,799,507	$590.08
4	Ripple	$8,872,381,573	$0.23
5	Litecoin	$4,196,792,392	$79.56
6	NEM	$2,770,884,000	$0.31
7	Dash	$2,689,302,539	$357.20
8	Ethereum Classic	$1,927,363,497	$20.26
9	Monero	$1,925,085,092	$128.13
10	IOTA	$1,839,117,905	$0.66

Table 21.5: Ranking By Market Capitalization

scales of market capitalization.[15] It has been said that more than 1,000 Altcoins have been created so far and many have already disappeared from the market. Accordingly, the list of top 10 rankings continues to change quarterly. Until recently, Bitcoin has dominated more than 50% of the market capitalization.

21.9.3 Central Bank Cryptocurrency (CBCC)

The current debt money system has been examined to have built-in system design failures that cause monetary and financial instability, government debt accumulation, income inequality and environmental destruction. Hence, the electronic public money (EPM) system has been proposed as its alternative system that eliminates these system failures. Recently a new possibility of utilizing blockchain technology for nation's settlement system is increasingly discussed and experimented by central banks around the world. Yet we have not discussed whether the design failures of debt money system could also be removed if central banks issue digital currencies (CBDC) and cryptocurrencies (CBCC). In other words, the issuance of CBDC and CBCC under the debt money system is left unanalyzed so far in this book.

To answer this question, it's essential to define CBDC and CBCC precisely. CBDC is digital currency issued by central banks; that is, electronic digits stored in the reserve accounts at their traditional data centers. Meanwhile, CBCC is the cryptocurrency (blockchain-based money) issued by central banks through distributed ledger technology and stored in the wallets of its users along with or in replace of central bank notes. Thus, CBCC and M_0-based EPM token (discussed below) become similar type of blockchain-based money in the sense that all EPM tokens are backed by base money under the current debt money system. Some technical proposals have already appeared to implement CBCC such as RSCoin (a permission-type blockchain)(Danezis and Meiklejohn, 2015, 2015).

<Public Money vs CBDC>

From the extended classification Table 21.4 of money after the year 2008, it becomes clear that CBDC has to be discussed vis-a-vis Public Money (PM) in the original PM system, because they are based on the same media of digital numbers. PM is defined above as the money issued by the Public Money Administration (whose issuance is authorized by Congress, Parliament or Diet) under the condition of the 100% reserve ratio for demand deposits in order to remove the four system design failures of the current system.

On the other hand, CBDC is issued when central banks newly allocate deposits accounts among non-banking financial institutions, non-financial corporations and households in addition to the traditional reserve accounts currently held by commercial banks and other financial institutions. In short, anyone can open demand deposit account with the central banks under CBDC.

Then, the question we have to pose more specifically becomes the following:

[15] Source: https://coinmarketcap.com/currencies/

Can CBDC thus issued fix the system design failures of debt money system? There are three major issues, it is analyzed, that would make the actual implementation of CBDC very difficult as follows.

1. Shortage of base money (M_0) due to the fractional reserve banking system
2. Disruptive payment services of private sectors
3. Continuing design failures of the debt money system.

The first issue occurs during the transition phase. Surely the transition from the current system to CBDC will be hindered as soon as reserves of commercial banks are dried up as the demand for conversion from demand deposits (functional-money) to CBDC (legal tender) increases. However, this hindrance could be avoided either by requiring 100% reserve ratio in advance or an additional supply of CBDC through central banks' purchases of government securities held by commercial banks, which has similar effects on the financial market as QE (Quantitative Easing) policies have had. However, QE policy and further injection of reserves into the banking system distorts the financial markets and incur various risks such as inflation under the current system.

The second issue is related to inconvenience caused by CBDC and disruption of financial innovation. Upon transition to CBDC, ordinary depositors will have to open at least two deposits accounts: CBDC demand deposit accounts at the central bank and savings accounts at the commercial banks. Would this inconvenience be accepted by them? Another issue is that CBDC would disrupt payment services industry since central banks will process all payments done by CBDC. Indeed, this is the issue that one of the Fed Governor has already pointed out:

> A central bank-issued digital currency would compete with these and other innovative private-sector products and may stifle innovation over the long run.[16]

Let us now consider the third issue by assuming that the transition is completed irrespective of such inconveniences experienced by users of CBDC. Even so, a more fundamental question remains unsolved. Under the current debt money system, the amount of CBDC (a part of M_0) in circulation is determined by the central banks that are privately owned in many nations. Under the circumstances, CBDC would still be issued at interest and the basic structure of debt money system remains the same. To avoid this monopolistic management of currency by private parties as well as political influences on them, we contend that central banks must be placed under the control of legislative branch of the constitutional government such as Congress, Parliament and Diet, as discussed in Section 21.5.2. Ironically, this reform turns out to be the same mechanism incorporated into the public money system for maintaining price stability.

[16] http://www.coindesk.com/fed-caution-central-bank-digital-currencies/

As we have examined this way, it becomes clear that CBDC cannot remove system design failures, and, consequently, its benefits are minimal in comparison to the public money system. In other words, monetary and financial stability is impossible unless the structural elements of the public money system are incorporated into CBDC.

In addition to these three issues, it should be further pointed out that CBDC could expose the vulnerability of cyber security, because it concentrates the current centralized settlement system furthermore into a single point of failure at the data center of central bank. This makes the nation's financial infrastructure a vulnerable target by an increased number of cyber attacks and potential terrorist attacks. In other words, CBDC will have less tolerance to external attacks and internal malfunctions than the current system.

<EPM vs CBCC>

CBCC is issued by central banks as cryptocurrency. Accordingly, it has to be compared with the blockchain-based money of EPM (Electronic Public Money) for the comparative analysis. Contrary to CBDC, CBCC uses blockchain and may avoid centralization of settlement system as in implementing CBDC. Except this point, implementation issues discussed above under CBDC apply similarly to CBCC since every demand deposits (functional-money) is not backed by base money under the factional reserve banking system, CBCC is continued to be issued by the same central bank of the debt money system.

Differences in institutional design between CBDC and CBCC become clear at this point. Commercial banks no longer need to collect time deposits for investment under CBCC, simply because all transactions will be done on peer-to-peer basis and private investors will find direct investment opportunities by themselves through online peer-to-peer investment platforms. Such peer-to-peer lending businesses are emerging by now.[17] Hence, under such landscape in the coming age of blockchain, it seems desirable that the nation's payment system such as CBCC and EPM will be run by blockchain or, more generally, by distributed ledger technology. An ultimate question then arises; Can CBCC thus issued fix the system design failures of debt money system? In other words, can monetary and financial stability, liquidation of government debt, and reduction of income inequality be attained under CBCC?

The answer would be Yes, if CBCC is to be integrated into EPM for the same reason as CBDC will be merged into PM in order to attain monetary and financial stability.

21.9.4 Crypto-token

To avoid price volatility of crypto-coins, crypto-token is proposed as *stable* token such that one unit of crypto-token is exchanged for one unit of money stock at any time. In Table 21.4, this type of crypto-token with stability of real money is

[17] http://www.coindesk.com/foxconn-wants-take-global-supply-chain-blockchain.

further broken down into the following three groups according to different types of money with which crypto-token is backed.

- M_1-backed Bank token
- M_1-backed Non-Bank token
- M_0-backed EPM token

M_1-backed Bank token

This is the crypto-token issued by banking institutions, and backed by money stock M_1; that is, currency in circulation and demand deposits. As an example, MUGF coin is issued by the Bank of Tokyo-Mitsubishi UFJ (MUFG), Japan's largest bank, at an exchange rate of one MUFG coin for one Yen. According to several media reports, it is under experiment, starting May, 2017, among about 27,000 employees of the bank, and planned to be made available as early as 2019 year as a large scale experiment among 100,000 users.

Another example is the token issued by Santander, a part of the Spanish Santander Group, which is using the Ethereum Blockchain technology. Santander will be the first bank, its officials confirmed, that utilizes the existing public Blockchain for issuing digital currency (or bank token in our classification)[18].

These banks experimenting M_1-backed bank tokens also belong to "R3 CEV's Consortium" that uses Ripple coin (XRP). The Consortium is said to consist of 42 Banks with combined $600 billion market capitalizations, 8 times as big as crypto-coin market capitalizations. Moreover, 60 % of these banks are said to be global SIFIs (Systemically Important Financial Institutions); namely, "too-big-to-fail" banks.

It is interesting to observe that these SIFIs in the Consortium were the banks which received massive bailouts from the US government after the Financial Crisis in 2008, according to the "United States Government Accountability Office (GAO) Report to Congressional Addressees, July 2011"; that is,

> Citigroup Inc., Morgan Stanley, Bank of America Corporation, Barclays, Goldman Sachs, Deutsche Bank, UBS, JP Morgan, Credit Suisse Group, Wells Fargo & Co., Societe Generale, BNP Paribas, Dresdner Bank.[19]

In addition, big Japanese banks and financial institution such as Mizuho, SMBC, and Nomura as well as non-Japanese HSBC are the consortium SIFI members. We predict that global token wars for issuing their own crypto-token will break up among these SIFIs sooner or later in order to enclose clients towards their own crypto-token networks. However, as long as crypto-tokens

[18] According to: https://cointelegraph.com/news/santander-confirms-fiat-backed-token-project-on-ethereum-blockchain

[19] On Nov. 2016, Goldman Sachs, Santander and Morgan Stanley withdrew from the R3 CEV Consortium. J.P Morgan also exited the consortium by April, 2017

are backed by M_1, their stability as blockchain-based money is subject to the system design failure of boom-bust banking crisis under the debt money system.

M_1-backed Non-Bank token

To avoid the volatility of crypto-coin values, another type of *stable* crypto-token backed by money stock M_1 is issued by non-bank consortium, consisting of fin-tech startups and other non-banking companies. For instance, Zen token issued by the Japanese non-bank consortium called Blockchain Collaborative Consortium is now under experiment.[20]

M_0-backed EPM token

M_0-backed EPM token is the third type of crypto-token, which is backed by M_0; that is, base money. In other words, this type of crypto-token is issued only in exchange for base money. In this sense, it is the *most stable* crypto-token. Practically, among two components of base money in equation (21.3), only currencies are in circulation outside of the banking system. Therefore, EPM token, which will be explained in the next chapter as a case, is issued in exchange for currencies (mainly central bank notes) at the designated exchangers who are, in turn, obliged to keep these exchanged notes at their vaults or their reserve accounts at central bank for future conversion into currency. By confining the issuance of crypto-token this way, EPM token has a functional feature of EPM itself as discussed in Section 21.8; 100% reserve ratio for demand deposits or "100% money" as described by Fisher (Fisher, 1945, 1935). Hence, crypto-tokens issued and backed only by base money are classified collectively as M_0-backed EPM token even if whichever type of blockchain technology is applied to the underlying transaction system.

EPM token is in this way introduced as a half way step towards the full implementation of the EPM system for pre-testing its safety and performances in a regional economic environment. Due to this feature of 100% money, EPM token is expected to attract steady demands as the most stable and safe crypto-token for P2P payments, compared with crypto-coins and M_1-backed crypto-tokens under the current debt money system.

21.10 EPM as Money of the Futures

21.10.1 Payments under EPM

So far we have illustrated 7 payment methods, ① through ⑦, using system dynamics stock-flow diagrams. As discussed in sub-section 21.5.5, payment methods do not change drastically under both debt money and public money systems; that is, payment methods ① through ⑥ under the debt money system as discussed in Section 21.4 remain the same under the public money system. Bitcoin payment is additionally added as peer-to-peer (p2p) payment method ⑦ in Figure 21.13.

[20]According to: http://bccc.global/ja/articles/20170705.html (last access on Sep 2, 2017).

What type of payment methods will be dominant when EPM is introduced then? Among these 7 payment methods (① through ⑦), we pose that payment method ① and ② will become peer-to-peer electronic payments as physical cash are replaced with electronic means and underlying payment system evolves to achieve higher transaction volumes under EPM system.

In order for our prediction to be accomplished, EPM has to be recognized as if it is undistinguishable from cash. Indeed, success of EPM as money of the futures depends on whether we can attain its protocol that makes it close to cash payments. We examine EPM protocol separately as money system and payment system.

21.10.2 Design Configuration of EPM Protocol

(A) As Monetary System

To implement EPM world-wide as money of the futures, new EPM protocol needs to be developed. Since the introduction of Bitcoin (Nakamoto, a, 2008), several approaches for attaining network-wide consensus on a single transaction history have been proposed such as Proof of Work (PoW), Proof of Stakes (PoS), Proof of Importance (PoI) and Practical Byzantine Fault Tolerance (PBFT). In the proposed EPM protocol design, issuance of EPM (coin generation transactions in Bitcoin) and transaction validation process must be functionally separated to overcome the technical problems that existing approaches are facing as viable system of money. Let us first discuss design configuration of EPM protocol as money system.

1. **EPM Issuance** EPM has to be exclusively issued by the Public Money Administration (PMA) as discussed in sub-section 21.5.2. In other words, PMA has to be the sole issuer of money, and any other network participants should not be allowed to create additional unit of account unlike commercial banks in the current debt money system and miners in Bitcoin. Hence, our first protocol requirement is that the issuance of EPM has to be solely made available by the PMA. The amount of new issuance is determined by the interplay of demand and supply between PMA and Treasury under the strict price stability objective. Once it is determined, new EPM is put into circulation through government expenditures.

2. **Uniform Tax Rate** Miners collect transaction fees from its users in Bitcoin protocol and payment service providers charges fees from consumers under the current debt money system. Additionally, in order for EPM to be legal tender that are widely used, the government has to accept it as tax payment. In EPM protocol we propose a uniform tax as way for collecting public service fees uniformly, and abolish all other types of taxing methods such as income tax, corporate tax and sales tax. That is to say, the government sets up a *uniform tax rate* as part of fees on all transactions, by building into payment protocol as *public service fees* by

the government. The introduction of the uniform tax rate will drastically simplify the complicated tax system since it could remove bureaucratic processes necessary under the current system, saving significant amount of operational costs while increasing efficiency and reducing frauds.

As an reference level for the tax rate, the Zengin system, Japanese Banks Payment Clearing Network, handled approximately 2,800 trillion yen of domestic fund transfer in 2012, out of the demand deposit of 600 trillion yen outstanding in total. In addition, there are 100 trillion yen of Bank of Japan notes outstanding, which we assume to be used in payments for final consumption expenditure of roughly 250 trillion yen per year. Assuming that the average velocity of cash as 10 times per year, about 1,000 trillion yen of transaction are made in cash payments. In total, about 4,000 trillion yen are used for total payments annually in Japanese economy. General tax revenues in Japan is about 55 trillion yen, and government expenditures are about 100 trillion yen. Given these rough estimates, a uniform tax rate of 2.5% would cover the current level of government expenditures without incurring fiscal deficits. Compared with 8% of the current consumption tax rate in Japan, the estimated uniform tax rate of EPM system is far smaller.

An another advantage of the uniform tax over the current system is individual privacy protection from the government as it is levied against all payments equally, eliminating the need for identification of tax payer's personal information and possibility for tax evasion. In this sense, uniform tax under the EPM system becomes more efficient, transparent and fair.

3. Circulation Adjustment Rate One of primary objectives of public money policy under EPM system is price level stability as discussed in section 21.5. To achieve this, an appropriate policy tool becomes necessary to adjust the amount of EPM in circulation. Whenever the economy is deemed inflationary, the PMA is responsible for withdrawing a portion of EPM in circulation by raising *circulation adjusting rate*, and pull back excess supply of EPM to the national currency vault (digital wallet of the PMA).

4. Anonymity Under existing payment method with physical cash, anonymity is guaranteed; parties involved in the transaction can keep related information private such as who paid to whom, when and how much. The privacy of transaction payments has to be similarly guaranteed if EPM were to be used as money of the futures.

Comparing with the level of anonymity and privacy with cash, many existing blockchain applications could reveal meta data around transactions. For instance, the amount of payments can be easily identified by tracing records and meta data analysis can be performed on the public blockchain. We propose that EPM protocol must provide the same level of anonymity and privacy as cash payments.

(B) As Payments System

So far we have discussed the requirements of EPM protocol as a monetary system. For the EPM to be used as money of the futures, it also has to be convenient and safe as a payment system. These protocol requirements are different from those of monetary system and are more of technical specifications. We propose here three technical requirements of EPM protocol as payment system.

5. Low Transaction Latency Cash payments can be done instantaneously peer-to-peer in a few second, meanwhile credit card payments may takes a month. International remittance by SWIFT may take a couple of days, though it could be shortened into a couple of hours in the near futures.

Compared with latency in the current payments, EPM payment has to be as fast as cash payment. Otherwise, consumers and its users would not switch to EPM payments.

6. Transaction Scalability Payment transactions in countries with high population density become very large. For instance they may be more than few thousands of transactions per second (tps) in Japan at a peak level. If EPM is to be a nation-wide payment system, high level of scalability has to be provided at the payment system level.

7. Security EPM has to be safely stored in every wallets as *store of value* like gold, and be transferred among every users. It also includes security against cryptanalytic attacks and quantum resistance.

We have now proposed seven requirements of EPM protocol. As in the original public money system, the PMA under the EPM system also has to be managed independently but in a perfectly democratic and transparent way to avoid the concentration of power. This includes the comprehensive disclosure of all information related to monetary policy decision process (conditions C1 and C2 discussed in Section 21.5.2). Thus, the EPM protocol must be carefully designed both as monetary and payment systems. For this purpose, the above proposed protocol may not be enough, especially when it is to be used across EPM regions. Figure 21.18 only illustrates payment system of a single EPM region in which the issuance of money is centrally administered by the PMA node(s).

Remark 1: EPM Regions

The effective region of EPM spans across physical borders of nation-states. Transactions of EPM can be made available everywhere on the planet as long as its users accept each nation-state's EPM just as central bank notes today are used everywhere in transactions with cash. Gradually, EPM regions of all nationality begin to emerge world-wide. Figure 21.19 illustrates how each EPM region starts to emerge and begin to overlap as if diverse colors of floral petals open up internationally.

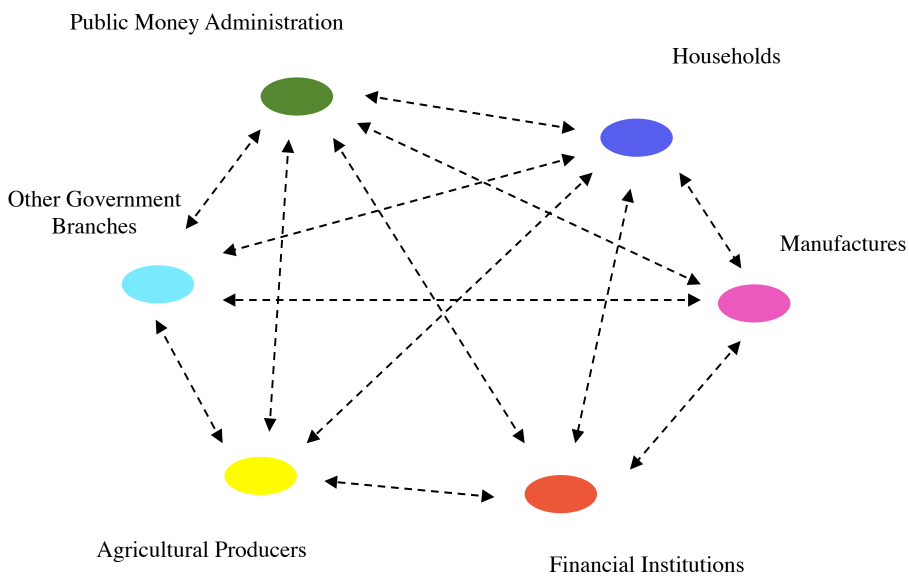

Figure 21.18: A Network within a Single EPM Region

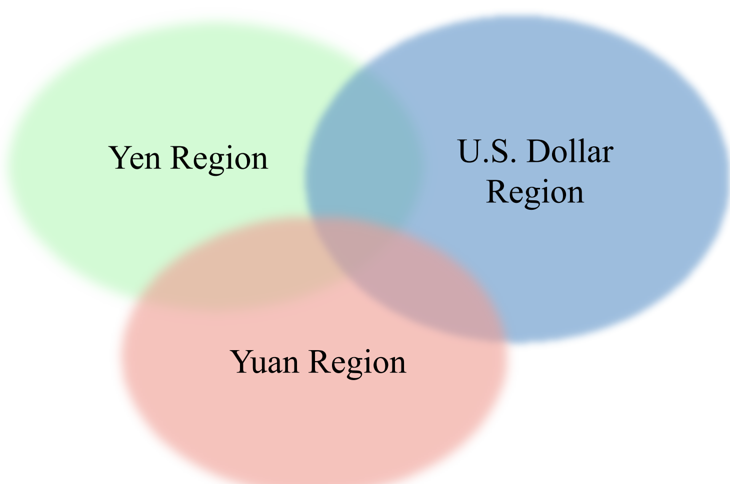

Figure 21.19: A Network of Worldwide EPM systems

Remark 2: Foreign Exchange Markets

Under the EPM system, anyone who wishes to sell or buy foreign currency may well be able to exchange on a peer-to-peer basis. In this sense, the current foreign exchange markets will expand even to individuals who previously had no choice but to pay unnecessarily high transaction fees to the foreign exchange service providers. How should such foreign exchange services be smoothly handled across different EPMs? This becomes another important foreign exchange protocol of EPM. Yet, EPM protocol of foreign exchanges required is left undiscussed here, simply it is beyond our capacity at this moment. Therefore, we'd like to call for World-wide EPM System Forum, instead, to agree such foreign exchange protocol of EPM payment system.

Conclusion

In addition to the overviews of money creation under the current debt money system and newly proposed public money system, this chapter identified four different types of blockchain-based money since the year 2008; Crypto-coin, CBCC, Crypto-token and EPM, and expanded the previous classification of money in Chapter 5.

Then, it is analyzed that all blockchain-based money except EPM are directly or indirectly dependent on the fractional reserve banking system that entails structural defects such as monetary and financial instabilities, government debt accumulation, income inequality and environmental destruction. The distinction between public money and debt money is particularly emphasized to clarify the need for and benefits of structural reform towards the public money system, which is designed to fix these system-driven problems. Then, an integrated design of electronic public money (EPM) system is proposed, which is designed to fully utilize the benefits of public money system by applying blockchain technology. Finally, we proposed seven design configurations of EPM protocol for EPM to become truly money of the futures. This chapter is concluded by calling for the advancement of design configuration and implementation of a world-wide EPM systems openly and inter-disciplinarily among blockchain developers, cryptography researchers, system engineers, economists as well as policy makers.

World-wide EPM System Forum
– as Money of the Futures –

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