Money and Macroeconomic Dynamics

Accounting System Dynamics approach

Edition 5

Kaoru Yamaguchi
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Accounting System Dynamics Approach

Edition 5.3

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Edition 1.0 is published in November, 2013.
Edition 5.0 is e-published in April, 2020.
Edition 5.3 is e-published in April, 2021.

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Cover Design: Daichi Yamaguchi,
       MS in Environmental Engineering

ISBN 978-4-907291-01-3

(Typeset on November 12, 2021)
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 Science University of Ankara
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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 macareconomics 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 Science 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 [90], yet it has been left unnoticed among mainstream 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 [93, 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 field 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 [23].

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 [33], [43], [49], [79] and [80], since my knowledge of accounting was limited in those
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 [95], 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 [97], [98], [99] and [100]. This series of macroeconomic modeling was completed in 2008 as [101] with a follow-up analytical refinement method of price adjustment mechanism in [102] 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. 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.

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1 In addition to these books, a paper dealing with corporate financial statements [3] was published in 2002. However, current research for modeling financial statements is independently carried out here with a heuristic objective in mind.
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: [19], [20], [21], [22], [24], [25], [26], [27], [28], [29], [30], [31], [37], [41], [71], [72]. 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 [86]”. 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 [101].

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 and toward a better world. On the next day of the presentation of my paper 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 occurred 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
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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!

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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.

Chapter 5 explores the nature of money and its creation through a fractional reserve banking under current debt money system. Functional-money creation processes under both flow and stock approaches are comparatively investigated step by step from the case of the gold standard to the case of loan to banks, then loan to government.

Chapter 6 continues the analysis of money creation from the previous chapter, 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 7 expands the analysis of money to interest and examines the equity distribution between non-financial sector and banks. 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.

Part III Macroeconomic Systems of Debt Money

Chapter 8 discusses a typical Keynesian macroeconomic model of aggregate demand where Say’s law no longer holds by applying system dynamics adjustment process. Then, a Keynesian IS-LM equilibrium model is explored within the framework of monetary circulation among producers, consumers, government and banks.

Chapter 9 integrates real part and monetary part of macroeconomic activities analyzed in the previous chapter by distinguishing nominal and real units of macroeconomic variables such as nominal vs real interest rates and nominal vs real GDP.

Chapter 10 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 IV Open Macroeconomic Systems of Debt Money

Chapter 11 sets off macroeconomic analyses of open debt money systems through chapter 11. 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 12 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 macroeconomic model of open macroeconomies as a closed system of debt money.

Part V Macroeconomic Systems of Public Money

Chapter 13 sets off our macroeconomic analyses of public money systems through chapter 15. 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 14 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 15 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 16 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 17 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 VI Electronic Public Money

Chapter 18 explores a new public money system in the age of blockchain and crypto-money. Electronic Public Money in the form of crypto-money is posed to be 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 the book 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.
Postscript
Due to the budgetary constraint\textsuperscript{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.

\textsuperscript{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\footnote{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.} 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\cite{17}. 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\cite{18}, 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.
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 [10], 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 a system consisting of about 30 thousand genes. Yet they are created by four building blocks of DNA.

**Textbooks and Softwares**

Several textbooks are now available for learning how to build a system with the above four building blocks such as [73] and [82] for business and management modeling, and [56] and [16] for sustainable environment. The reader is strongly recommended to learn system dynamics with these textbooks. I regularly use [73], [82] and [56] 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 $\tau$; that is, time is depicted as a real number such that $\tau = 1, 2, 3, \ldots$. 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 $\tau$ 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 $\tau$, 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 $\tau$. Then stock can be defined as $x(\tau)$ where $\tau$ can be any real number.
CHAPTER 1. SYSTEM DYNAMICS

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

<table>
<thead>
<tr>
<th>Physical Stock</th>
<th>Non-Physical Stock</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Natural Stock</td>
<td>• Information</td>
</tr>
<tr>
<td>• Capital Stock</td>
<td>• Psychological Passion</td>
</tr>
<tr>
<td>• Goods-in-Process and Use</td>
<td>• Indexed Figures</td>
</tr>
</tbody>
</table>

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, \( \tau = 0, 1, 2, 3, \ldots \) 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, \( \tau \) 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, $\tau$ 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 $\tau$ 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.

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

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

To avoid a confusion derived from dual notations of time, $\tau$ 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 $\tau$ 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 $\tau$ and $\tau + 1$, the amount of stock at the $t$-th interval $x(t)$ could be defined as a balance at a beginning point $\tau$ of the period or an ending point $\tau + 1$ of the period; that is,

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

or

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

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

$$x(t+1) = x(t) + f(t) \quad t = 0, 1, 2, 3, \cdots \quad (1.4)$$
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

\[
x(t) = x(t-1) + f(t) \quad t = 1, 2, 3, \cdots \tag{1.5}
\]

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:

\[
x(t) = x(t) - \frac{1}{n} \left( t - \frac{t}{n} \right) + f \left( t - \Delta t \right) \frac{\Delta t}{n} \tag{1.7}
\]

Let us further define

\[
\lim_{\Delta t \to 0} \frac{x(t) - x(t - \Delta t)}{\Delta t} = \frac{dx}{dt} \tag{1.8}
\]

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

$$ dx = f(t)dt $$

Here, $dt$ is technically called \textit{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

$$ x(t) = x(0) + \int_0^t f(u)du $$

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. 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:

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

$$ x(t) = x(t - dt) + f(t - dt) \ast dt, $$

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

$$ x(t) = \text{INTEG}(f(t), x(0)). $$
- 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

\[
f(t) = a \tag{1.12}\]

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

\[
x(t) = x(0) + \int_0^t a \, du = x(0) + at \tag{1.16}\]

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. DYNAMICS IN ACTION

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:\(^3\):

\[
 f(t) = t \tag{1.17}
\]

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](image)

**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 approximation.

---

\(^3\) 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).

\[
 f(t) = t \times \text{unit converter}
\]

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.
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, $10 \times 10 \times 1/2 = 50$. 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.
1.3. DYNAMICS IN ACTION

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

<table>
<thead>
<tr>
<th>$t$</th>
<th>$x(t)$</th>
<th>$dx$</th>
<th>$t$</th>
<th>$x(t)$</th>
<th>$dx$</th>
<th>$t$</th>
<th>$x(t)$</th>
<th>$dx$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.0</td>
<td>0.00</td>
<td>0.00</td>
<td>5.0</td>
<td>11.25</td>
<td>2.50</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0.5</td>
<td>0.00</td>
<td>0.25</td>
<td>5.5</td>
<td>13.75</td>
<td>2.75</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1.0</td>
<td>0.25</td>
<td>0.50</td>
<td>6.0</td>
<td>16.50</td>
<td>3.00</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>3</td>
<td>1.5</td>
<td>0.75</td>
<td>0.75</td>
<td>6.5</td>
<td>19.50</td>
<td>3.25</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>4</td>
<td>2.0</td>
<td>1.50</td>
<td>1.00</td>
<td>7.0</td>
<td>22.75</td>
<td>3.50</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>5</td>
<td>2.5</td>
<td>2.50</td>
<td>1.25</td>
<td>7.5</td>
<td>26.25</td>
<td>3.75</td>
</tr>
<tr>
<td>6</td>
<td>6</td>
<td>6</td>
<td>3.0</td>
<td>3.75</td>
<td>1.50</td>
<td>8.0</td>
<td>30.00</td>
<td>4.00</td>
</tr>
<tr>
<td>7</td>
<td>7</td>
<td>7</td>
<td>3.5</td>
<td>5.25</td>
<td>1.75</td>
<td>8.5</td>
<td>34.00</td>
<td>4.25</td>
</tr>
<tr>
<td>8</td>
<td>8</td>
<td>8</td>
<td>4.0</td>
<td>7.00</td>
<td>2.00</td>
<td>9.0</td>
<td>38.25</td>
<td>4.50</td>
</tr>
<tr>
<td>9</td>
<td>9</td>
<td>9</td>
<td>4.5</td>
<td>9.00</td>
<td>2.25</td>
<td>9.5</td>
<td>42.75</td>
<td>4.75</td>
</tr>
<tr>
<td>10</td>
<td>10</td>
<td>10</td>
<td>5</td>
<td>11.25</td>
<td>2.50</td>
<td>10.0</td>
<td>47.50</td>
<td></td>
</tr>
</tbody>
</table>

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

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

<table>
<thead>
<tr>
<th>$f(t)\ dt$</th>
<th>1</th>
<th>1/2</th>
<th>1/4</th>
<th>1/8</th>
<th>1/16</th>
</tr>
</thead>
<tbody>
<tr>
<td>Euler</td>
<td>45</td>
<td>47.5</td>
<td>48.75</td>
<td>49.375</td>
<td>49.6875</td>
</tr>
<tr>
<td>Runge-Kutta</td>
<td>50</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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.

$$x(t + dt) = x(t) + f(t + rac{dt}{2})dt$$  \hspace{1cm} (1.20)

In our simple linear example here, it is calculated as

$$f(t + rac{dt}{2}) = t + rac{dt}{2}$$  \hspace{1cm} (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:

\[ f(t) = t^2 \]  

(1.22)

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

\[ x(t) = \int_0^t u^2 \, du = \frac{t^3}{3} \]  

(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 \( t \).

![Nonlinear Flow of Time](image)

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:

\[ x(t) = \sum_{i=0}^{t-1} i^2 \]  

(1.24)
1.3. DYNAMICS IN ACTION

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 \( dt \).

\[
f(t + \frac{dt}{2}) = t^2 + tdt + \frac{dt^2}{4}
\]

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 \( x(6) \)

<table>
<thead>
<tr>
<th>( f(t) )( dt )</th>
<th>1</th>
<th>1/2</th>
<th>1/4</th>
<th>1/8</th>
<th>1/16</th>
</tr>
</thead>
<tbody>
<tr>
<td>Euler</td>
<td>55</td>
<td>63.25</td>
<td>67.55</td>
<td>69.75</td>
<td>70.87</td>
</tr>
<tr>
<td>Runge-Kutta 2</td>
<td>71.5</td>
<td>71.87</td>
<td>71.96</td>
<td>71.99</td>
<td>71.99</td>
</tr>
<tr>
<td>Runge-Kutta 4</td>
<td>72.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

\[
x(t + dt) = x(t) + \frac{f(t) + 4f(t + \frac{dt}{2}) + f(t + dt)}{6} \, dt
\]

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.

\footnote{For detailed explanation, see [12], section 2.8, pp.103 - 107 and 388 - 391.}
Table 1.5: 2nd- and 4th-Order Runge-Kutta Method \((dt = 1)\)

<table>
<thead>
<tr>
<th>(t)</th>
<th>(x(t))</th>
<th>Runge-Kutta 2</th>
<th>(x(t))</th>
<th>Runge-Kutta 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0.25</td>
<td>0</td>
<td>0.33</td>
</tr>
<tr>
<td>1</td>
<td>0.25</td>
<td>2.25</td>
<td>0.33</td>
<td>2.33</td>
</tr>
<tr>
<td>2</td>
<td>2.5</td>
<td>6.25</td>
<td>2.66</td>
<td>6.33</td>
</tr>
<tr>
<td>3</td>
<td>8.75</td>
<td>12.25</td>
<td>9</td>
<td>12.33</td>
</tr>
<tr>
<td>4</td>
<td>21</td>
<td>20.25</td>
<td>21.33</td>
<td>20.33</td>
</tr>
<tr>
<td>5</td>
<td>41.25</td>
<td>30.25</td>
<td>41.66</td>
<td>30.33</td>
</tr>
<tr>
<td>6</td>
<td>71.5</td>
<td></td>
<td>72</td>
<td></td>
</tr>
</tbody>
</table>

\[ f(t) = \text{RANDOM UNIFORM (Minimum, Maximum)} \] (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.

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:

\[ x(t + 1) = x(t) + f(x(t)), \quad t = 0, 1, 2, \cdots \]  

(1.28)

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

\[ \frac{dx}{dt} = f(x) \]  

(1.29)

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

\[ f(x) = ax \]  

(1.30)

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

\[ \frac{dx}{dt} = ax \]  

(1.31)

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

\[ x(t) = x(0)e^{at} \quad \text{where} \; e = 2.7182818284590452354 \cdots \]  

(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:

\[ x(t + 1) = x(t) + ax(t), \; t = 0, 1, 2, \cdots \]  

(1.33)

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

\[ x(t) = x(0)(1 + a)^t \]  

(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

<table>
<thead>
<tr>
<th>$f(t) , dt$</th>
<th>1</th>
<th>1/2</th>
<th>1/4</th>
<th>1/8</th>
<th>1/16</th>
</tr>
</thead>
<tbody>
<tr>
<td>Euler</td>
<td>259.374</td>
<td>265.33</td>
<td>268.506</td>
<td>270.148</td>
<td>270.984</td>
</tr>
<tr>
<td>Runge-Kutta 2</td>
<td>271.408</td>
<td>271.7191</td>
<td>271.8004</td>
<td>271.8212</td>
<td>271.8264</td>
</tr>
<tr>
<td>Runge-Kutta 4</td>
<td>271.8279</td>
<td>271.828169</td>
<td>271.828182</td>
<td>271.828182</td>
<td>271.828182</td>
</tr>
</tbody>
</table>

\[
x(t) = x(0) \left[ \lim_{n \to \infty} \left( 1 + \frac{a}{n} \right)^n \right]^t
= x(0) \left[ \lim_{n \to \infty} \left( 1 + \frac{1}{n} \right)^{nt} \right]
= x(0)e^{at}
\] (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 $x(10) = 100e^{0.1 \times 10} = 100e^1 = 271.828182459 \cdots$. 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 $\uparrow$ $\rightarrow$ an increase in stock $\uparrow$ $\rightarrow$ an increase in flow $\uparrow$. 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.

\[
ln2 = at \implies t = \frac{0.693147}{a}
\] (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 [73].

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](image)

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 \( t, t = 0, 1, 2, \ldots \), 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

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

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

\[
f(0) = \frac{f(t)}{e^{at}} : \text{Present Value (Continuous)} \quad (1.38)
\]
Streams $f(t)$, $t = 0, 1, 2, \ldots$, 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:

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

In the case of continuous time, they are obtained as

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

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 continuous. 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\( \uparrow \) \( \rightarrow \) a decrease in stock\( \downarrow \) \( \rightarrow \) a decrease in flow\( \downarrow \). This stabilizing relation is called a balancing or negative feedback in system dynamics. Figure 1.11 illustrates this balancing feedback stock-dependent relation.

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

\[
f(x) = \frac{x^* - x(t)}{AT}
\]

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

\[
\frac{d(x(t) - x^*)}{x(t) - x^*} = -\frac{dt}{AT}
\]

Then integrate both side to obtain

\[
ln(x(t) - x^*) = -\frac{t}{AT} + C,
\]

where \( ln \) denotes natural logarithm. This is further rewritten as

\[
x(t) - x^* = e^{-\frac{t}{AT}} e^C
\]
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](image)

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.

\[
 f(x) = -\frac{x(t)}{AT} \tag{1.47}
\]

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.

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.

![Figure 1.13: Exponential Decay](image)
Examples of Exponential Decay

Figure 1.14 illustrates this stock-dependent feedback relation.

![Figure 1.14: Examples of Exponential Decay](image)

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](image)

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

\[
\begin{align*}
\text{Inflow} &= \text{Stock} \times \text{Inflow Fraction} \\
\text{Units: unit/Year} \\
\text{Inflow Fraction} &= 0.1 \\
\text{Units: 1/Year } [0,1,0.01] \\
\text{Outflow} &= \text{Stock} \times \text{Outflow Fraction} \\
\text{Units: unit/Year} \\
\text{Outflow Fraction} &= 0.04 \\
\text{Units: 1/Year } [0,1,0.01] \\
\text{Stock} &= \text{INTEG ( Inflow-Outflow, 100)} \\
\text{Units: unit}
\end{align*}
\]

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:
1.5. SYSTEM DYNAMICS WITH ONE STOCK

\[ f(x) = ax(t)b(t), \text{ where } b(t) = \frac{x^*-x(t)}{x^*} \]  

(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.

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.

\[ f(x) = (a - b(t))x(t) \]  

(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

\[ b(t) = a \frac{x(t)}{x^*} \]  

(1.50)
In this case the above function becomes

\[ f(x) = (a - b(t))x(t) = a \left( \frac{x^* - x(t)}{x^*} \right) x(t) \]  

(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 $y$.

\[
\begin{align*}
\frac{dx}{dt} &= f(x, y) \\
\frac{dy}{dt} &= g(x, y)
\end{align*}
\] (1.52)

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.

\[
\frac{dx}{dt} = -f(x, y) \quad (1.54)
\]

\[
\frac{dy}{dt} = f(x, y) = ax(t)y(t) = a(b - y(t))y(t) \quad (1.55)
\]

Figure 1.22: S-shaped Growth Model

Figure 1.23 illustrates its behaviors for the values \(a = 0.001\) and \(b = 100\).

This relation is also reduced to

\[
\frac{dx}{dt} + \frac{dy}{dt} = 0 \quad (1.56)
\]

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](image1)

![Figure 1.25: Overshoot & Collapse Behavior](image2)
Examples of Overshoot and Collapse

One of the favored examples of overshoot and collapse model is the decline of the Mayan empire in [4].

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:

\[
\frac{dx}{dt} = ay, \ x(0) = 1, \ a = 1
\]  
(1.57)

\[
\frac{dy}{dt} = -bx, \ y(0) = 1, \ b = 1
\]  
(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](image)

![Figure 1.27: Oscillation under Euler Method](image)
1.7. DELAYS IN SYSTEM DYNAMICS

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 [7] 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 [36, 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...
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](image)

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.
1.7. DELAYS IN SYSTEM DYNAMICS

1.7.1 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.

![First-Order Information Delays Diagram](image)

**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 [73].
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.

![Second-Order Information Delays](image)

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).
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
CHAPTER 1. SYSTEM DYNAMICS

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 \( x \rightarrow y \rightarrow z \rightarrow x \), and \( x \rightarrow z \rightarrow y \rightarrow x \). 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.

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) [51], 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 \( z \).

\[
\frac{dx}{dt} = f(x, y, z) \quad (1.59)
\]

\[
\frac{dy}{dt} = g(x, y, z) \quad (1.60)
\]

\[
\frac{dz}{dt} = h(x, y, z) \quad (1.61)
\]
1.8. SYSTEM DYNAMICS WITH THREE STOCKS

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:

\[
\begin{align*}
\frac{dx}{dt} &= -a(x - y) \quad (1.62) \\
\frac{dy}{dt} &= -xz + bx - y \quad (1.63) \\
\frac{dz}{dt} &= xy - cz \quad (1.64)
\end{align*}
\]

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.

![Lorenz Feedback Loop](image)

Figure 1.37: Lorenz Feedback Loop

Equilibrium of this Lorenz equations is obtained such that:

\[
\begin{align*}
x^* &= \pm \sqrt{(b - 1)c} \quad (1.65) \\
y^* &= \pm \sqrt{(b - 1)c} \quad (1.66) \\
z^* &= b - 1 \quad (1.67)
\end{align*}
\]

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 [42]).

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
equilibrium, instead they begin to be attracted to a phase diagram, called \textit{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.

\textbf{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 \textit{strange attractor} or \textit{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.
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:

\[ x_{t+1} = ax_t(1 - x_t) \quad t = 0, 1, 2, 3, \ldots \]  

(1.68)

(See Chapter 15 Discrete Dynamical Systems in [42])

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

\[ f(t) = ax_t(1 - x_t) - x_t \]  

(1.69)

Figure 1.40: Chaos in Logistic Function

As coefficient a increases stock x produces n-period oscillations \( n = 2, 4, 8, \ldots \), 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

\[ y_{t+1} = y_t + ay_t(b - y_t) \quad t = 0, 1, 2, 3, \ldots \]  

(1.70)

In other words, flow becomes

\[ f(t) = ay_t(b - y_t) \]  

(1.71)
which also becomes the same as the right-hand side of the equation (1.68) for $b = 1$.

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 $a = 0.0272$. 

Figure 1.41: Chaos in S-shaped Limit to Growth
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,
\[
\frac{dx}{dt} = f(t, x)
\]  
(1.72)

Accordingly, the Runge-Kutta methods need to be more generally formulated as follows\(^5\)

2nd-Order Runge-Kutta Method

\[
\begin{align*}
dx_1 &= f(t, x)dt \\
dx_2 &= f(t + dt, x + dx_1)dt \\
dx &= \frac{dx_1 + dx_2}{2} \\
&= \frac{f(t, x) + f(t + dt, x + dx_1)}{2} dt
\end{align*}
\]  
(1.73-1.75)

4th-Order Runge-Kutta Method

\[
\begin{align*}
dx_1 &= f(t, x)dt \\
dx_2 &= f(t + \frac{dt}{2}, x + \frac{dx_1}{2})dt \\
dx_3 &= f(t + \frac{dt}{2}, x + \frac{dx_2}{2})dt \\
dx_4 &= f(t + dt, x + dx_3)dt \\
dx &= \frac{dx_1 + 2dx_2 + 2dx_3 + dx_4}{6}
\end{align*}
\]  
(1.76-1.80)

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.

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Chapter 2

Demand and Supply

This chapter 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

---

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
2.2. UNIFYING THREE SCHOOLS IN ECONOMICS

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 [78]. 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 [90]. 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 [87] under the supervision of Professor Jay W. Forrester. The reader can easily replace them with his or her own demand and supply schedules.

<table>
<thead>
<tr>
<th>Price</th>
<th>Quantity Demanded</th>
<th>Quantity Supplied</th>
</tr>
</thead>
<tbody>
<tr>
<td>$ 5</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>$ 10</td>
<td>73</td>
<td>40</td>
</tr>
<tr>
<td>$ 15</td>
<td>57</td>
<td>57</td>
</tr>
<tr>
<td>$ 20</td>
<td>45</td>
<td>68</td>
</tr>
<tr>
<td>$ 25</td>
<td>35</td>
<td>77</td>
</tr>
<tr>
<td>$ 30</td>
<td>28</td>
<td>84</td>
</tr>
<tr>
<td>$ 35</td>
<td>22</td>
<td>89</td>
</tr>
<tr>
<td>$ 40</td>
<td>18</td>
<td>94</td>
</tr>
<tr>
<td>$ 45</td>
<td>14</td>
<td>97</td>
</tr>
<tr>
<td>$ 50</td>
<td>10</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 2.1: Demand and Supply Schedules in [87]

\footnote{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.

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 [90]. 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
2.3. TÂTONNEMENT ADJUSTMENT BY AUCTIONEER

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

$$D(p^*) = S(p^*)$$  \hspace{1cm} (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 [90]. 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].

![Figure 2.3: Auctioneer’s Tâtonnement Model](image)

Mathematically, the model is formulated as follows:
\[
\frac{dp(t)}{dt} = f(D(p) - S(p), \lambda)
\]

where \( f \) is excess demand function and \( \lambda \) is a price adjustment coefficient. In the model \( f \) is further specified as

\[
f = \lambda \frac{D(p) - S(p)}{D(p) + S(p)} p
\]

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. 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
illuminates. I encountered this chaotic price behavior unexpectedly when I was constructing a pure exchange economic model using S language under UNIX environment in [91].

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 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 [90]. 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 [87], 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 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%.

<table>
<thead>
<tr>
<th>Inventory Ratio</th>
<th>0.6</th>
<th>0.7</th>
<th>0.8</th>
<th>0.9</th>
<th>1</th>
<th>1.1</th>
<th>1.2</th>
<th>1.3</th>
<th>1.4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effect on Price</td>
<td>1.8</td>
<td>1.55</td>
<td>1.35</td>
<td>1.15</td>
<td>1</td>
<td>0.875</td>
<td>0.75</td>
<td>0.65</td>
<td>0.55</td>
</tr>
</tbody>
</table>

Table 2.2: Effect of Inventory Ratio on Price

Mathematically, the model is formulated as follows:

\[
\frac{dp(t)}{dt} = p^* - p(t) \quad \text{PCD}
\]  

(2.4)

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

\[
p^* = p(t)g(\theta)
\]  

(2.5)

Function \( g(\theta) \) is a formal presentation of "Effect on Price", and \( \theta \) 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

\[
\frac{dx(t)}{dt} = S(p) - D(p)
\]  

(2.6)

\[
x^* = \alpha D(p)
\]  

(2.7)

where \( \alpha \) 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
\[
g(\theta) = \frac{1}{\theta e}, \quad \text{where} \quad \theta = \frac{x(t)}{x^*} \quad \text{in this section} \quad (2.8)
\]
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
\[
p^* = p(t) g(\theta) = p(t) \frac{1}{\theta e} = \frac{p(t)}{(\frac{x(t)}{x^*}) e} \quad (2.9)
\]

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 \( \theta \) is obtained as a ratio of labor supply and demand. For interest rate adjustment, \( g(\theta) \) becomes effect on interest rate and \( \theta \) is calculated as a ratio of money stock and demand.

---

³ Elasticity of the function \( g \) can be easily calculated as
\[
\text{Elasticity} \equiv - \frac{dg}{g} \frac{d\theta}{\theta} = - \frac{d\theta}{\theta} \frac{\theta}{g} = - \left( \frac{-e}{\theta^{e+1}} \right) \frac{\theta}{g} = e
\]
The function \( g(\theta) \) is, thus, shown to have a uniform elasticity \( e \) over its entire range.
2.5. LOGICAL VS HISTORICAL TIME

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.

Figure 2.9: Effects of the Changes in Demand, Supply and Inventory Coverage 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 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.
CHAPTER 2. DEMAND AND SUPPLY

Figure 2.10: Auctioneer vs Inventory Price Mechanism Compared

Figure 2.11: Auctioneer vs Inventory Price Behaviors

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.

### 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 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:

\[
\text{Supply (Inventory)} = \text{Supply Function (Price (Inventory))} + \frac{\text{Inventory Gap}}{\text{Inventory Adjustment Time}} \tag{2.10}
\]

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

\[
\frac{dx(t)}{dt} = S^*(p) - D(p) \tag{2.11}
\]

\[
S^*(p) = S(p) + \frac{x^* - x(t)}{IAT} \tag{2.12}
\]

where \(IAT\) is inventory adjustment time.

![Figure 2.12: Historical Price Stability with Adjusted Supply Schedule (1)](image)

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)](image)

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 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 [65] 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 [90, 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[90, 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 [40, pp.51-51]." I have indicated [90] 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, [40] and [70]. 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.

\[
\begin{align*}
\text{Consumer 1} &= (10, 6) \\
\text{Consumer 2} &= (6, 15) 
\end{align*}
\]  

(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
Let us assume that commodity 1 becomes a numéraire, 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].

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\(^4\)See the appendix for detail.
2.7. A PURE EXCHANGE ECONOMY

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 excess demand, and \( \alpha, \lambda \) 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](image)

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 mech-
anism 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.

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 [91] for details).

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, 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 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 2.20: Price Movement of Period 1, 2, 4 and Chaos Caused by Tastes](image)

Figure 2.21 is produced by changing the values of preferences $\alpha$. It indicates that as the values of $\alpha$ 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 [91] and [92]).
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 [90], 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” [93, Chapter 5] and “Toward A New Social Design” [90, 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

![Diagram showing co-flows of goods and 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 [114]. 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:

$$\vec{x}^h = (x^h_1, x^h_2, \ldots, x^h_n), \quad h \in H.$$  \hfill (2.14)

Total supply of commodities in the economy is obtained as

$$\bar{x}_i = \sum_{h \in H} \vec{x}^h_i, \quad i = 1, 2, \ldots, n.$$  \hfill (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

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

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

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

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

where $\hat{\alpha}_i^h = \frac{\alpha_i^h}{\sum_{i=1}^{n} \alpha_i^h}$ and $\sum_{i=1}^{n} \hat{\alpha}_i^h = 1$.  \hfill (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

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

Then, excess demand functions are calculated as

$$\zeta_i(p) = \frac{1}{p_i} \sum_{h \in H} \hat{\alpha}_i^h I_h(p) - \bar{x}_i, \quad i = 1, 2, \ldots, n.$$  \hfill (2.21)
An equilibrium of the economy is defined to be a situation in which all markets clear for some price $p^*$, that is,

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

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

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

where $a_{ij} = \sum_{h \in H} \hat{\alpha}_{i,j}^h \bar{x}_h$.

It is shown in [40, p.100] that there exists a non-trivial positive equilibrium price $p^* > 0$. The existence of equilibria in an exchange economy is more generally shown by Smale[70]. 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

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

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

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

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

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

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

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

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

$$\frac{p_1^*}{p_2^*} \bigg|_{\zeta_1 = 0} = \frac{p_1^*}{p_2^*} \bigg|_{\zeta_2 = 0} \quad (2.29)$$
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 $\lambda$ is given exogenously:

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

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

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

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

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

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

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

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)

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

Alternative composite tâtonnement adjustment (ac)

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

Minmax composite tâtonnement adjustment (mc)

$$p_i(t + 1) = \min \{\hat{p}_i, \max \{p_i(t) + \lambda_i(t) \zeta_i(p(t)), \underline{p}_i\}\}, \quad i = 1, 2. \tag{2.36}$$

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 [2] 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 [76, 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.

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

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

Equilibrium prices are attained under a condition that an adjustment coefficient \(\lambda\) 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 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 behave 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 avoid 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 [43]. 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.

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 [53] 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 [33], [43], [49], [79], [80], since my knowledge of accounting was limited. 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 [43]. 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 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,

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2 In addition to these books, a paper dealing with corporate financial statements [3] is recently published. However, current research for modeling financial statements is independently carried out here with a heuristic objective in mind.
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 [94]. Stock-flow relation is illustrated in Figure 3.1.

![Figure 3.1: Stock-Flow Relation](image)

**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 [43].

### Balance Sheet

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

Table 3.1: Balance Sheet in [43]

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. [9, 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.

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.

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, and income taxes. These stock-flow relations are illustrated in Figure 3.4.

<table>
<thead>
<tr>
<th>Income Statement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>1 -2 = 3</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>5</td>
</tr>
<tr>
<td>6</td>
</tr>
<tr>
<td>4+5+6=7</td>
</tr>
<tr>
<td>3-7=8</td>
</tr>
<tr>
<td>9</td>
</tr>
<tr>
<td>10</td>
</tr>
<tr>
<td>8+9-10=11</td>
</tr>
</tbody>
</table>

Table 3.2: Income Statement in [43]

\[ \text{Gross Margin} = \text{Net Sales} - \text{Cost of Goods Sold} \]
\[ \text{Operating Expenses} = \text{Sales & Marketing} + \text{Research & Development} + \text{General & Administrative} \]
\[ \text{Income From Operations} = \text{Gross Margin} - \text{Operating Expenses} \]
\[ \text{Net Income} = \text{Income From Operations} - \text{Net Interest Income} - \text{Income Taxes} \]

Figure 3.4: Income Statement as Stock-Flow Relation

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

<table>
<thead>
<tr>
<th>Cash Flow Statement</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Beginning Cash Balance</td>
</tr>
<tr>
<td>b. Cash Receipts</td>
</tr>
<tr>
<td>c. Cash Disbursements</td>
</tr>
<tr>
<td>b-c=d. Cash Flow From Operations</td>
</tr>
<tr>
<td>e. PP&amp;E Purchase</td>
</tr>
<tr>
<td>f. Net Borrowings</td>
</tr>
<tr>
<td>g. Income Taxes Paid</td>
</tr>
<tr>
<td>h. Sale of Capital Stock</td>
</tr>
<tr>
<td>a+d-e+f-g+h=i. Ending Cash Balance</td>
</tr>
</tbody>
</table>

Table 3.3: Cash Flow Statement in [43]

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

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.
3.4. **PRINCIPLE OF ACCOUNTING SYSTEM DYNAMICS**

![Diagram](image)

**Figure 3.6:** Double Entry Rule of Bookkeeping (1)

(2) **Debit:outflow \leftrightarrow 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).

![Diagram](image)

**Figure 3.7:** Double Entry Rule of Bookkeeping (2)

(3) **Debit:inflow \leftrightarrow 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 \leftrightarrow 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).
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:

\[ \text{Transaction} \Rightarrow \text{[Stock 1 ±]} \leftrightarrow \text{[Stock 2 ±]} \]

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:

\[ \Rightarrow \text{T: Accrued Expenses Paid} \Rightarrow \text{[Accrued Expenses -]} \leftrightarrow \text{[Cash -]} \]

This formula implies that payment of accrued expenses lowers both the levels of accrued expenses and cash. Such an identification 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 Simpli-
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:

\[ T: \text{Sales Revenues} \]
\[ \Rightarrow [\text{Retained Earnings} +] \leftrightarrow [\text{Accounts Receivable} +] \]

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

\[ T: \text{Cost of Goods Sold} \]
\[ \Rightarrow [\text{Retained Earnings} -] \leftrightarrow [\text{Inventories} -: \text{Shipment}] \]

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:

\[ T: \text{Non-Operating Revenues} \]
\[ \Rightarrow [\text{Retained Earnings} +] \leftrightarrow [\text{Accounts Receivable} +] \]

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

\[ T: \text{Receipts} \]
\[ \Rightarrow [\text{Accounts Receivable} -] \leftrightarrow [\text{Cash/Deposits} +] \]

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:

\[ T: \text{Operating Expenses} \]
\[ \Rightarrow [\text{Retained Earnings} -] \leftrightarrow [\text{Cash/Deposits} -: \text{Payments}] \]

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

\[ T: \text{Non-Operating Expenses} \]
\[ \Rightarrow [\text{Retained Earnings} -] \leftrightarrow [\text{Cash/Deposits} -: \text{Payments}] \]

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

\[ T: \text{Income Taxes} \]
\[ \Rightarrow [\text{Retained Earnings} -] \leftrightarrow [\text{Cash/Deposits} -: \text{Payments}] \]
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 [43]. 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.

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\(^4\) 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.
### Table 3.4: All Transaction Data

| 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 |
|--------------|----|----|----|----|----|----|----|----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 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 Tax Paid | 26,000 | 26,000 |
| T: Insurance Premia Paid | 26,000 |
| T: Wages | 9,020 | 9,020 |
| T: Payroll-associated Fringe Benefits 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 |
| T: Cost of Goods Sold | 1,000 | 15,000 | 176,400 |

**Data:** Price Change -0.24 0.24

**Table 3.4:** All Transaction Data

---

3.6. ACCOUNTING SYSTEM DYNAMICS IN ACTION
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 -]


⇒ 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.)
CHAPTER 3. ACCOUNTING SYSTEM DYNAMICS

⇒ 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 +]

As production starts, raw material use may be written as follows.
3.6. **ACCOUNTING SYSTEM DYNAMICS IN ACTION**

⇒ 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 -]
CHAPTER 3. ACCOUNTING SYSTEM DYNAMICS

$\leftrightarrow$ [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.

\[ T: \text{Accounts Payable Paid (= $150,000)} \]
\[ \leftrightarrow [\text{Account Payable -}] \leftrightarrow [\text{Cash -}] \]

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>K.</td>
<td>Receive a month’s raw material supply less labels. (see T10)</td>
</tr>
<tr>
<td>L.</td>
<td>Move a month’s supply of raw materials into WIP. (see T12).</td>
</tr>
<tr>
<td>M.</td>
<td>Pay hourly workers/ supervisor for another month. (see T12)</td>
</tr>
<tr>
<td>N.</td>
<td>Book manufacturing depreciation for the month. (see T13)</td>
</tr>
<tr>
<td>O.</td>
<td>Book “all other” mfg. overhead for another month. (see T13)</td>
</tr>
<tr>
<td>P.</td>
<td>Move 19,000 cases to finished goods standard cost.</td>
</tr>
<tr>
<td>Q.</td>
<td>Scrap 150 cases from WIP. (see T16)</td>
</tr>
</tbody>
</table>

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.

\[ T: \text{Raw Material Purchase (= $166,200)} \] (K)
\[ \leftrightarrow [\text{Raw Material Inventory +}] \leftrightarrow [\text{Accounts Payable +}] \]

\[ T(\text{Cash-}): \text{Wages (= $9,020)} \] (M)
\[ \leftrightarrow [\text{Work in Process Inventory +}] \leftrightarrow [\text{Cash -}] \]

\[ T: \text{Payroll-associated Fringes and Taxes (= $8,160)} \] (M)
\[ \leftrightarrow [\text{Work in Process Inventory +}] \leftrightarrow [\text{Accrued Expenses +}] \]

\[ T: \text{Depreciation (= $7,143)} \] (N)
\[ \leftrightarrow [\text{Work in Process Inventory +}] \leftrightarrow [\text{Book Value of PP&E -}] \]

\[ T: \text{All Other Overhead (= $8,677)} \] (O)
\[ \leftrightarrow [\text{Work in Process Inventory +}] \leftrightarrow [\text{Account Payable +}] \]

\[ T: \text{Scrapped Cases (= 150 cases)} \] (Q)
\[ (\Rightarrow \text{Scrapped Cases Value (= 150 \times 10.2 dollar = $1,530)}) \]
\[ \leftrightarrow [\text{Work in Process Inventory -}] \]
\[ \leftrightarrow [\text{Retained Earnings -: Cost of Goods Sold}] \]
In addition, raw material use and completion of work in process may be written as follows.

\[ T: \text{Production} = 20,000 \text{ cases} \]
\[ \Rightarrow \text{Raw Material Use} = 20,000 \times 8.55 = 171,000 \] (L)
\[ \Rightarrow [\text{Raw Material Inventory} - ] \leftrightarrow [\text{Work in Process Inventory} + ] \]

\[ T: \text{Completion} = 19,000 \text{ cases} \]
\[ \Rightarrow \text{Completion Value} = 19,000 \times 10.2 \text{ dollar} = 193,800 \] (P)
\[ \Rightarrow [\text{Work in Process Inventory} - ] \leftrightarrow [\text{Finished Goods Inventory} + ] \]

**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.

\[ T: \text{Sales & Marketing} = 103,250 \]
\[ \Rightarrow [\text{Account Payable} + ] \leftrightarrow [\text{Retained Earnings} - : \text{Operating Expenses}] \]

**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.

\[ T: \text{Customer Order} = 1,000 \text{ cases} \]
\[ \Rightarrow \text{Net Sales} = 1,000 \times 15.90 = 15,900 \]
\[ \Rightarrow [\text{Retained Earnings} + : \text{Revenues}] \leftrightarrow [\text{Accounts Receivable} + ] \]

\[ \Rightarrow \text{Shipment Value} = 1,000 \text{ cases} \times 10.2 \text{ per case} = 10,200 \]
\[ \Rightarrow [\text{Finished Goods Inventory} - ] \leftrightarrow [\text{Retained Earnings} - : \text{Costs of Goods Sold}] \]

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.

\[ T: \text{Sales & Marketing} = 318 \]
\[ \Rightarrow [\text{Retained Earnings} - ] \leftrightarrow [\text{Accrued Expenses} + ] \]
CHAPTER 3. ACCOUNTING SYSTEM DYNAMICS

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.

\[ \Rightarrow \text{T: Customer Order (}= 15,000 \text{ cases}) \]
\[ \Rightarrow \text{Net Sales (}= 15,000 \times 15.66 = 234,900) \]
\[ \Rightarrow \text{[Retained Earnings +: Revenues] } \leftrightarrow \text{[Accounts Receivable +]} \]

\[ \Rightarrow \text{Shipment Value (}= 15,000 \text{ cases } \times 10.2 \text{ per case } = 153,000) \]
\[ \Rightarrow \text{[Finished Goods Inventory -]} \]
\[ \leftrightarrow \text{[Retained Earnings -: Costs of Goods Sold]} \]

\[ \Rightarrow \text{T: Sales & Marketing (}= 4,698) \]
\[ \Rightarrow \text{[Retained Earnings -] } \leftrightarrow \text{[Accrued Expenses +]} \]

**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).
3.6. ACCOUNTING SYSTEM DYNAMICS IN ACTION

⇒ 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 [43]. 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](image)
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](image)

### 3.7 Making Financial Statements

Transactions given in the book [43] 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.
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...
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.
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 [43], 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**

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

\[
\text{Asset Turn} = \frac{\text{Net Sales}}{\text{Assets}}
\]

\[
\text{Accounts Receivable Days} = \frac{\text{Accounts Receivable} \cdot (365)}{\text{Net Sales}}
\]
CHAPTER 3. ACCOUNTING SYSTEM DYNAMICS

**Liquidity Ratios**
- Current Ratio
  \[ \text{Current Ratio} = \frac{\text{Current Assets}}{\text{Current Liabilities}} \]
- Quick Ratio
  \[ \text{Quick Ratio} = \frac{\text{Cash} + \text{Accounts Receivable}}{\text{Current Liabilities}} \]

**Profitability Ratios**
- Return on Assets (ROA)
  \[ \text{ROA} = \frac{\text{Net Income}}{\text{Assets}} \]
- Return on Equity (ROE)
  \[ \text{ROE} = \frac{\text{Net Income}}{\text{Shareholders' Equity}} \]
- Return on Sales (Profit Margin)
  \[ \text{Profit Margin} = \frac{\text{Net Income}}{\text{Net Sales}} \]
- Gross Margin (Gross Profits)
  \[ \text{Gross Margin} = \frac{\text{Gross Margin}}{\text{Net Sales}} \]

**Asset Management Ratios**
- Inventory Turns
  \[ \text{Inventory Turns} = \frac{\text{Net Sales}}{\text{Inventories}} \]
- Asset Turn
  \[ \text{Asset Turn} = \frac{\text{Net Sales}}{\text{Assets}} \]
- Accounts Receivable Days
  \[ \text{Accounts Receivable Days} = \frac{\text{Net Sales}}{\text{Accounts Receivable}} \times 365 \]

**Leverage Ratios**
- Debt-to-Equity
  \[ \text{Debt-to-Equity} = \frac{\text{Current Portion of Debt} + \text{Long-Term Debt}}{\text{Shareholders' Equity}} \]
- Debt Ratio
  \[ \text{Debt Ratio} = \frac{\text{Current Portion of Debt} + \text{Long-Term Debt}}{\text{Assets}} \]

Figure 3.17: Ratio Analysis Diagram
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.

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 [43], 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 \( i, i = 1, 2 \ldots, 8 \): 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 [97, 2004], [98, 2005], [99, 2006], [100, 2007], [101, 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.

![Macroeconomic System Overview](image)

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 [90, 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

\[ pC_W + S_W = wL^s \]  

(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

\[ pC_O + S_O = \Pi(= pY - wL^d) \]  

(4.2)

where \( \Pi \) 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

\[ pI = I_d \]  

(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.

\[ p(C_W + C_O + I - Y) + w(L_d - L^s) + (S_W + S_O - I_d) = 0 \]  

(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 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:

\[
\text{Net Cash Flow} = \text{Cash Inflow} - \text{Cash Outflow} = \text{Consumption} + \text{Investment} - \text{Wages} - \text{Profits (Dividends)} - \text{Investment} = \text{Consumption} - \text{National Income at Factor Cost} = - \text{Saving} \quad (4.5)
\]
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)

### 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 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
4.4. FUND-RAISING METHODS

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 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 instance, 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
CHAPTER 4. MACROECONOMIC SYSTEM OVERVIEW

Figure 4.5: A Macroeconomic System Flow Chart with Investment Institutions
4.4. FUND-RAISING METHODS

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).

![Image of Macroeconomic System Flow Chart of MuRatopian Economy](image)

**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 [90, 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 [36, 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

$$Y = \frac{K}{\theta} \quad \text{(Production Function)} \quad (4.6)$$

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

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

where $\alpha$ 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:

$$\frac{dw}{dt} = w^* - w \frac{1}{AT} \quad \text{(Determination of Wage Rate)} \quad (4.8)$$

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

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

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 ($e$).

1 In the original Goodwin model, a wage rate is assumed to be determined as a linear approximation of Phillips curve such that

$$\frac{dw}{dt}/w = -\gamma + \rho \left( \frac{L^d}{L^s} \right) \quad \text{(Linearized Phillips Curve)}$$

where $\gamma$ is an intersection of the y-axis and $\rho$ is its slope. Our standard wage determination process, it is claimed, includes the Phillips curve adjustment.
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

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

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

$$S_O = \Pi(= Y - wL^d) \quad \text{(Capitalists' Saving)} \quad (4.11)$$

Producers raise fund directly from the saving of capitalists so that their budget equation (4.3) becomes

$$I = I^d = S_O \quad \text{(Investment = Saving = Profits)} \quad (4.12)$$

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

$$\frac{dK}{dt} = I - \delta K \quad \text{(Net Capital Accumulation)} \quad (4.13)$$

where $\delta$ 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. 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.

\[2\] 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.
CHAPTER 4. MACROECONOMIC SYSTEM OVERVIEW

Figure 4.7: Causal loops of the Goodwin Model

Figure 4.8: The Goodwin Growth Cycle Model
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:

\[
w = (1 - \delta) \alpha \quad \text{(No Capital Accumulation)} \quad (4.14)
\]

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

\[
L^s = L^d \quad \text{(Full Employment).} \quad (4.15)
\]

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.

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).
4.5. A GOODWIN GROWTH CYCLE MODEL

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 $L^* = 110$. 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 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 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, 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 begins to expand horizontally, under the $L_s = 110$, as the elasticity of desired wage rate increases from $\epsilon = 0.2$ 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
Figure 4.14: A Monetary Goodwin Model
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 $\theta = 3$, $\alpha = 1$, $L^* = 100$ 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, producers 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 breaks down the steady-state equilibrium; that is, a monetary or cash constraint. Money is no longer 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

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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.
4.6. A MONETARY GOODWIN MODEL

Business Cycle

Wage Rate : Equilibrium (Cash=28) Dollar/(Year*worker)
Investment : Equilibrium (Cash=28) Dollar/Year
Capital : Equilibrium (Cash=28) Dollar
Output : Equilibrium (Cash=28) Dollar/Year

Figure 4.15: Business Cycle caused by A Monetary Constraint

Due to this lending restriction, producers can no longer borrow their desired amount for investment. This investment gap is illustrated as a gap between desired investment (line 1) and actual investment (line 2). Credit crunch thus caused by the banks now affects output and employment as demonstrated by
CHAPTER 4. MACROECONOMIC SYSTEM OVERVIEW

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 is a monetary behavior which has been thoroughly neglected in the standard analysis of Goodwin model. Behind the well-discussed business cycles, a runaway 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.

Figure 4.18: Accumulating Debt caused by A Business Cycle and Credit Crunch
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 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:

\[
\text{Profits} = \text{Output} - \text{Wages} - \text{Interest Income (Banks)}
\]  (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, \(L = 110\) that causes perpetual 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

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\(^4\) 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.
Figure 4.19: Balance Sheet of the Monetary Goodwin Model with Interest
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.

Figure 4.21: Output and Unemployment with Interest Rate: 30 - 50 years

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. In other words, it may be conjectured that

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5 Refer to lines 3 in Figures 4.26 and 4.27 below.
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 4.22 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” [45, 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 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 [45, 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.

**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
Debt-GDP Ratio and Unemployment Rate

- 16 Year: 0.3 Dmnl and 0.5 Dmnl
- 6 Year: 0.15 Dmnl and 0.21 Dmnl
- -4 Year: 0 Dmnl and -0.08 Dmnl

Figure 4.25: Debt-GDP Ratio and Unemployment Rate: 20 - 50 years

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

Output

Figure 4.26: Recovering Output with Interest Rate: 30 - 55 years
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.

![Unemployment Rate Chart](image)

Figure 4.27: Recovering Unemployment with Interest Rate: 30 - 55 years

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. 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 and Its Creation

This chapter first explores the nature of money with its classification table, then its creation by a fractional reserve banking system under the current debt money system. Following the classification of money, two different approaches of money creation are introduced; that is, flow approach of banks as intermediaries and stock approach of banks as deposit(credit) creators. Then, 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 securities 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.

5.1 What is Money?

5.1.1 Aristotle’s Definition of Money

What is money? Where does it come from? These are fundamental questions that have been repeatedly raised through human history. The Lost Science of Money by Zarlenga [114, 2002] is one of the best books on money for authentic economists to explorer these questions. In the book, Greek philosopher Aristotle (384-322 BC) is quoted to have articulated money as follows:

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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. [114, 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 5.1.

![Figure 5.1: Coflow of Money and Commodity](image)

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 in many standard textbooks:

1. **Unit of Account** (unit of money stock as *information* has to be determined before modeling)
2. **Medium of Exchange** (flow amount of money stock has to be determined to coflow commodity)
3. **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 5.1 can be equivalently described in Table 5.1 as follows:

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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 [108, 2015].
5.1. WHAT IS MONEY?

<table>
<thead>
<tr>
<th>Buyers</th>
<th>Sellers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Debit (Assets)</td>
<td>Credit (Assets)</td>
</tr>
<tr>
<td>Commodity (+)</td>
<td>Cash (-)</td>
</tr>
<tr>
<td>Cash (-)</td>
<td>Commodity (-)</td>
</tr>
</tbody>
</table>

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. [114, 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 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 have 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 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).

### 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.

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.

---

\(^3\) 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 [66, 2014].
5.1. WHAT IS MONEY?

### Classification of Money

<table>
<thead>
<tr>
<th>Front: Issuance</th>
<th>Public Money</th>
<th>Debt Money (at interest)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Back: Fiat Status</td>
<td>Money as Legal Tender</td>
<td>Functional-Money</td>
</tr>
<tr>
<td>Non-metal Commodities</td>
<td>Shell, Cloth (Silk)</td>
<td>Woods, Stones, etc</td>
</tr>
<tr>
<td>Metal Coinage</td>
<td>Non-precious Metal Coins</td>
<td>Metal Ingots (such as Gold)</td>
</tr>
<tr>
<td>Paper Notes</td>
<td>Public Money Notes by PM Admin.</td>
<td>Goldsmith Certificates Central Bank Notes</td>
</tr>
<tr>
<td>Digital Accounts &amp; Cards</td>
<td>Public Money Deposits</td>
<td>Central Bank Reserves Bank Deposits (Credits by Loans)</td>
</tr>
<tr>
<td>Digital Tokens (Blockchain etc.)</td>
<td>(since 2008)</td>
<td>To be covered in Part VI (Bitcoin, etc.)</td>
</tr>
</tbody>
</table>

Table 5.2: Public Money vs Debt Money

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 [38, 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. 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.

---

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 5.2 illustrates the state of currency (coins and banknotes) as legal tender.

![Figure 5.2: Base Money as Legal Tender](image)

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
5.1. WHAT IS MONEY?

of these parts are called base money\(^5\): that is,

\[
\text{Base Money} = \text{Currency Outstanding} + \text{Reserves} \quad (5.1)
\]

Hence, base money is by definition the only legal tender as illustrated in Figure 5.2.

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 5.3, 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 sectors such as producers, consumers and government, to be explained below. Figure 5.4 illustrates that bank deposits thus created are used for transactions

\[\text{Figure 5.4: Deposits as Functional-Money}\]

\(^5\)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.
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

<table>
<thead>
<tr>
<th>Buyers</th>
<th>Credit (Assets)</th>
<th>Debit (Assets)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commodity (+)</td>
<td>Deposits (-)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sellers</th>
<th>Debit (Assets)</th>
<th>Credit (Assets)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deposits (+)</td>
<td>Commodity (-)</td>
<td></td>
</tr>
</tbody>
</table>

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 [69, p.13, 2008].

What is meant here is that deposits are accepted for commodity transaction in Figure 5.4 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 functional-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

$$\text{Money Stock} = \text{Currency in Circulation} + \text{Deposits}$$

(5.2)

Money stock 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:

---

6Money stock is alternatively named money supply, and they are interchangeably used in this book.
5.1. WHAT IS MONEY?

Money Stock (Data) = Currency Outstanding + Deposits \hspace{1cm} (5.3)

This relation is illustrated in the above Figure 5.2. The difference of these two definitions is "vault cash" held by commercial banks such that

Currency Outstanding = Currency in Circulation + Vault Cash (Banks) \hspace{1cm} (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.

![Diagram of Debt Money System](image)

Figure 5.5: Debt Money System

Current macroeconomies are being run under this type of debt money. Hence, our economic system is a debt money system as illustrated in Figure 5.5. Almost all of macroeconomic textbooks in use such as [39, 1997], [54, 2003], [59, 2006], [55, 2008] justify the current macroeconomic system of debt money, as if it is the only system, without mentioning the alternative system of public money.

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, we have further defined money stocks, whenever appropriate in this book, as follows [111, 2019].

\(M_0\) consists of Government Coins (Public Money), Banknotes and Bank Reserves 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.

\(M_1\) 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 fictitious or fake money.

\(M_T\) 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.

---

7 The Bank of Japan defines various concepts of the amount of money as follows.

\[M_0 = \text{Base Money}\]
\[M_1 = \text{Currency Outstanding} + \text{Demand Deposits}\]
\[M_2 = M_1 + \text{Quasi-money} + \text{CD (Certificate of Deposit)}\]
\[\quad \text{(Quasi-money} = \text{Time Deposits} + \text{Foreign Exchange Deposits, excluding the Japan Post Bank, Japan Agricultural Cooperatives, etc.)}\]
\[M_3 = M_1 + \text{Quasi-money} + \text{CD (Certificate of Deposit)}\]

8 When functional-money is more comprehensively defined as money stock that is not backed up by \(M_0\) (denoted here by \(M_f\)), we have, for the money stock \(M_3\), \(M_f \equiv M_3 - M_0 = M_f + M_T\). 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.
### Table 5.4: Money Stock & its Composition in Japan (2018)

<table>
<thead>
<tr>
<th>Money Stock (Front)</th>
<th>Trillion Yen</th>
<th>(% of M₁)</th>
<th>(% of M₃)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coins (Public Money)</td>
<td>4.8</td>
<td>0.6</td>
<td>0.3</td>
</tr>
<tr>
<td>Banknotes</td>
<td>107.6</td>
<td>12.9</td>
<td>7.6</td>
</tr>
<tr>
<td>Reserves</td>
<td>393.9</td>
<td>47.4</td>
<td>27.6</td>
</tr>
<tr>
<td>Base Money M₀</td>
<td>506.3</td>
<td>60.9</td>
<td>35.5</td>
</tr>
<tr>
<td>Functional Money M₇</td>
<td>324.9</td>
<td>39.1</td>
<td>22.8</td>
</tr>
<tr>
<td>Money Stock M₁</td>
<td>831.2</td>
<td>100.0</td>
<td>58.3</td>
</tr>
<tr>
<td>Time Deposits M₇</td>
<td>594.5</td>
<td></td>
<td>41.7</td>
</tr>
<tr>
<td>Money Stock M₃</td>
<td>1,425.8</td>
<td></td>
<td>100.0</td>
</tr>
</tbody>
</table>

### Table 5.5: Classification of Money (Front & Back)

<table>
<thead>
<tr>
<th>Money (Front) (Issuance)</th>
<th>Public Money (Classified)</th>
<th>Debt Money (at interest) (99.7%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1,420.9</td>
<td>(Total Sum of Firms, Households and Government)</td>
</tr>
<tr>
<td>Money Stock (Classified)</td>
<td>Coins (Public Money) 4.8</td>
<td>Banknotes 107.6 Reserves 393.9 Functional-Money (M₇) 324.9</td>
</tr>
<tr>
<td>Base Money (M₀)</td>
<td>506.3</td>
<td></td>
</tr>
<tr>
<td>Money Stock (Classified)</td>
<td>Currency (Cash) 112.4</td>
<td>Demand Deposits 718.8 Time Deposits (M₇) 594.5</td>
</tr>
<tr>
<td>Money Stock (M₁)</td>
<td>831.2</td>
<td></td>
</tr>
<tr>
<td>Money Stock (M₃)</td>
<td>1,425.7</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Money (Back) (Fiat Status)</th>
<th>Legal Tender (35.5%)</th>
<th>Expanded Functional-Money (M₇) (64.5%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>506.3</td>
<td>919.4</td>
</tr>
</tbody>
</table>
$M_3$ 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:

\[
M_0 = \text{Government Coins} + \text{Banknotes} + \text{Reserves (Legal Tender)} \quad (5.5)
\]
\[
M_1 = \text{Government Coins} + \text{Banknotes} + \text{Demand Deposits}
    = \text{Government Coins} + \text{Banknotes} + \text{Reserves} + \text{Functional Money}
    = M_0 \text{ (Base Money)} + M_f \text{ (Functional Money)} \quad (5.6)
\]
\[
M_3 = M_1 + M_T \text{ (Time Deposits)}
    = M_0 + M_f + M_T. \quad (5.7)
\]

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 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 over time. Figure 5.6 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.

\(^9\) 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.
5.2. CLASSIFICATION OF MONEY IN JAPAN

Figure 5.6: \( M_0 + M_f = M_1 \) in Japan (1980 - 2018)

Figure 5.7 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 5.6. 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 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 the *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 5.8 shows the reorganized three sectors among which deposits is being created.

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:

$$\text{Assets} = \text{Liabilities} + \text{Equity} \quad (5.8)$$

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
5.3. FLOW APPROACH OF FUNCTIONAL-MONEY CREATION

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. To balance the account,

\[ \text{To be precise, government coins are not liabilities of the central bank. Yet, in practice, the Bank of Japan, for instance, integrates them as a part of its currency outstanding as} \]

![Figure 5.8: Three Sectors for Money Stock](image-url)
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 5.3.

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.

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 [38, 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 5.9. 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. monetary data due to the small amount of their values.
5.3. **FLOW APPROACH OF FUNCTIONAL-MONEY CREATION**

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

\[
\text{Required Reserve Ratio}\, (\beta) = \frac{\text{Required Reserves}}{\text{Deposits}} \quad (5.10)
\]

(2) Then, the remaining amount of deposits are loaned out to borrowers.

(3) Now borrowers receive cash as assets.

\(^{11}\) Whenever appropriate, a reserve ratio is further broken down as follows:

\[
\text{Reserve Ratio}\, (\beta) = \frac{\text{Required Reserves}}{\text{Deposits}} + \frac{\text{Excess Reserves}}{\text{Deposits}} = \beta_r + \beta_e. \quad (5.9)
\]
(4) Since the public as a whole needs not to hold all the amount of cash at hand as liquidity, a portion of cash is deposited with banks according to a currency ratio ($\alpha$) such that

\[
\text{Currency Ratio (} \alpha \text{)} = \frac{\text{Currency in Circulation}}{\text{Deposits}} \tag{5.11}
\]

In other words, one dollar put into circulation is further divided between currency in circulation and deposits according to the following proportion:

\[
1 \Rightarrow \left\{ \frac{\alpha}{\alpha + 1} : \text{Currency in Circulation} \right\} \left\{ \frac{1}{\alpha + 1} : \text{Deposits with Banks} \right\} \tag{5.12}
\]

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;

\[
\text{Accumulated money stock put into circulation through bank loans} = 1 + \frac{1 - \beta}{\alpha + 1} + \left( \frac{1 - \beta}{\alpha + 1} \right)^2 + \left( \frac{1 - \beta}{\alpha + 1} \right)^3 + \cdots
\]

\[
= \frac{1}{1 - \frac{1 - \beta}{\alpha + 1}}
\]

\[
= \frac{\alpha + 1}{\alpha + \beta} \tag{5.13}
\]

This is a process of creating money in circulation \textit{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,

\[
\text{Money Multiplier (} m \text{)} = \frac{\alpha + 1}{\alpha + \beta} = \frac{\alpha + 1}{\alpha + \beta_r + \beta_e} \tag{5.14}
\]

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 5.8 play a role of determining these ratios. Depositors in

\[12\] 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.
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:

\[
1 \Rightarrow \begin{cases}
\frac{\alpha}{\alpha + 1} \frac{\alpha + 1}{\alpha + \beta} = \frac{\alpha}{\alpha + \beta} : \text{Currency in Circulation} \\
\frac{1}{\alpha + 1} \frac{\alpha + 1}{\alpha + \beta} = \frac{1}{\alpha + \beta} : \text{Deposits with Banks}
\end{cases}
\] (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,

\[
\text{High-Powered Money} = \text{Currency in Circulation} + \text{Reserves} \quad (5.17)
\]

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:

\[
\begin{align*}
\text{Money Stock} &= \text{High-Powered Money} \\
&= \frac{\text{Currency in Circulation} + \text{Deposits}}{\text{Currency in Circulation} + \text{Reserves}} \\
&= \frac{\text{Currency in Circulation}/\text{Deposits} + 1}{\text{Currency in Circulation}/\text{Deposits} + \text{Reserves}/\text{Deposits}} \\
&= \frac{\alpha + 1}{\alpha + \beta}
\end{align*}
\] (5.18)

This ratio becomes exactly the same as money multiplier obtained in equation (5.14). Thus, money stock can be uniformly expressed as\(^\text{13}\)

\[
\text{Money Stock} = m \times \text{High-Powered Money} \quad (5.19)
\]

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

\(^\text{13}\) 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”.
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” [59, p. 394, 2006]. 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).

\[
\text{Money Stock (Base)} = m \times \text{Base Money}
\] (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:

\[
\text{Money Stock (Data)} = \text{Currency Outstanding + Deposits}
\] (5.21)

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 5.10. This is the definition diagram of money stocks used from now on in our money creation models of both 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

\[
\text{High-Powered Money (as legal tender)} = mc \times \text{Money Stock}
\] (5.22)

in which \(mc\) is defined as \textit{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
5.3. FLOW APPROACH OF FUNCTIONAL-MONEY CREATION

money convertibility coefficient becomes \( mc = 0.25 \). 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 5.10.

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 5.11 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

\[ mc = 0.25 \]

\[ m = M_1/M_0 \]

\[ mc = M_0/M_1 \]

\[ mc = 0.25 \]
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 5.11: Money Multiplier and Convertibility Coefficient in Japan

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 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)\(^\text{15}\). Under the situation, can the

\(^{15}\)Whenever transactions are traced back in this way, balance sheet of flow approach becomes
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", be-
cause 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). [13, p.12, 1935].

Hence, deposits are legally owned by banks and they can make loans out of
depositors’ money. In this way, fraudulent-looking loans out of deposits’
money have been made legitimate under the fractional reserve banking system.

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 5.4. 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.

<table>
<thead>
<tr>
<th>Buyers</th>
<th>Sellers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Debit (A)</td>
<td>Credit (A)</td>
</tr>
<tr>
<td>Commodity (+)</td>
<td>Cash (-)</td>
</tr>
<tr>
<td>Commodity (+)</td>
<td>Deposits (-)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Debit (A)</th>
<th>Credit (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cash (+)</td>
<td>Commodity (-)</td>
</tr>
<tr>
<td>Deposits (+)</td>
<td>Commodity (-)</td>
</tr>
</tbody>
</table>

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.
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).

16In Japan this practice is guaranteed by Article 590, Civil Code.
CHAPTER 5. MONEY AND ITS CREATION

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. [13, p.7, 1935, 2011]

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 5.12. 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\(^\text{17}\).

\(^{17}\text{In the stock approach model, deposits are assumed to go directly into "Reserves (Banks)". In practice, when customers put deposits at the bank, they are first debited as "Cash (Banks)" instead of "Reserves (Banks)" as in the flow approach. Deposits of cash in the stock approach are assumed to be directly debited as Reserves, and the amount of Vault Cash is later adjusted according to liquidity demand by non-banking sector.}\)
5.4. **STOCK APPROACH OF FUNCTIONAL-MONEY CREATION**

The last equation holds only when bank’s deposits are fully reserved with the central bank; that is, Deposits(Banks) = Reserves(Banks).

(2) Under the fractional reserve banking system, banks try to lend maximum loanable funds according to the following formula\(^ {18}\):

\[
\text{Maximum Loanable Funds (Banks)} = \frac{\text{Reserves (Banks)}}{\text{Required Reserve Ratio}} - \text{Deposits (Banks)} = \frac{1 - \beta}{\beta} \text{Reserves (Banks)} \quad (5.23)
\]
(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 borrowers 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. 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” [13, p.xviii, 1935]\(^{19}\).

(4) Borrowers withdraw cash out of their deposits account according to the currency ratio(\( \alpha \)), 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.

<table>
<thead>
<tr>
<th>Banks</th>
<th>Non-Banking Public Sector</th>
</tr>
</thead>
<tbody>
<tr>
<td>Debit (Assets)</td>
<td>Credit (Liabilities)</td>
</tr>
<tr>
<td>Loan (+)</td>
<td>Deposits (+)</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Debit (Assets)</td>
<td>Credit (Assets)</td>
</tr>
<tr>
<td>Commodity (+)</td>
<td>Deposits (-)</td>
</tr>
</tbody>
</table>

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 [13, 2011]" pointed out:

The creation of units of account by MFIs (monetary financial institutions) that are masquerading as demand deposits defined by the

\(^{19}\) This issue will be discussed in Chapter 14.

\(^{20}\) FASB = Financial Accounting Standards Board, IASB = International Accounting Standards Board, IFAC = International Federation of Accountants
5.4. STOCK APPROACH OF FUNCTIONAL-MONEY CREATION

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). [68, p.2, 1st May 2013].

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)\footnote{In fact, cash and deposits items in many balance sheets are integrated as an inseparable Cash/Deposits asset.}. 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.

<table>
<thead>
<tr>
<th>Buyers</th>
<th>Sellers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Debit (Assets)</td>
<td>Credit (Assets)</td>
</tr>
<tr>
<td>Commodity (+)</td>
<td>Deposits (-)</td>
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<td>Cash (-)</td>
</tr>
<tr>
<td>Deposits (+)</td>
<td>Commodity (-)</td>
</tr>
<tr>
<td>Cash (+)</td>
<td>Commodity (-)</td>
</tr>
</tbody>
</table>

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\footnote{In fact, cash and deposits items in many balance sheets are integrated as an inseparable Cash/Deposits asset.}.

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, Richard Werner [85, 2015] classifies the flow approach further into two theories; the financial intermediation theory of banking and the fractional reserve theory of banking. In the working paper of the Bank of England, Jakob and Kumhof [44, 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 [58, 2015] 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-known economists. They are: Keynes(1936); Gurley and Show (1955); Tobin (1963, 1969); Sealey and Lindley (1977); Balerinsperger (1980); Mises(1980); Diamond and Dybvind (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); Matthews 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); Gulberston (1958); Ascheheim (1959); Soloman (1959); Paul Smith (1966); Guttentag and Lindsay (1968); Stiglitz(1997).

**Stock Approach:** Examples of the credit creation theory are: Macleod(1856); Wickell (1939); 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 [58, 2014]; Jakob and Kumhof [44, 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 Irving Fisher [13, 1935] till quite recently as if it has been a taboo subject for economists (Adair Turner [81, p.31, 2013]).

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 Werner paper [85, 2015] for detailed references.
5.5. FUNCTIONAL-MONEY CREATION UNDER GOLD STANDARD

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.

5.5 Functional-Money Creation under Gold Standard

5.5.1 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: 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 \( \beta \) becomes equal to the required reserve ratio \( \beta_r \). 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 securities 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 securities will be introduced into the model.

Figures 5.13 illustrates our simple money creation model under gold standard. In the model, currency outstanding in the central bank and currency in circulation in non-financial 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.
Figure 5.13: Money Creation Model under Gold Standard: Flow Approach
5.5. FUNCTIONAL-MONEY CREATION UNDER GOLD STANDARD

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 \(m = \frac{0.2 + 1}{0.2 + 0.1} = 4\). Meanwhile, from the balance sheet of 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 dollars. 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 (= \(4 \times 200\)) 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 5.14: Money Stock under Gold Standard](image)

Figure 5.14 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.

\[
\text{Money Stock (Base)} > \text{Money Stock (Data)} > \text{Money Stock (5.24)}
\]

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.

\[ \text{Base Money} > \text{High-Powered Money}, \quad (5.25) \]

which then leads to the following inequality from the definitions in equations (5.19) and (5.20):

\[ \text{Money Stock (Base)} > \text{Money Stock}. \quad (5.26) \]

It also leads to

\[ \text{Currency Outstanding} > \text{Currency in Circulation}, \quad (5.27) \]

which in turn implies

\[ \text{Money Stock (Data)} > \text{Money Stock}. \quad (5.28) \]

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 (5.25) it is easily proved that

\[ \text{Money Stock (Base)} > \text{Money Stock (Data)}^{23}. \quad (5.29) \]

Hence, the orderly equation (5.24) 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 (5.25) is reversed. This reversed order can be observed in Figures 5.18 and 5.19 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-financial sectors such as producers and households and cash held in the vaults of all commercial banks. Hence, the following relation holds:

\[ \text{Money multiplier } m \text{ in equation (5.18) is rewritten as } m = \frac{C+D}{C+R}. \quad \text{Then we have} \]

\[ \frac{dm}{dC} = \frac{R-D}{(C+R)^2} < 0. \]

Accordingly, under the condition: Currency Outstanding \((O) >\) Currency in Circulation \((C)\), it is easily shown that

\[ \text{Money Stock (Base)} = \frac{C+D}{C+R} \ast (O + R) > O + D = \text{Money Stock (Data)}. \]

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\(^{23}\) Money multiplier \(m\) in equation (5.18) is rewritten 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

\[ \text{Money Stock (Base)} = \frac{C+D}{C+R} \ast (O + R) > O + D = \text{Money Stock (Data)}. \]
Cash outside Central Bank = Currency in Circulation + Vault Cash(Banks)  
\[ (5.30) \]
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-financial sector and commercial banks).

\[ \text{Currency Outstanding} = \text{Cash outside Central Bank} \quad (5.31) \]

Figure 5.15: Currency Outstanding and Cash outside the Central Bank

Figure 5.15 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:

\[ \text{Vault Cash(Banks)} = \text{Currency Outstanding} - \text{Currency in Circulation} \]
\[ = \text{Base Money} - \text{High-Powered Money} > 0 \quad (5.32) \]

which in turn leads to the above inequality relations of equation (5.25) 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 $1,200$ and $200$. 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 5.16 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 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-financial 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.
5.5. FUNCTIONAL-MONEY CREATION UNDER GOLD STANDARD 173

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.

![Figure 5.17: Money Stock when Vault Cash Rate is 0.5.](image)

As Figure 5.17 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.

**Currency Ratio**

Let us now consider the second situation in which non-financial 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 ($= 2.8 \times 200$).

![Figure 5.18 illustrates how money stock is reduced due to a sudden increase in liquidity preference in the non-financial sector. Three expressions of money stock tend to converge again.](image)

Figure 5.18 illustrates how money stock is reduced due to a sudden increase in liquidity preference in the non-financial 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 [13, 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-financial 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-financial 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-financial 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 5.19 illustrates.

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 \textit{out of nothing}! It comes from the non-financial public sector’s debt, Debt (Public) of $600, as line 3 of Figure 5.20 indicates, which also becomes equal to Functional-Money (line 4).
5.5. FUNCTIONAL-MONEY CREATION UNDER GOLD STANDARD

In other words, source of functional-money becomes debts, without which no functional-money creation takes place. Non-financial sector’s wealth remains the same as its equity of gold assets of $200. It has never been increased through this process of functional-money creation under the fractional reserve banking system.

5.5.2 Stock Approach Simulations

Let us now construct stock approach model of Gold Standard according to the conceptual Figure 5.12. 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 5.21.

How are money stocks created under stock approach, then? Compared with diversified behaviors of money stocks in Figure 5.14, money stock (base), money stock (data), and money stock now coincide as indicated by lines 1, 2 and 3 in Figure 5.22, because banks are assumed not to hold vault cash under the stock approach here. Accordingly, base money and high-powered money become the same (lines 4 and 5). In other words, orderly relations disclosed in equations (5.24) and (5.25) 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.

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24 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.
CHAPTER 5. MONEY AND ITS CREATION

Figure 5.21: Money Creation Model under Gold Standard: Stock Approach
5.5. FUNCTIONAL-MONEY CREATION UNDER GOLD STANDARD

Figure 5.22: Money Stock under Gold Standard: Stock Approach

**Functional-Money = Debts (by Non-Financial Sector)**

This stock approach reveals a true nature of functional-money creation under the fractional reserve banking system more vividly as illustrated in Figure 5.23. 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 [13, 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-financial sector (producers and households) has revealed this fact. This could be the main reason why almost all macroeconomics textbooks have adopted the 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 5.23, 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 [13, 1935]. This issue will be further investigated in Chapter 14.

5.5.3 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 in 1849, 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.

5.6 Functional-Money Creation out of Discount Loans to Banks

5.6.1 Discount Loans: Flow Approach Simulations

Let us assume that a growing economy has to meet an increasing demand for money from non-financial 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-financial 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 5.24 [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 5.25 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-financial sector. Line 3 in Figure 5.25 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-financial sector’s assets also increases to $1,200, as illustrated by line 1 in in Figure 5.26. 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
Figure 5.24: Money Creation Model out of Discount Loans to Banks
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 [83, 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 commercial banks according to their own preferences. Moreover, functional-money thus created by commercial banks can buy anything such as military weapons,
5.6. FUNCTIONAL-MONEY CREATION OUT OF DISCOUNT LOANS TO BANKS

Figure 5.27: Money Creation Model out of Loan to Banks: Stock Approach
5.6.2 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 5.27 is the stock approach model, thus built, of the fractional reserve banking [Companion model: 2a Money(Loan-S).vpmx].

![Figure 5.28: Money Stock Creation out of Loans to Banks: Comparison](image)

Figure 5.28 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.

5.7 Functional-Money Creation out of Loans to Government

5.7.1 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 securities are introduced and central
5.7. FUNCTIONAL-MONEY CREATION OUT OF LOANSTO GOVERNMENT

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-financial sector (producers and households), government, commercial banks and central bank. With the introduction of government securities, our expanded money creation model becomes a little bit complicated. To avoid a further complication the model is explained as four sub-models.

Non-Financial Sector (Producers and Households)

Non-financial sector consists of producers and households (non-banking financials are excluded here). It is called public sector. With the introduction of government, a stock of government securities (public) is newly added as assets. A balance sheet of non-financial sector is illustrated in Figure 5.29.

![Figure 5.29: A Complete Money Creation Model: Non-Financial Sector](image)

Government

Figure 5.30 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 securities so long as they are purchased by consumers and producers and govern-
ment spends the amount it borrowed within the non-financial sector, as shown below.

![Diagram](image)

Figure 5.30: Non-Financial Sector (Government)

**Commercial Banks**

A stock of government securities 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 securities. Government securities are paid out of reserves account of commercial banks with the central bank. Figure 5.31 illustrates the sector of commercial banks.

**Central Bank**

A stock of government securities 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 securities, and their payments are handled through reserves account of commercial banks\(^{25}\). 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 securities to the non-financial sector and commercial banks, these payments are withdrawn from reserves account of commercial banks, decreasing reserves of commercial banks by the same amount,

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\(^{25}\) Direct purchase of government securities, or direct loans to government by the central bank is prohibited in Japan. Therefore, such purchases has to be indirectly performed through markets.
5.7. **FUNCTIONAL-MONEY CREATION OUT OF LOANSTO GOVERNMENT**

and hence base money as a whole. Purchases and sales of government securities by the central bank are known as open market operations. Figure 5.32 illustrates these operations of the central bank. In this way, with the introduction of government securities, 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.

**Open Market Operations: Flow Approach**

Let us explore how our complete functional-money creation model works. It includes the functional-money creation structures of the previous two models; that is, gold standard and discount loans to banks. Accordingly, the reader can easily confirm the previous behaviors of functional-money creation with this integrated model.

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26 Recently, purchases of government securities and private bonds held by commercial banks and non-banking financials are known as *quantitative easing (QE)* policies.
It is assumed here that government issues securities (and borrow money) of 100 dollars at the period \( t = 8 \), 70% of which are assumed to be purchased by commercial banks and 30% by the public (households and producers). Yet, this only interrupts money stock temporarily, which tends to converge eventually to 800 dollars as before as illustrated by lines 1, 2 & 3 in Figure 5.33. Temporal drops of money stocks at time 8 are caused by a time lag of borrowing and spending by government. Therefore, it is essential to understand at this stage that money stock cannot be increased at all by the government debt, contrary to the general belief that government borrowing is a root cause of inflation.

Figure 5.34 illustrates how open market operations affect the behavior of money stock. At the period \( t = 16 \) the central bank purchases 50% of government securities held by the public and commercial banks through open market purchase operation. Accordingly, base money (line 4) is now increased from the original 200 dollars to 240 dollars. Money stock (base) (line 1) begins to increase from 785.6 (\( t = 16 \)) to 950.8 (\( t = 22 \)), 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 securities it holds, and base money decreases to 2224 dollars next year. Money stock (base) (line 1) begins to decrease from 950.8 (\( t = 22 \)) to 897.5 dollars (\( t = 30 \)). Eventually three expressions of money stock converge to this level as shown in Figure 5.34.
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 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 5.35 illustrates the case in which a currency ratio is additionally 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 922.4 (t=24) to 631.5 dollars (t=30); a reduction of money stock by 290.9 dollars. Three expressions of money stock all converge to this reduced amount.

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 (public). 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 5.36. All changes in assets are balanced by debt.
5.7. FUNCTIONAL-MONEY CREATION OUT OF LOANS TO GOVERNMENT

5.7.2 A Complete Money Creation Model: Stock Approach

A complete money creation model by stock approach is demonstrated in Figure 5.37 [Companion model: 3a Money(Stock-approach).vpmx]. With this model, the reader can run similar simulations as in the above flow approach to confirm the similar results.

Open Market Operations: Stock Approach

Specifically, similar open market behaviors of stock approach are confirmed in Figure 5.38 under the same parametric conditions, as in the open market behaviors of flow approach illustrated in Figure 5.34. 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 to converge at t-30. Now we have completed the comparative analyses of flow and the stock approaches of money stock.

Can Government Debt increase Money Stock?

The above analysis of government debt may needs some remarks. Recently due to the influence of MMT (Modern Money Theory) such as [89, 2012], misperception spreads such that whenever government borrows and spends money stock 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 inappropriate. Money stock can only be increased so long as base money $M_0$ is increased as our simulations above have demonstrated. Let us consider the following three cases.

Case 1 When government borrows money directly from the public (households and producers), its debt moves from the deposits account of the public to the government account, then goes back to the public account. In this case money stock does not increase. This is a well-known case of mainstream theory which causes crowding-out effect, causing only interest rate to go up.

Case 2 When government borrows money directly from commercial banks, its debt is paid out of the banks’ reserve accounts, which in turn forces to reduce their loans to the public and deposits of the public, cancelling out the increase of government’s spending into the public deposits. The reader can easily examine this case by running either the flow or stock approach model.

Case 3 Only when government borrows money directly from commercial banks which can pay out of their excess reserves, its debt increases money stock. The existence of excess reserves implies that banks are not making full
Figure 5.37: A Complete Money Creation Model: Stock Approach
amount of loans available under a fractional reserve banking. Hence, government debt plays a role to fill in this gap of loans. MMT inaccurately seems to assume only this recessionary case.

5.8 Identical Creations of Functional-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 (security purchase). Our simulation results have indicated that both flow and stock approaches of functional-money creation entail 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.

2. Discount Loans to Banks: $100 at $t=6.
3. Government Debt: $100 at $t=8.$^{27}$
4. Open Market Purchase: 50% purchase of existing Gov Securities at $t=16.$
5. Open Market Sale: 50% sale of Gov Securities held by Central Bank at $t=22.$

Figure 5.39 illustrates the flow approach behaviors of Base Money (left-hand diagram) and Money Stock (Data) (right-hand diagram) under five different

\[^{27}\text{Here government is assumed to issue its securities of$100, instead of$50 issued in our analysis above.}\]
CHAPTER 5. MONEY AND ITS CREATION

simulations; gold standard (line 1), discount loans to commercial banks (line 2), government debt (loans to the government) (line 3), open market purchase of government securities (line 4), and open market sale of government securities (line 5).

To be more specific, first, base money of 200 dollars is assumed under the gold standard. Second, discount loans to banks is made with 100 dollars at $t=6$, which increases money stock to 1,200 dollars. Third, government borrows 100 dollars (by issuing securities of 100 dollars) at $t=8$, which, however, does not affect money stock; that is, a temporal drop of money stock eventually converges to the same level of previous 800 dollars. Fourth, central bank exercises open market purchase of 50% of outstanding securities (50 dollars) at $t=16$, which surely increases money stock to a new level of 960 dollars at $t=30$. Fifth, central bank exercises open market sale of 50% of its holding securities at $t=22$, which decreases money stock to 901 at $t=30$.

Figure 5.40 illustrates the stock approach behaviors of Base Money and Money Stock (Data) under the same simulations as in the flow approach. To be more specific, first, base money of 200 dollars is assumed under the gold standard. Second, discount loans to banks is made with 100 dollars at $t=6$, which increases money stock to 1,200 dollars. Third, government borrows 100 dollars (by issuing securities of 100 dollars) at $t=8$, which, however, does not
affect money stock; that is, a temporal drop of money stock eventually converges to the same level of previous 800 dollars. Fourth, central bank exercises open market purchase of 50% of outstanding securities (50 dollars) at \( t=16 \), which surely increases money stock to a new level of 962 dollars at \( t=30 \). Fifth, central bank exercises open market sale of 50% of its holding securities at \( t=22 \), which decreases money stock to 900 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 main 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-financial 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 [85, 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-financial 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 securities. 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-financial sector due to functional-money creation are always balanced by the same increased amount of debts. In consequence, the equity or wealth of non-financial 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. 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. 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-financial sectors 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 through Open Market Purchase Operations (Run 3a Money(Flow-approach).vpmx).

3. 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 Securities at t=16.
(5) Open Market Sale: 50% sale of Gov Securities 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-financial 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 securities) affects Money Stock.

4. 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?

5. It will also be affected by a change in currency ratio $\alpha$. Discuss why the fractional reserve banking system becomes "the chief cause of both booms and depressions (Irving Fisher [13, p.xviii, 1935])."

6. Who owns the central bank in your country?

7. Do we really need the central bank to manage money stock and run the economies? Without the central bank, what problems will arise?

8. 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?

9. (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

Money as Total 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 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.

6.1 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 [112, 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

\[ \text{Money Stock} = \text{Legal Tender } (M_0) + \text{Functional Money } (M_f) \] (6.1)

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

\[ \text{Money Stock} = \text{Public Money} + \text{Debt Money} \] (6.2)

Public money is referred to as the money that is issued by public (sovereign) authorities at interest-free, while debt money is the one issued by private banks at interest. Figure 6.1 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, 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 6.1: Money Stock = Public Money + Debt Money
6.1. MONEY STOCK \simeq TOTAL DEBTS

Figure 6.2 [Companion model: 4a Money(Stock-Instability).vpmx] illustrates these two different classifications of money, front face and back face, which are represented by the equations (6.1) and (6.2), respectively. Equation (6.1), back face, is illustrated as

Money Stock (line 3) = Base Money (line 1) + Functional Money (line 2).

In the model, money stock is $1,200 and functional money is $900, while base money consists of gold certificates ($200) and discount loans to commercial banks ($100) issued at t=6.

Equation (6.2), 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 $1,000.

Debt Money \simeq 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 our monetary history money has been treated as

Money Stock = Public Money = Legal Tender \quad (6.3)
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:

\[
\text{Money Stock} = \text{Public Money (Gold)} + \text{Functional Money} \quad (6.4)
\]

Under the gold standard, gold has been public money. Accordingly our gold standard model in the previous chapter 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. As a result, base money as legal tender has become a mixture of public money and debts money such that

\[
\text{Legal Tender} = \text{Public Money (Coins)} + \text{Debt Money (Banknotes & Reserves)} \quad (6.5)
\]

In this way, debt money has become nowadays

\[
\text{Debt Money} = \text{Debt Money (Banknotes & Reserves)} + \text{Functional Money} \quad (6.6)
\]

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,

\[
\text{Total Debts} = \text{Loans (Banks)} + \text{Government Securities (Banks)} + \text{Government Securities (Central Bank)} \quad (6.7)
\]

**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.

\[
\text{Total Debts} = \text{Public Debts} + \text{Government Debts} \quad (6.8)
\]
6.1. **MONEY STOCK $\simeq$ TOTAL DEBTS**

where Government Debt is defined in the model as

\[
\text{Government Debts} = \text{Debt (Government)} - \text{Government Securities (Public)}
\]  \hspace{1cm} (6.9)

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 6.2, we can easily observe that

\[
\text{Debt Money (line 5)} = \text{Total Debts (line 6)} \quad (6.10)
\]

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 $\simeq$ 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 (6.2) and (6.10) we have

\[
\text{Money Stock} \simeq \text{Debt Money} = \text{Total Debts} \quad (6.11)
\]

Moreover, this also implies, from equation (6.1), that

\[
\text{Debt Money} \simeq \text{Legal Tender} (M_0) + \text{Functional Money} (M_f) \quad (6.12)
\]

Figure 6.3 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 (6.11) as

\[
\text{Money Stock (line 3)} = \text{Debt Money (line 5)} = \text{Total Debts (line 6)}
\]

where money stock etc. are all $1,200.

Equation (6.12) is similarly confirmed as

\[
\text{Debt Money (line 5)} = \text{Base Money (line 1)} + \text{Functional Money (line 2)}
\]

where debt money is $1,200, base money is $300 and functional money is $900.

This relation implies that base money consisting of only 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.

In addition to functional money ($M_f$) that is created out of nothing, we have now revealed that almost all money stock (more than 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.

6.2 Balance Sheet Analysis of Money Stock as Total Debts

6.2.1 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. Figure 6.4 illustrates balance sheets of six macroeconomic sectors: central bank, commercial banks, the government, producers (non-financial corporations), households and overseas. By looking at 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 described in its simplest form by using the worksheet format shown in Figure 6.4.

**Figure 6.4: Balance sheets of Six Sectors as Worksheet of Macroeconomy**

Quadruple-Entry Bookkeeping

In accounting system each transactions are recorded with double-entry bookkeeping rules for financial reporting and business management as discussed in

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3 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.
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 represent 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.

### 6.2.2 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.
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 6.5 illustrates change in balance-sheets as a result of these transactions.
6.2. BALANCE SHEET ANALYSIS OF MONEY STOCK AS TOTAL DEBTS

(Start with Debts (F) of 1,000 million yen)

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<thead>
<tr>
<th>Central Bank</th>
<th>Assets</th>
<th>Liabilities</th>
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<td>CB Loans</td>
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<td>Equity</td>
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<td>CB Loans</td>
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<td>Time Deposits</td>
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<td>Dividends (Bankers)</td>
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Figure 6.5: Money Creation by Bank Loans - Producers

6.2.3 Households going into Debt

Transaction steps of households are listed as below. Figure 6.6 illustrates the balance sheets from these transactions.
Figure 6.6: 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.
6.2. BALANCE SHEET ANALYSIS OF MONEY STOCK AS TOTAL DEBTS

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.

6.2.4 Government going into Debt

Transaction steps of the government are listed as below. Figure 6.7 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 transferring 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.
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

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</tr>
<tr>
<td><strong>Equity</strong></td>
<td></td>
</tr>
<tr>
<td>Income</td>
<td>970</td>
</tr>
<tr>
<td>Interest</td>
<td></td>
</tr>
<tr>
<td>Dividends (Bank)</td>
<td>30</td>
</tr>
</tbody>
</table>

(Start with Debts (G) of 1,000 million yen)

Figure 6.7: Money Creation by Bank Loans - Government
6.2. BALANCE SHEET ANALYSIS OF MONEY STOCK AS TOTAL DEBTS

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 6.1, increases at this stage.

6.2.5 Central Bank’s Operation of Purchasing 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 result 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 6.8 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 6.1. Only after step 3 and 4 did money stock increase slightly as independent from market operations.

6.2.6 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 6.9 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.
6.3 Money Stock $\approx$ 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. 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), Central government bonds (D-b), Local government securities (D-c), etc.

This section is based on the paper [111, 2019]: Money Stock $\approx$ 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).
CHAPTER 6. MONEY AS TOTAL DEBTS

Using these transaction items and following assets approach discussed in the above section, let us define Total Debts as follows.

\[
\text{Total Debts} = \text{Loans by Banks (C-c)} + \text{Government Debts (D-a, D-b and D-c)},
\]

(6.13)

where

Government Debts

\[
= \text{Treasury Bills (D-a) (held by Banks and Central Bank)} + \text{Central Government Bonds (D-b) (held by Banks and Central Bank)} + \text{Local Government Securities (D-c) (held by Banks)}
\]

(6.14)

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 6.10. 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.

Figure 6.10: Correlation Coefficients of All Money Stocks and Debts

Additionally, Figure 6.11 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 discussions above.\(^5\) Unexpectedly, in the Japanese economy between 1980 through

\(^5\) \(M_3\) 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.
6.3. MONEY STOCK $\simeq$ TOTAL DEBTS: A CASE IN JAPAN

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 6.12 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.\(^6\) Moreover, we claim that this approximate relation universally holds under the debt money system so that \textit{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).

\(^6\) 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 [5, 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 6.12: Money Stock $M_3 \simeq$ Total Domestic Debts (1980-2018)

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.

\[
M_3 \equiv M_T + M_1 \simeq \text{Total Debts (corr.coef =0.987)} \quad (6.15)
\]
\[
M_T \simeq \text{Loans by Banks (corr.coef =0.928)} \quad (6.16)
\]
\[
M_1 \simeq \text{Government Debts (corr.coef =0.992)} \quad (6.17)
\]

Equation (6.15) holds true in any economy under debt money system, meanwhile, equations (6.16) and (6.17) may be specific to Japan.
6.3. MONEY STOCK $\simeq$ TOTAL DEBTS: A CASE IN 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 (6.15) is now illustrated in Figure 6.13. 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 6.13: Linear Regression of $M_3$ as Total Domestic Debts (1980-2019)

\[
M_3 = 17,307 + 1.0166 \times \text{Total Debts} \quad (6.18)
\]

\[
R^2 = 0.9743
\]

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 6.14. It illustrates a simplified balance sheet of banks.
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 ⇒ M1.** 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 6.15 illustrates linear regressions of our second and third findings. Their linear regression equations are obtained as follows.

\[
M_T = 30,092 + 0.9012 \times \text{Loans by Banks} \quad (R^2 = 0.8608) \tag{6.19}
\]
\[
M_1 = 26,173 + 1.1254 \times \text{Government Debts} \quad (R^2 = 0.9849) \tag{6.20}
\]

Equation (6.19) indicates that the increased amount of bank loans to producers and households ends up with time deposits by the factor of 0.9012. Equation (6.20) 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 6.16.

<table>
<thead>
<tr>
<th>Debtor</th>
<th>Creditor</th>
<th>( M_0 ) (Reserves)</th>
<th>( M_f ) (Deposits)</th>
<th>( M_1 )</th>
<th>GDP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Private Sectors</td>
<td>Banks</td>
<td>0</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>(Producers &amp;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Households)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Government</td>
<td>Central Bank</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Banks</td>
<td>0</td>
<td>+</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Private Sector</td>
<td>0</td>
<td>0</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Quantitative</td>
<td>Banks</td>
<td>+</td>
<td>-</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Easing (QE)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Central Bank</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(M_0 + M_f = M_1)

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.

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 \( M_1 \).

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 6.5. See [111, 2019] for our analysis of the failures of QE in Japan.
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 \( M_1 \) may decrease. As a result, \( M_1 \) may not increase as expected (to be discussed below).

### 6.4 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.

#### 6.4.1 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*.[48, 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 money⁸ 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.

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⁸Check-book money here means demand deposits or functional-money in our terminology. Meanwhile, pocket-book money here implies cash or currency.
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[13, 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.

6.4.2 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 6.17 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 6.2. 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.

Figure 6.17: Causes of Money Stock Destruction
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 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 $= 0.3 \rightarrow 0.1$, and Lending Period $= 3 \rightarrow 6$.

(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 $= 0.2 \rightarrow 0.5$.

(3) Repayments of Debts at $t=20$. Finally, forced repayments start taking place such that Repayment Ratio $= 0 \rightarrow 0.2$.

Left-hand diagram of Figure 6.18 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 $= 0 \rightarrow 0.2$. 

Figure 6.18: Destruction of Money Stock Compared
(b) Liquidity Preferences: Bank runs at $t=15$. That is, Currency Ratio $= 0.2 \rightarrow 0.5$.

(c) Loans Cutbacks at $t=20$. That is, Lending Ratio $= 0.3 \rightarrow 0.1$, and Lending Period $= 3 \rightarrow 6$.

Right-hand diagram of Figure 6.18 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.

6.5 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 purchased 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 30%. Left-hand diagram of Figure 6.19 illustrates a prolonged destruction of money stock to $655$.

![Figure 6.19: Recessions and Open Market QE policy](image)
To rescue from this shortage of money stock, and following recessions, government now implements Keynesian fiscal policies by issuing securities of $250 at t=15. Simultaneously at t=15, central bank enacts its QE policy by purchasing 50% of the government securities for 5 years. The QE policy increases base money from $300 to $524.4; that is, 74.8% increase. This increased base money successfully restores money stock from $657 at t=15 to the almost original level of $1,195 at t=30; that is, 81.9% 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 6.19. 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. 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=15 when QE policy is introduced such that Lending Ratio = 0.3 → 0.1. This assumption may be justified because bank loans are still being discouraged when QE policies are introduced.

Figure 6.20: Failure of QE policy

Figure 6.20 indicates how money stock failed to increase after t=16 against the increase in base money. Money stock increased from $657 at t=15 only to $802 at t=30; that is, only 22.1% increase against the base money increase in 74.8%. This simulation suggests that the QE policy in this simulation failed to

---

stimulate bank loans. Our ASD model is successful to refute the mainstream refractionary theory such that expected inflation with lowered interest rate will increase bank loans, and eventually stimulate economic growth.

6.6 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.

\[
\text{Currency Ratio} = 0.2 + (\sin(2\pi \cdot \text{Time}/\text{Business Cycle Period}) \cdot \text{Business Cycle Scale} + \text{RANDOM NORMAL}(\text{Min}, \text{Max}, \text{C Ratio Mean}, \text{C Ratio SD}, \text{Seed}))
\]

(6.21)

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 cycle of 8 years. Figure 6.21 illustrates two separate behaviors of business cycle and random normal distribution of currency ratio.

![Figure 6.21: Business Cycle and Random Normal Distribution](image)

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 6.22. 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 $953 and maximum value of $1,548 with mean value of $1,180. If currency ratio is stable and could be governed by central bank, money stock would have behaved very steadily as line 6 indicates ($1,200 at t=30).

Figure 6.22: 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!

6.7 "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 6.23 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 (6.1), we have

$$\text{Money Stock} = \text{Legal Tender} (M_0) \quad (6.22)$$

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 [13, 1945].

Figure 6.23: From 100% Money Stock to Public Money Stock

As a result, money stock now is severely decreased from the peak of $1,548 (at t=8) to the base money level of $300. 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 3 years (= $900). Money Stock then increases to $1,221 from the original level: $340 at t=15, as illustrated by the right-hand diagram of Figure 6.23. 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 (= $1,221).

Yet even under this stable situation we still have, from the equation (6.2),

$$\text{Legal Tender}(M_0) = \text{Public Money} + \text{Debt Money} \quad (6.23)$$

That is, original debt money of $100 (issued as discount loans to banks) still remains in the base money. Numerically speaking we still have

$$\text{Legal Tender}(1,221) = \text{Public Money}(1,121) + \text{Debt Money}(100).$$

This relation can be easily confirmed from Figure 6.1. 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.
6.7. "100% MONEY" FOR MONETARY STABILITY

b. Elimination of functional-money \( (M_f \rightarrow 0) \): 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 6.1 below.

<table>
<thead>
<tr>
<th>Debt Money System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Front: Issuance</td>
</tr>
<tr>
<td>Back: Fiat Status</td>
</tr>
</tbody>
</table>

\[ \downarrow \quad \downarrow \quad \downarrow \]

<table>
<thead>
<tr>
<th>Public Money System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Front: Issuance</td>
</tr>
<tr>
<td>Back: Fiat Status</td>
</tr>
</tbody>
</table>

Table 6.1: 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 debts 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 6.22 analyzed how Juglar 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 6.12 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 7

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 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 5, 6 and 7 on money.

7.1 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 [55]).

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 better systems, 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 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 5. 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.

1. **Gold Standard 0**: Base run of the gold standard model in the previous chapter 5 with the initial amount of gold $200 by default.
2. **Gold Standard**: Our economy starts with the initial amount of gold held by the public with the introduction of interest rate and prime rate.
3. **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.
4. **Government Debt**: $100 at $t = 8$. Government is further forced to issue its securities to meet its budget deficits, or implement Keynesian fiscal policies to stimulate economic activities.
5. **Open Market Purchase**: 50% purchase of existing government securities at $t = 16$. Central bank exercises open market purchase operations to buy existing government securities in the market in order to increase base money, and money stock.
6. **Open Market Sale**: 50% sale of government securities 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).

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...
7.2 Money and Interest under Gold Standard

7.2.1 (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 are booked as outflows from the equity. Figure 7.1 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 7.2.

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 7.2. 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 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
Figure 7.1: Money and Interest under Gold Standard: Flow Approach
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.

7.2.2 (1) Stock Approach

Stock approach model [Companion model: 1a Money-Interest(Gold-S).vpmx] is illustrated in Figure 7.3. 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 7.4.

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 (instead of $183.4 under flow approach) at t=30 as illustrated by lines 2 and 3 in the right-hand diagram of Figure 7.4. Compositions of the equity among the public (line 2) and banks (line 3) are 29.2% and 70.8% at t=30. Hence,
Figure 7.3: Money and Interest under Gold Standard: Stock Approach
7.3 Money and Interest under Loans to Banks

7.3.1 (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 7.5 (in the previous chapter 5 without interest it was $1,200).

Zoom into Figure 7.5: Money Stock and Equity under Loans to Banks

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),\footnote{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.} 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 (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.

7.3.2 (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 7.6.

![Figure 7.6: Money Stock and Equity under Loans to Banks](image)

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 discount loans to commercial banks. Total equity of the public, banks and central bank remains the same under the 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 causes of inequality remain the same; the introduction of interest.

7.4 Money and Interest under Government Debt

7.4.1 (3) Flow Approach

What happens if government borrows by issuing its securities 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 previous chapter 5 it is discussed that government debt merely does not increase money stock (represented by "Government Debt 0") file here). Money stock can be increased only when base money (mainly reserves) or high-powered money increases. With the introduction of interest rate and prime rate as well as security interest rate which is assumed to be the same as the interest rate of 2%, government debt now increases money stock (represented by "Government Debt" file) as follows. Currency in circulation drops from $200 to $155.5, which reduces actual currency ratio from 0.2 to 0.144, which in turn increases money multiplier from 4 to 4.586 at t=30. Simultaneously, high-powered money decreases from $300 to $269.5, and base money decreases from $300 to $276.6 at t=30. These changes increase money stock slightly from $1,200 to $1,236, and money stock(data) from $1,200 to $1,243 at t = 30. Left-hand diagram of Figure 7.7 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.

Figure 7.7: Money Stock and Equity under Government Debt Compared

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 7.8, money stock becomes $1,236 (line 4) at t=30 as compared with $1,272 (line 3), meanwhile line 1 and 2 are money stocks under gold standard without interest and with interest; that is, $800, and $902.1, respectively. This indicates that government debt does not merely increase money stock by the introduction of interest.

Right-hand diagram shows a new distribution of equity among non-financial 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 securities at t=8. This gives us an impression that government debt 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 $51.1 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, $-102.4 at t=30.

On the other hand, equity of banks go beyond the equity of the economy as a whole ($200) to $278.9 (line 3) at t=30. 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 $23.4%. 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 6) becomes 25.5%, 139.5%, 11.7% and -76.7% at t=30.

7.4.2 (3) Stock Approach

We now run the stock approach model [Companion model: 3a Money-Interest(Stock-approach).vpmx]. In the previous chapter 5 it is pointed out that government debt merely does not increase money stock (represented as "Government Debt 0") file here). However, we have discussed above that government debt increases money stock under flow approach because of the introduction of interest rate, prime rate and security interest rate.
Let us contend here that this is no longer true under the stock approach (represented as "Government Debt" file). Left-hand diagram of Figure 7.9 illustrate money stock of $1,200 (line 1) (without interest rates) and money stock of $1,071 (line 2). This simulation result shows that mere government debt decreases money stock 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.

![Figure 7.9: Money Stock and Equity Compared (Stock Approach)](image)

Right-hand diagram indicates that government equity further drops 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 between discount loans to banks (phase (2)) and government debt (phase (3)). As illustrated in the left-hand diagram of Figure 7.10, money stock becomes $1,071 (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 $7669, respectively.

![Figure 7.10: Money Stock and Equity under Government Debt: Stock Approach](image)

Right-hand diagram shows a new 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 $289.6 at t=9 from the original values of $200 (144.8% increase compared with 139.4% under flow approach at
t=9), following the issues of government securities at t=8. Again this gives us an impression that government debt increases non-financial sector’s equity as in the flow approach. 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, which further drops to $-153.5 at t=30. Eventually, equity(public) begins to decline to $101.5 at t=30 (compared with $51.5 under flow approach). Combined non-financial sector’s equity (line 6) sooner or later becomes negative; that is, $-51.9 at t=30.

On the other hand, equity of banks go beyond the equity of the economy as a whole ($200) to $228.5 at t=30 (compared with $278.9 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 $23.4 at t=30. In summary, compositions of the equity among the public (line 2), banks (line 3), central bank (line 4) and government (line 6) becomes 50.8%, 114.3%, 11.7% and -76.8% at t=30.

These simulation results indicate that equity distribution exhibits similar trends as in the flow approach, though equity (public) gets slightly improved from 25.5% to 50.8%.

### 7.5 Money and Interest under Open Market Operations

#### 7.5.1 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 7.11 indicates that money stock under open market purchase operation (50% at t=16) increases from $1,236 (line 4) to $1,403 at t=30 (line 5), as expected from our discussions above on the creation of money by government debt. In other words, open market purchase operation increases base money from $276.6 to $311.1 as well.

---

Figure 7.11: Open Market Purchase and Sale Operations: Flow Approach
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 $311.1 to $294.9 as well as high-powered money from $303.7 to $289.9 at \( t=30 \), which in turn decreases money stock from $1,403 to $1,339. Right-hand diagram show a distribution of equity.

![Public and Government Equities under Open Market Operations](image)

Figure 7.12: 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 7.12 illustrates the equity of public sector. Lines 4, 5 and 6 are equities of the public under government debt, 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 debt, open market purchase and sale operations, respectively. These values become exactly the same; $-142.9 at \( t=30 \). This implies that once government debt gets incurred, its equity becomes negative under any situation.

![Banks and Central Bank Equities under Open Market Operations](image)

Figure 7.13: Banks and Central Bank Equities under Open Market Operations

Left-hand diagram of Figure 7.13 illustrates the equity of banks. Their equities become $280.6 under open market purchase at \( t=30 \) (line 5), and $283.8 under open market sale (line 6). In other words, their equities exceed the total equity of the economy; that is, $200. This extreme distribution in favor of banks
are made possible by negative value of government equity of $-142.9 at t=30. Right-hand diagram of Figure 7.13 illustrates the equity of central bank. Its equity becomes $34.3 (line 5) and $31.9 (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 $-114.9 and $-115.7 under open market purchase and sale operations, respectively. Figure 7.14 illustrates its case of open market purchase operation by line 3. On the other hand, consolidated equity of commercial banks and central bank, called financial equity, becomes $314.9 and $315.7 under open market purchase and sale operations, respectively. Its case of open market sale 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.

Our analysis here demonstrates that whenever government borrows by issuing its securities, it inevitably spreads the total equity of the economy 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 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 become a root cause of income inequality between financial and non-financial sectors; that is, the so-called inequality between 1% vs 99%.

7.5.2 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 7.15 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 7.16 indicates distribution of equity(public) under 6 phases. Right-hand diagram of Figure 7.16 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.
7.5. MONEY AND INTEREST UNDER OPEN MARKET OPERATIONS

Table 7.1 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). From the table

<table>
<thead>
<tr>
<th>(at $t=30$)</th>
<th>Money Creation</th>
<th>Equity Distribution (= $200)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$M_0$</td>
<td>$M$</td>
</tr>
<tr>
<td>Gold Standard</td>
<td>0</td>
<td>200</td>
</tr>
<tr>
<td>Gold Standard</td>
<td>200</td>
<td>768.7</td>
</tr>
<tr>
<td>Discount Loans</td>
<td>276.6</td>
<td>1,058</td>
</tr>
<tr>
<td>Gov. Debt</td>
<td>276.6</td>
<td>1,071</td>
</tr>
<tr>
<td>OM Purchase</td>
<td>304.2</td>
<td>1,181</td>
</tr>
<tr>
<td>OM Sale</td>
<td>291.2</td>
<td>1,131</td>
</tr>
</tbody>
</table>

Table 7.1: Summary Table of Open Market Purchase: Stock Approach

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)
CHAPTER 7. INTEREST AND EQUITY

continues to increase beyond the original equity held by the public ($200). 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, which forcefully sucks non-financial sector's equity into financial sector's equity, causing inequality of equity (wealth) distribution between non-financial sector and financial sector. This is a design failure of the so-called 1% vs 99% inequality that is built in the current debt money system.

7.6 Equity Distribution under 100% Money

Can we fix this equity inequality, 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 here the same bullish lending attitudes of loans adopted in section 6.7 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 7.17 indicates money stock continues to decrease to $320.6, which is close to the level of base money; that is, $304.2 at t=30. To regain this loss of money stock,
public money of 240 dollars is issued for 4 period starting $t=12$; that is, in total $960$. Then, Public Money in circulation increases from the initial amount of $200 to $1,160 at $t = 30$ (bold line 6), which becomes almost the same level as money stock under Open Market Purchase; that is, $1,181 at t = 30$. In this way, debt money created out of nothing at interest is replaced with public money at interest-free.

![Equity Distribution under Public Money: Stock Approach](image)

Figure 7.18: Equity Distribution under Public Money: Stock Approach

Figure 7.18 illustrates the equity distribution under 100% public money. Total equity becomes $1,160; that is, the initial equity of $200 and newly issued public money of $960. This indicates that public money issued by the government directly becomes the equity of the economy as a whole. This contrasts with the government debt of issuing securities which only constitutes its liability but does not increase the total equity at all. Bold line 3 represents non-financial equity (public and government) which becomes $1,402 at $t=30$. Equity(public) (line 1) becomes $1,456 at $t=30$. The difference of $54$ is due to the equity (government) of $-54$. This implies that by converting from debt money to public money, equity(public) jumps from $47.93$ (Phase (4)) to $1,402 at $t=30$ (an increase of factor 29!).

On the other hand bold line 6 represents financial equity which becomes $-242.5$. In this way, financial equity drops from $274.8$ (Phase (4)) to $-242.5$

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2 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.

3 In this model, government debt of $100 at $t=8$ is assumed to remain and its interest is also added to the principal debt, so that government debt continues 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.

4 In this model, banks are assumed to pay interest to the public for its deposits and central
(a drop of factor 1.9!). The reader can easily confirm that the sum of financial and non-financial equities is equal to the total equity of $1,160.

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 in place of the current debt money system.

### 7.7 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 7.19. 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 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.
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) through (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

Macroeconomic Systems of Debt Money
Chapter 8

Aggregate Demand Equilibria

This chapter 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 incorporate the interest rate, whose introduction enables the analysis of aggregate demand equilibria as well as transactions of savings and deposits, and government debt and securities. Finally, a flexible price is introduced to adjust an interplay between aggregate demand equilibrium and full capacity output level. A somewhat surprise result of business cycle is observed from the analysis.

8.1 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-financial sector consisting of consumers, producers 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. Since money stock is assumed to be exogenously determined in this chapter, central bank is excluded. Our analysis is also limited

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to a closed macroeconomic system and foreign sector is not brought to the dis- 
cussion here. Figure 8.1 illustrates the overview of the standard macroeconomy 
in this chapter.

Figure 8.1: Macroeconomic System Overview

How can we describe transactions among four 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.

8.2 A Keynesian Model

Since macroeconomics is one of the major subjects in economics, many standard 
textbooks are in circulation. As references, textbooks such as [11], [54], [55], and 
[59] are occasionally used to examine a standard approach to macroeconomics.

A simple Keynesian macroeconomic model is described as follows.

\[ Y = AD \quad \text{(Determination of GDP)} \] (8.1)
8.2. A KEYNESIAN MODEL

\[ AD = C + I + G \] (Aggregate Demand) \hfill (8.2)

\[ C = C_0 + cY_d \] (Consumption Decisions) \hfill (8.3)

\[ Y_d = Y - T - \delta K \] (Disposable Income) \hfill (8.4)

\[ T = \bar{T} \] (Tax Revenues) \hfill (8.5)

\[ I = \bar{I} \] (Investment Decisions) \hfill (8.6)

\[ G = \bar{G} \] (Government Expenditures) \hfill (8.7)

\[ \frac{dK}{dt} = I - \delta K \] (Net Capital Accumulation) \hfill (8.8)

\[ Y_{full} = F(K, L) \] (Production Function) \hfill (8.9)

\[ Y_{full} = Y \] (Equilibrium Condition) \hfill (8.10)

This macroeconomic model consists of 10 equations with 9 unknowns; that is, \( Y_{full}, Y, K, AD, C, I, G, Y_d, T \), with 7 exogenously determined parameters \((L, C_0, c, \bar{T}, I, \delta, \bar{G})\).\(^2\) Obviously, one equation becomes redundant. A possible redundant equation is equations (8.1) or (8.10). Which equation should be deleted from the analysis of macroeconomic model?

According to the neoclassical view, supply creates its own demand in the long run, and in this sense the equation (8.1) becomes redundant. Left-hand diagram of causal loops in Figure 8.2 illustrates how full capacity supply and aggregate demand are separately determined without the equation (8.1). Therefore, in order to complete this neoclassical logic, we need to add another equation of price mechanism which adjusts discrepancies between \( Y_{full} \) and \( AD \) such as

\[ \frac{dP}{dt} = \Psi(AD/P - Y_{full}). \] \hfill (8.11)

In this way, we have 10 unknown variables and 10 equations. The equilibrium attained this way is called neoclassical long-run equilibrium.

\(^2\) 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

\[ \frac{dL}{dt} = nL \]

which will be done in the chapters to follow.

\(^3\) Whenever price is explicitly introduced, all variables have to be expressed (or interpreted) as real values.
On the other hand, according to a Keynesian view GDP is determined by the aggregate demand in the short-run. In this sense, the equation (8.10) becomes redundant. Right-hand diagram shows that GDP is determined by the aggregate demand without the equation (8.10). 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 (8.9). Contrary to the neoclassical view, the economy has no autonomous mechanism to attain an equilibrium in which output produced by the equation (8.9) is equal to the aggregate demand; that is, a neoclassical long-run equilibrium. This is because price is regarded as sticky in the short-run, and cannot play a role to adjust a discrepancy between aggregate supply of output and aggregate demand. Hence, Keynesian economists argue that such a neoclassical long-run equilibrium could only be attained in the short run through changes in aggregate demand made possible by monetary and fiscal policies.

Can we create a synthesis model to deal with these controversies between neoclassical and Keynesian schools? 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 Adjustment Process**

Let us start with a Keynesian approach by deleting the equation (8.10). We have now 9 equations with 9 unknowns; that is, $Y, AD, C, I, G, Y_d, T, K, Y_{full}$ with 7 exogenously determined parameters $(C_0, c, T, I, G, L)$.

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4 I once posed this question in the book [90]. At that time, I was unaware of system dynamics and unable to model my general equilibrium framework for simulation.
8.2. A KEYNESIAN MODEL

A level of GDP that holds \( Y = AD \) is obtained in terms of the parameters as follows:

\[
Y = C_0 + cT + I + G \tag{8.12}
\]

Let us assign some numerical values to these parameters \((C_0, c, I, G, T) = (24, 0.6, 120, 80, 40)\), then we have \( Y^* = 500 \).

How can such a Keynesian equilibrium GDP be attained if aggregate supply and aggregate demand are not equal initially? The Keynesian model assumes that aggregate supply is determined by the size of aggregate demand. Fig 8.3 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 model these static comparisons dynamically, the determination equation of GDP (8.1) has to be replaced with the following differential equation:

\[
\frac{dY}{dt} = (AD - Y)/AT \tag{8.13}
\]

where \( AT \) is an adjustment time.
CHAPTER 8. AGGREGATE DEMAND EQUILIBRIA

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 8.4 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].

![Keynesian SD Model of GDP](image)

Figure 8.4: Keynesian SD Model of GDP

Left-hand diagram of Figure 8.5 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 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 (8.9) the maximum amount of output is produced by fully utilizing the existing capital stock $K$ and labor force $L$.

$$Y_{full} = Y(K, L)$$  \hspace{1cm} (8.14)

Obviously, there is no guarantee that the Keynesian equilibrium GDP of $Y^*$ is equal to $Y_{full}$, and the equilibrium equation (8.10) 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 (8.12), we have

\[
\Delta Y = \frac{-c\Delta T + \Delta I + \Delta G}{1-c}
\]

Thus, multipliers for \( I, G \) and \( T \) are calculated as follows:

\[
\frac{\Delta Y}{\Delta I} = \frac{\Delta Y}{\Delta G} = \frac{1}{1-c} = 2.5 ; \quad \frac{\Delta Y}{\Delta T} = \frac{-c}{1-c} = -1.5
\]

Suppose that \( Y_{\text{full}} = 560 \). Then, to attain a full capacity level of GDP, we need to increase \( \Delta Y = Y_{\text{full}} - Y^* = 60 \). 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 8.3 illustrates how \( Y_{\text{full}} \) is attained by increasing aggregate demand such as investment and government expenditures.

**System Dynamics Adjustment Process**

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 John Sterman’s book \[73\]. 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 (8.13) now needs to be revised as follows:

\[
\frac{d I_{nv}}{dt} = (Y - AD) \tag{8.17}
\]

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:

\[
Y^D = \frac{\text{Desired Inventory} - \text{Inventory}}{\text{Inventory Adjustment Time}} + \text{AD Forecasting} \tag{8.18}
\]

where desired inventory is an exogenous parameter and set to be 30 dollars in our model. Then, redefine the aggregate supply as

\[
Y = Y^D \quad (\text{Desired Production}) \tag{8.19}
\]

Figure 8.6 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 8.7. 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.

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 8.5. 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.

### 8.3 Aggregate Demand (IS-LM) Equilibria

In the above Keynesian macroeconomic model, taxes, investment and government expenditures are assumed to be exogenously determined. To make it
more complete, we now try to construct these variables to be endogenously determined. Let us begin with government taxes by assuming that they consist of three parts: lump-sum taxes such as property taxes ($T_0$), income taxes that are proportionately determined by an income level, and government transfers such as subsidies ($T_r$):
\[ T = T_0 + tY - T_r \]  
(8.20)

where \( t \) is an income tax rate.

Next, investment is assumed to be determined by the interest rate:

\[ I(i) = \frac{I_0}{i} - \alpha i \]  
(8.21)

where \( \alpha \) is an interest sensitivity of investment. We have now added a new unknown variable of the interest rate to the model, and hence an additional equation is needed to make it complete. 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:

\[ \frac{M^*}{P} V = aY - bi \]  
(8.22)

where \( V \) is velocity of money having a unit 1/year, \( a \) is a fraction of income for transactional demand for money, and \( b \) is an interest sensitivity of demand for money. \( P \) is a price level and it is treated as a sticky exogenous parameter.

From the equilibrium condition in the goods market, a relation between GDP and interest rate, which is called IS curve, is derived as follows:

\[ Y = \frac{C_0 + I_0 + G + c(T_r - T_0)}{1 - c(1 - t)} - \frac{\alpha}{1 - c(1 - t)} i \]  
(8.23)

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

\[ Y = \frac{1}{a} \frac{M^*}{P} V + \frac{b}{a} i \]  
(8.24)

Equilibrium GDP and interest rate \((Y^*, i^*)\) are now completely determined by the IS and LM curves. For instance, the aggregate demand equilibrium of GDP is obtained as

\[ Y^* = \frac{C_0 + I_0 + G + c(T_r - T_0)}{1 - c(1 - t) + \alpha(a/b)} + \frac{\alpha/b}{1 - c(1 - t) + \alpha(a/b)} \frac{M^*}{P} V \]  
(8.25)

This is a standard Keynesian process of determining an aggregate demand equilibrium of GDP in the short run in which price is assumed to be sticky. Figure 8.8 illustrates how IS and LM curves determine the equilibrium GDP and interest rate \((Y^*, i^*)\).

As discussed in the previous section, 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

We have successfully made variables such as $T$ and $I$ endogenous. The only remaining exogenous variable is government expenditures, $G$. They are usually determined by a democratic political process, and in this sense could be left outside the system as an exogenously determined parameter.

Instead, we try to 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

$$\frac{dG}{dt} = g(t)G. \quad (8.26)$$

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:

$$G = \beta T \quad (8.27)$$
where $\beta$ 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 macroeconomic system.

Let us analyze the second case furthermore. In this case IS curve becomes

$$Y = C_0 + I_0 + (\beta - c)(T_0 - T_r) - \frac{\alpha}{1 - c - (\beta - c)t}i$$

(8.28)

By rearranging, the aggregate demand equilibrium of GDP is calculated as

$$Y^* = C_0 + I_0 + (\beta - c)(T_0 - T_r) + \frac{\alpha/b}{1 - c - (\beta - c)t + \alpha(a/b)} \frac{M_s}{P} V$$

(8.29)

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 (8.29)

$$\frac{dY}{dT_0} = \frac{1 - c}{(1 - c)(1 - t) + \alpha(a/b)} > 0$$

(8.30)

On the other hand, in the case of the exogenously determined expenditures, we have from the equation (8.25)

$$\frac{dY}{dT_0} = \frac{-c}{1 - c(1 - t) + \alpha(a/b)} < 0$$

(8.31)

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.

### 8.4 Modeling Aggregate Demand Equilibria

Now we are in a position to construct our SD macroeconomic model of aggregate demand equilibria based on IS-LM curves [Companion model: 3 GDP(IS-LM).vpmx]. To do so, the equilibrium condition (8.22) in the money market needs to be replaced with a dynamic adjustment process of interest rate as a function of excess demand for money:

$$\frac{d}{dt}i = \Phi \left( (aY - bi) - \frac{M_s}{P} V \right)$$

(8.32)

Applying the formalization of adjustment processes discussed in the equations (2.8) and (2.5) in Chapter 2, adjustment process of the interest rate can be further specified as
8.4. MODELING AGGREGATE DEMAND EQUILIBRIA

\[ \frac{d i}{dt} = \frac{i^* - i}{\text{DelayTime}} \]  

(8.33)

where the desired interest rate \(i^*\) is obtained as

\[ i^* = \frac{i}{\left(\frac{M}{P}V/(aY - b_i)\right)^e}, \]  

(8.34)

in which \(e\) denotes a money ratio elasticity of desired interest rate.

Figure 8.9 illustrates the adjustment process of interest rate.

With this replacement, we could directly build a SD macroeconomic model of aggregate demand model in a mechanistic way such that IS and LM curves interact one another as developed in Figure 8.8 in the previous section. This could be a better approach than the comparative static analysis in which IS and LM curves are manually sifted to observe how aggregate demand equilibrium of \((Y^*, i^*)\) is changed as usually done in the standard textbooks.

However, from a system dynamics point of view, this mechanistic approach of modeling aggregate demand equilibria may incur many causal loopholes. For instance, when consumers save, they receive interests from banks. If government spends more than receives, its deficit has to be funded by consumers as a purchase of government securities, against which they also receive interests. Whenever the macroeconomy is viewed as a wholistic economic system, these transactions play important feedback roles and such feedback effects need not be neglected. Therefore, as a complete system it should include those transactions among consumers, producers, banks and government from the beginning.

Due to the existence of these causal loopholes, standard macroeconomic framework has resulted in offering many open spaces which macroeconomists are invited to fill in with their own ideas and theories. We believe these open spaces have been intrinsic causes of many macroeconomic controversies such as the one
between neoclassical and Keynesian schools of economics. These controversies, moreover, give us an impression that their macroeconomic models are mutually exclusive and cannot be integrated like oil and water.

On the contrary, as system dynamics researchers we believe that macroeconomy as a system could be modeled as an integrated whole so that controversies such as described above are nothing but different behaviors caused by slightly different conditions of the same system structure. In this sense, its system dynamics model, if built completely, could synthesize these controversies as different macroeconomic system behaviors, rather than the behaviors of different economic system structures. This has been our main motivation for constructing a wholistic SD macroeconomic model in this book.

For the construction of synthetic model, a double entry accounting system of corporate balance sheet turns out to be very effective for describing many transactions among macroeconomic sectors. To some reader this approach seems to make our modeling unnecessarily complicated compared with the standard macroeconomic framework. We pose, however, that this is the simplest way to describe complicated macroeconomic behaviors per se.

**Producers**

Let us now describe some fundamental transactions which are missing in the standard textbook framework. We begin with 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 equation (8.19) by following a system dynamics approach of inventory management, while investment decision is assumed to be made by a standard macroeconomic investment function (8.21).

Based on these decisions, major transactions of producers are, as illustrated in Figure 8.10, summarized as follows.

- Producers are constantly in a state of cash flow deficits as analyzed in Chapter 4. To make new investment, therefore, they have to borrow money from banks and pay interest to the banks.

- Out of the revenues producers 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.

- The remaining profits are paid to the owners (that is, consumers) as dividends.

**Consumers**

Consumers have to make two decisions: how much to consume and how much to invest the remaining income between saving and government securities - a
Figure 8.10: Transactions of Producers
Figure 8.11: Transactions of Consumer
portfolio choice. Consumption decision is assumed to be made by a standard consumption function (8.3). (It could also be made dependent on their financial assets). As to the portfolio decision we simply assume that consumers first save the remaining income as deposits, out of which, then, they purchase government securities.

Transactions of consumers are illustrated in Figure 8.11, some of which are summarized as follows.

- Consumers receive wages and dividends.
- In addition, they receive interest from banks and the government that is derived from their financial assets consisting of bank deposits and government securities.
- Financial investment of government securities is made out of the account of deposits. (In this model, no corporate shares are assumed to be purchased).
- Out of the cash income as a whole, consumers pay income taxes, and the remaining amount becomes their disposal income.
- Out of their disposal income, they spend on consumption. The remaining amount is saved. Accordingly, no cash is assumed to be withheld by the consumers.

**Government**

Government faces decisions such as how much taxes to levy as revenues and how much to spend as expenditures. Tax revenues are assumed to be collected according to the standard formula in (8.20), while expenditures are determined either by growth-dependent amount (8.26) or revenue-dependent amount (8.27). In the model, expenditures are easily switched to either one. Revenue-dependent expenditure is set as default.

Transactions of the government are illustrated in Figure 8.12, some of which are summarized as follows.

- Government receives, as tax revenues, income taxes from consumers and corporate taxes from producers. It also levies excise tax on production.
- Government spending consists of government expenditures and payments to the consumers such as 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 by newly issuing government securities.
Figure 8.12: Transactions of Government
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Figure 8.13: Transactions of Banks
Banks

In our model, banks are assumed to play a very passive role; that is, they only make loans to producers by the amount asked by them. In other words, they don’t purchase government securities and accordingly need to make no portfolio decisions between loans and securities. This assumption is dropped in the following chapters. Transactions of banks are illustrated in Figure 8.13, some of which are summarized as follows.

- Banks receive deposits from consumers, against which they pay interests.
- They make loans to producers and receive interests. Prime interest rate for loans is assumed to be the same as the interest rate for deposits. This assumption is dropped in the following chapters.
- Their retained earnings thus become interest receipts from producers less interest payment to consumers.

8.5 Behaviors of Aggregate Demand Equilibria

We now see how aggregate demand equilibrium of \( (Y^*, i^*) \) is attained in our SD model constructed above. This model is built by deleting the equation (8.10) and in this sense, as already discussed above, \( Y^* \) needs not be equal to a production level of full capacity, \( Y_{full} \). Surely, the full production level is a maximum level of output in the economy beyond which no physical output is possible. To introduce this upper bound of production level, the equation (8.19) has to be revised as follows.

\[
Y = \min(Y_{full}, Y^D) \tag{8.35}
\]

By introducing the concept of GDP Gap, the equilibrium condition in the equation (8.10) is now re-defined as

\[
\text{GDP Gap} \equiv Y_{full} - Y = 0 \quad \text{(Equilibrium Condition)} \tag{8.36}
\]

The full capacity output level in equation (8.14) is here specified as follows:

\[
Y_{full} = e^{\kappa t} \frac{1}{\theta} K \tag{8.37}
\]

where \( \kappa \) is an annual increase rate of technological progress, and \( \theta \) is a capital-output ratio. For simplicity, labor force is not considered here. The production process of GDP in our SD model is illustrated in Figure 8.14.

Now let us run the model: 3 GDP(IS-LM).vpmx thus constructed. From Figure 8.15, GDP Gap (line 1) is shown to be zero. Hence, our default simulation path named equilibria is shown to be in a state of equilibrium.

\footnote{Note that when \( Y^D > Y_{full} \), our economy is running beyond full capacity, yet GDP Gap becomes zero according to our definition here, and this state is also regarded as an equilibrium state. When price is made flexible below, this over-capacity state is reflected as an increase in price; that is, inflationary.}
Figure 8.14: Full Capacity Production
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Figure 8.15: GDP Gaps of All Simulations

Top diagram in Figure 8.16 shows our default growth path of production (line 1) around full capacity level (line 6). Bottom diagram Figure 8.16 is loci of aggregate demand equilibrium \((Y^*, i^*)\) such as an intersection between IS-LM curves as illustrated in Figure 8.8. Our model can capture these dynamic movements of the aggregate demand equilibria in contrast with comparative static ones in standard textbooks. This may be another contribution of SD macroeconomic modeling.

Causes of Disequilibria

According to the IS-LM analysis, disequilibria or recessions are caused by the shift of IS and LM curves in Figure 8.8 to the left. What causes the shift of the IS curves, then? They are the deduction of consumption, investment, government expenditures, and tax increases. When IS curve shifts to the left, both GDP and interest rate drop and the economy is triggered to the recession. The reader can examine these five causes by changing the related model parameters.

Here we consider a disequilibrium case which is triggered by decreasing the amount of basic consumption from 61 to 41; that is, by 20 at \(t=4\). Top diagram in Figure 8.17 shows that initial equilibrium amount of \(Y = 409.09\) is thrown into disequilibrium until a discrepancy between full production and desired production is brought to an equilibrium about \(Y^* = 422\) around the period 9 once again. Beyond this point, however, the economy is once again thrown into recession; that is to say, aggregate demand equilibrium of GDP is shown to be constantly lower than the full production level. Bottom diagram is loci of aggregate demand disequilibrium \((Y^*, i^*)\) such as an intersection between IS-LM curves as illustrated in Figure 8.8.

Whenever aggregate demand (line 2) is smaller than production (line 1), it
8.5. BEHAVIORS OF AGGREGATE DEMAND EQUILIBRIA

Figure 8.16: Aggregate Demand Mostly Equilibria

tends to lower production, vice versa, as we have analyzed in the SD determination process in Figure 8.7

Fiscal Policy 1: Government Expenditures

Now we try to attain a $Y_{full}$ equilibrium through fiscal policy in place of monetary policy. Specifically we try to increase government expenditures by 18 at period 8. According to textbook explanation, this increase shifts the IS curve to the right and stimulates the economy by increasing $Y^*$. However, as illustrated in the bottom diagram of Figure 8.18, it also pushes up $i^*$, and eventually discourages investment, which is a well known crowding-out effect of government expenditures.

To confirm this, let’s take a look at the top diagram, in which a full capacity equilibrium is shown to be attained again around $Y_{full} = Y^* = 432$ around
period 15. Beyond this point, however, aggregate demand and production continues to decline, while full capacity output also begin to decline over the period 21 due to a continued increase in interest rate and discouraged investment following it. This movement suggests the existence of crowding-out effect caused by fiscal policy. Figure 8.19 compares the behaviors of interest rate among disequilibria (line 1), monetary policy (line 2), and fiscal policy (line 3). Compared with the case of monetary policy which lowers interest rate to stimulate investment, fiscal policy pushes up interest rate, discouraging the investment.

**Government Debt**

Figure 8.20 shows how government debt has accumulated by this fiscal policy from 0 at the period 14 to 417 at the period 35, which is close to the GDP of 427. In reality the increasing government debt will lower the price of government securities, and further increase the interest rate. This will not only cause a loss of
government credibility, but also bring investment activities simultaneously to a complete standstill; in short, a total breakdown of national economy eventually.

In standard textbooks fiscal policy is usually introduced as a very effective policy to stimulate the economy, while the skyrocketing effect of government debt, the other side of the coin, is left out from the picture, giving an impression to the students that fiscal policy works well without any problem. Our system dynamics analysis is able to successfully capture the other side of the coin. Hence, this could be another contribution of our SD macroeconomic modeling.

In this Keynesian aggregate demand analysis, no feedback structure is built in to reverse the situation of hyper-inflation and a possible collapse of the economy, simply because price is assumed to be fixed, which will be dropped in the next section.

This leads to austerity policy.
CHAPTER 8. AGGREGATE DEMAND EQUILIBRIA

Figure 8.19: Behaviors of Interest Rate Compared

Figure 8.20: Skyrocketing Government Debt

Fiscal Policy 2: Tax Cut

Simulation of this policy is left to the reader.

Monetary Policy

How can we, then, attain a true $Y_{full}$ equilibrium in which full capacity output is completely sold out? As already illustrated in Figure 8.3, it could be done by an increase in aggregate demand. The essence of the Keynesian theory is that
aggregate demand can be stimulated by monetary and fiscal policies; that is, macroeconomy is manageable!

Let us examine monetary policy first by increasing the amount of money stock by 10 at period 8. According to textbook explanation, this increase in money stock shifts the LM curve to the right, and accordingly $i^*$ is lowered while $Y^*$ increases. In the top diagram of Figure 8.21 a full capacity equilibrium is shown to be attained again around $Y_{full} = Y^* = 440$ at period 17. Unfortunately, however, this equilibrium cannot be sustained, because capital continues to accumulate and accordingly production capacity also continues to increase, eventually exceeding aggregate demand.

Bottom diagram shows how interest rate begins to decline due to the increase in money stock. However, it eventually begins to increase as aggregate demand fails to sustain a full capacity equilibrium.

Figure 8.21: Effect of Monetary Policy
8.6 Limitations of the IS-LM Analysis

Mainstream macroeconomic theory has be represented by the IS-LM curves in many textbooks.

8.6.1 Failure of Monetary Policy

The monetary policy we discussed above indicates that economic recession can be overcome by the monetary policy of increasing money stock. The theory assumes that money stock is increased by the Open Market Purchase Operation of government stock. Yet, it only increased base money $M_0$, but failed to increase $M_1$ which is needed for transactions.

In Japan the Bank of Japan increased base money through open market purchase policy of the government bonds, which is called Quantitative Easing Policy. Yet it failed to increase money stock as assumed by the IS-LM analysis.
This implies that the shift of LM curves didn’t take place as predicted by the theory.

The failure of the theory is the assumption that the central bank can control money stock $M_1$. It can only control $M_0$.

### 8.6.2 Erroneous Money Hypothesis of the Great Depression

When money stock shrinks, the LM curves shift to the left, causing recession. Money Hypothesis claims that this has been the main cause of Great Depression. If this theory is correct, interest rate should have increased due to the shortage of money stock. Yet, interest rate dropped during the Great Depression. This indicates that Money Hypothesis failed to explain the behaviors of the Great Depression.

True explanation is as follows. After the bubble burst, a rumor of bankruptcy spread, causing bank runs among depositors. This increases the liquidity preferences or cash ratio in Chapter 5, forcing the reserves by the banks. Under the fractional reserve banking system a tiny reduction of reserves multiple larger deduction of deposits; that is, money stock as indicated in the Table on Great Depression.

This decrease in money stock constrains the corporate and housing investment, in spite of the decrease in interest rate. Hence, bubble burst decreases money stock (shift of LM curve), then almost simultaneously decreases consumption and investment (shift of IS curves).

Irvin's Fisher correctly pointed out the fractional reserve banking system as a main cause of the Great Depression. Hence, he advocated 100% reserve system, which turned into our analysis of the Public Money System in Part IV.

### 8.7 Neoclassical Policy of Price Flexibility

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 monetary and fiscal policies are carried out.

In fact, let us rewrite the aggregate demand equilibrium of GDP obtained in equation (8.25) as a function of price:

$$Y^*(P) = A + B \frac{M^e}{P} V, \quad (8.38)$$

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 now obvious that, unless price is flexible, there exists no mechanism to attain a true equilibrium such that

$$Y_{full} = Y^*(P) \quad (8.39)$$
CHAPTER 8. AGGREGATE DEMAND EQUILIBRIA

It is shown in the previous section that, even though monetary and fiscal policies can attain a full capacity production equilibrium, central bank and government need to constantly fine-tune their policies to sustain such equilibrium. Can they really perform the task under a sticky price in the short run? If so, how short is a short run, practically speaking, to apply such policies?

From a dynamic point of view, it’s very hard to specify how short is a short run. Is this moment in the short run or in the long run? It depends on when to specify an initial point. This moment could be in the short run to justify current policies. Or it could be already in the long run, and a long-run price adjustment mechanism, to be discussed below, may be under way. If so, current policy applications might worsen economic situations.

Accordingly, a better way of modeling a macroeconomic system has to allow price flexibility in the model from the beginning and let the price adjust disequilibria, including a fixed price as its special case. To do this formally, we have to bring a previously neglected equation (8.10). To avoid a redundancy of equation by doing so, we need to introduce another variable of price, and let it adjust discrepancies between full capacity output $Y_{full}$ and desired production $Y^D$ as in the equation of price adjustment mechanism (8.11). Such discrepancies are called GDP gap. Price, however, may also adjust directly to the discrepancies between inventory $I_{nv}$ and its desired inventory $I_{nv}^*$, which are called inventory gap here. This is an adjustment process of attaining stability on a historical time already discussed in Chapter 2.

Hence, such an adjustment equation could be described as

$$\frac{dP}{dt} = \Psi(Y^D - Y_{full}, I_{nv}^* - I_{nv}).$$

(8.40)

Let us specify the equation, as in the interest equation (8.33), as follows:

$$\frac{dP}{dt} = \frac{P^* - P}{Delay Time}$$

(8.41)

where the desired price $P^*$ is obtained as

$$P^* = \frac{P}{(1 - \omega) \frac{Y_{full}}{Y^D} + \omega \frac{I_{nv}^*}{I_{nv}}}$$

(8.42)

where $\omega, 0 \leq \omega \leq 1$, is a weight between production and inventory ratios, and $\epsilon$ is an elasticity.

This completes our SD macroeconomic modeling of Keynesian IS-LM model. Figure 8.23 illustrates adjustment processes of price and interest rate.

With the introduction of flexible price (which is attained by setting a ratio elasticity of effect on price = 1.0), behaviors of the model turns out to be surprisingly different from the previous model under a fixed price. First, aggregate demand equilibrium, $Y^*$, can no longer be attained as in the previous fixed price case. Instead, as top diagram of Figure 8.24 illustrates, they fluctuates alternatively, which we call aggregate demand alternations.
Second, this alternation moves along a full capacity output level, and occasionally approaches to a full capacity equilibrium such that $Y_{full} = Y^*$ as if butterflies moves around flowers and occasionally rest on them. This vividly contrast with the previous fixed price case in which aggregate demand equilibrium can be attained through monetary and fiscal policies, but it will eventually diverge from a full capacity output level. Therefore, under a flexible price, monetary and fiscal policies might not be effective to attain full capacity equilibrium.

Third, economic growth rates turn out to fluctuate periodically as illustrated in the left-hand diagram of Figure 8.25, in which the business cycle of growth rates, produced by the inner forces of the system structure itself, can be observed to have a period of about 15 years. This is an entirely unexpected behavior to us. Can we avoid this business cycle by practicing monetary and fiscal policies? These will be open questions to be challenged later. Right-hand diagram shows cyclical movements of real money stock, demand and interest rate, which have similar fluctuation periods as business cycle of growth rate.

Figure 8.26 illustrates aggregate demand curve (line 1) and aggregate supply curves of production (lines 2) and full production (and 3). Aggregate demand curve is observed to be, roughly speaking, a downward-sloping, while aggregate supply curves to be horizontal.
CHAPTER 8. AGGREGATE DEMAND EQUILIBRIA

Aggregate Demand (GDP) Equilibria

Production : Flexible Price Dollar/Year
Aggregate Demand : Flexible Price Dollar/Year
Consumption : Flexible Price Dollar/Year
Investment : Flexible Price Dollar/Year
Full Production : Flexible Price Dollar/Year
Growth Rate : Flexible Price 1/Year

Aggregate Demand (IS-LM) Equilibria

Supply of Money : Flexible Price Dollar/Year
Demand for Money : Flexible Price Dollar/Year
Interest Rate : Flexible Price Percent/Year

Money Supply, Demand and Interest Rate

Figure 8.24: Flexible Price Equilibria

Figure 8.25: Growth, Price, Money Stock, Demand and Interest Rate
8.7. NEOCLASSICAL POLICY OF PRICE FLEXIBILITY

Disequilbria under Price Flexibility

To create a disequilibrium situation, let us change the basic consumption from 101 to 90 in the same fashion as previous section. Under flexible price, no disequilibrium situation is successfully produced as the Figure 8.27 illustrates.

In other words, similar business cycles are observed, this time, at a larger scale. This can be confirmed with Figure 8.28.

Growth-dependent Money Stock

It will be interesting to see how a change in money stock affects the behaviors of the above disequilbria under price flexibility, that is, price coefficient = 1.0. To do so, however, our macroeconomic model here must be first of all integrated with the money stock model developed in the previous chapters. Otherwise, it will be misleading to merely change money stock without examining its feedback relations within the system.

Even so, just for our curiosity, let us change money stock proportionally to an economic growth rate. Monetarist argue that money is neutral so that a change in money supply along with the economic growth does not affect true behaviors of its real part.

To observe the effect, let us introduce growth-dependent money stock in the same fashion as we introduced growth-dependent government expenditures in equation (8.26):

\[
\frac{dM^*}{dt} = g(t)M^*.
\] (8.43)
CHAPTER 8. AGGREGATE DEMAND EQUILIBRIA

Aggregate Demand (GDP) Equilibria

Aggregate Demand (IS-LM) Equilibria

Figure 8.27: Flexible Price Disequilibria

Figure 8.28: Growth, Price, Money Stock, Demand and Interest Rate
8.7. NEOCLASSICAL POLICY OF PRICE FLEXIBILITY

Figure 8.29: Growth-dependent Money Stock and its Effect on Interest Rate

In Figure 8.29, line 1 indicates a reference curve with constant money stock. Line 2 represents the behaviors with a growth-dependent money stock. Line 3 shows the behaviors with a growth-dependent money stock under disequilibria.

Specifically, left-hand diagram illustrates that real supply of money keeps fluctuating. Right-hand diagram shows that interest rate also continues to decrease as predicted by the theory.

Left-hand diagram of Figure 8.30 illustrates that production continues to grow. Right-hand diagram shows constant growth of money stock not only stimulate an economic growth incessantly, but destabilize the economic behaviors, contrary to a monetarist belief that constant growth of money according to the economic growth stabilizes the economy.

Figure 8.30: Growth-dependent Money Stock on GDP and Growth Rate

Figure 8.31 demonstrates that IS-LM curves extends to the right as the increasing money stock shifts LM curve to the right.

As pointed out above, however, true interpretations of these behaviors have to be postponed until the current macroeconomic model is integrated with the money supply models in the previous chapters.
CHAPTER 8. AGGREGATE DEMAND EQUILIBRIA

Aggregate Demand (IS-LM) Equilibria

![Graph showing Aggregate Demand (IS-LM) Equilibria](image)

Figure 8.31: Growth-dependent Money Stock on IS-LM

8.8 A Comprehensive IS-LM Model

Keynesian IS-LM model has a serious limitation; that is, money stock is exogenously given. On the contrary our SD approach of IS-LM model can treat money stock endogenously, which is now presented in this section [Companion model: 4 GDP(IS-Money).vpmx]. Money stock is defined in the previous chapters as follows:

\[
\text{Money Stock} = \text{Currency in Circulation} + \text{Deposits} \quad (8.44)
\]

Currency in circulation in our model consists of stocks of cash held by consumers, producers, government and banks. These cash stocks as well as deposits constitute money stock.

On the other hand, demand for money is also obtained in our model as outflows of the stocks of cash by consumers, producers, government and banks. In this way, supply of money and demand for money are endogenously determined in our comprehensive IS-LM model.

Based on these changes, desired interest rate defined in equation (8.34) also needs to be revised as

\[
i^* = \frac{i}{\left( \frac{\text{Supply of Money}}{\text{Demand for Money}} \right)^\varphi} \quad (8.45)
\]

Figure 8.32 shows a revised processes of interest rate and price adjustment.

In this way, our IS-LM model now becomes more comprehensive. Yet, it has a serious theoretical flaws. First, money stock cannot be changed without the
central bank, and secondly, real and monetary quantities are being mixed up. These will be fixed in the next chapter by integrating real and monetary sectors presented in this and previous two chapters.

Even so, it’s worth a while to observe how our comprehensive SD model behaves in comparison with a traditional Keynesian IS-LM model presented above.

Behaviors of the model

In the model aggregate demand equilibria are attained by setting a value of velocity of money to be 0.52, with all other model values remaining the same as before.

One of the Disequilibria can be triggered, as before, by reducing the amount of basic consumption from 101. Equilibria can be restored by introducing fiscal policy as before, with a skyrocketing government debt accumulated. This simulation is left to the reader.

There is no way, however, of introducing monetary policy in our model, simply because no central bank exists to create money stock within the system.
Figure 8.32: Interest Rate and Price Adjustment Process Revisited
8.8. **A COMPREHENSIVE IS-LM MODEL**

**Price Flexibility**

Let us now trigger disequilibria in a different way by introducing a technological progress of 0.3 % annually.

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**Figure 8.33:** Disequilibria triggered by A Technological Progress

As Figure 8.33 indicates, aggregate demand and production fail to catch up with full production around the period of 14 due to the increase in its productivity. Under the circumstance, let us allow a price flexibility by setting a value of ratio elasticity of effect on price to be 1.5.

Figure 8.34 illustrates how a production gap can be filled with business cycles.

Figure 8.35 illustrates aggregate demand and supply curves.
8.9 Conclusion

In this chapter, we have successfully built a real part of macroeconomic system, based on our analytical tool of double entry accounting system. Our model comprises dynamic processes of determining GDP, interest rate and price level. It integrates both Keynesian and neoclassical frameworks, starting first with a standard Keynesian model, then expanding it as an aggregate demand equilibrium model of IS-LM curves, and finally introducing neoclassical long-run feature of price flexibility.

From the analysis of our SD macroeconomic modeling, some of the main features we have obtained are as follows.

- A standard Keynesian macroeconomic adjustment process overshoots an
equilibrium GDP when SD inventory adjustment process is introduced.

- Under a balanced budget, a reduction in lump sum taxes does not stimulate the aggregate demand.

- Under a Keynesian sticky price, full capacity equilibrium cannot be sustained by monetary and fiscal policies unless they are constantly fine-tuned.

- Fiscal policy to attain full capacity equilibrium will skyrocket the government debt.

- Keynesian aggregate demand equilibria can be presented as loci of the intersections of IS-LM curves.

- Specifically, fiscal policy crowds out the investment opportunities by increasing interest rate. At the same time government debt continues to accumulate, which may eventually leads to an incredibility of government securities and a total collapse of the economy with worsening production capacity caused by the decrease in investment.

- Under a flexible price, aggregate demand equilibria can no longer be attained, instead production and aggregate demand alternates. Moreover, they fluctuates around a full capacity output level.

- Under such circumstances, monetary and fiscal policies might be no longer effective as a tool to attain full capacity equilibrium.
When money stock is fixed under a flexible price, price and interest rate continue to fluctuate.

When money stock is changed proportionately to an economic growth rate, price and interest rate, as well as real money stock, begin to fluctuate larger than in the fixed money stock. Moreover, price and interest rate fluctuates oppositely to money stock.

Keynesian IS-LM model thus presented above has a serious limitation; that is, money stock is exogenously given.

It may be too early to confirm some of the above features until we integrate the model presented in this chapter with the model of money stock in the previous two chapters, because an endogenous change in money stock may trigger an overall feedback reactions among all macroeconomic sectors, and the mechanistic change in money stock introduced here might be misleading.

Apparently, this leads to our next target toward the integration of the real and monetary economic models developed so far.
8.9. CONCLUSION

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 8.3 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 (8.12). Calculate MPC elasticity of equilibrium GDP \( (\frac{\partial Y^*}{\partial c}) \). 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

\[ \text{Change in Tax} \implies \text{Change in MPC} \implies \text{Consumption} \implies \text{GDP}. \]

In other words, tax cut may have more positive impact on GDP than generally considered by the standard Keynesian models.

4. Balance sheet of producers in the model: 3 GDP(IS-LM).vpmx is slightly different from the simplified corporate balance sheet in Chapter 3 in the way inventory and account receivable are treated. Discuss why?

5. (Fiscal and Monetary Policies by IS-LM Approach)
   Traditional Keynesian IS-LM model is thoroughly reconstructed by the ASD Keynesian macroeconomic model: 3 GDP(IS-LM).vpmx. This ASD 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

\[
\text{Full Production} = \text{Production} = \text{Aggregate Demand}.
\]

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


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.

6. (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."

(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.
Appendix: SD Macroeconomic Model

Core part of our SD macroeconomic model is described as follows.

\[ Y_{\text{full}} = \frac{1}{\theta} K \]  
[8.46] (Full Capacity Output)

\[ Y = \min(Y_{\text{full}}, Y^D) \]  
[8.47] (Production Decision)

\[ Y^D = (I^*_n - I_{nv}) + AD \]  
[8.48] (Desired Production)

\[ \frac{dI_{nv}}{dt} = Y - AD \]  
[8.49] (Inventory Adjustment)

\[ AD = C + I + G \]  
[8.50] (Aggregate Demand)

\[ C = C_0 + cY_d \]  
[8.51] (Consumption Decisions)

\[ Y_d = Y - T - \delta K \]  
[8.52] (Disposable Income)

\[ T = T_0 + tY - Tr \]  
[8.53] (Tax Revenues)

\[ I = \frac{I_0}{r - \alpha i} \]  
[8.54] (Investment Decisions)

\[ \frac{dK}{dt} = I - \delta K \]  
[8.55] (Net Capital Accumulation)

\[ \frac{dG}{dt} = gG \]  
[8.56] (Government Expenditures)

\[ \frac{dP}{dt} = \Psi(Y^D - Y_{\text{full}}, I^*_n - I_{nv}) \]  
[8.57] (Price Adjustment)

\[ m^* = \frac{M^*}{P} \]  
[8.58] (Real Money Supply)

\[ m^d = aY - bi \]  
[8.59] (Demand for Money)

\[ \frac{d i}{dt} = \Phi(m^d - m^*) \]  
[8.60] (Interest Adjustment)

This macroeconomic model consists of 15 equations with 15 unknown variables; that is, \( Y_{\text{full}}, K, Y, Y^D, I_{nv}, AD, C, I, G, Y_d, T, I, P, MS, MD \).
Chapter 9

Integration of Real and Monetary Economies

In the previous three chapters, monetary and real parts of macroeconomies are built separately. In this chapter, 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.

9.1 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 9.1 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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9.2 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\(^2\).

\[
\text{Nominal interest rate} = \text{Real interest rate} + \text{Inflation rate} \quad (9.1)
\]

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 9.2.

Investment Function

The amount of desired investment is obtained as the difference between desired and actual capital stock plus depreciation such that

\[
I(i) = \frac{K^*(i) - K}{\text{Time to Adjust Capital}} + \delta K \quad (9.2)
\]

where \(\delta\) is a depreciation rate. Desired capital stock could be approximated by

\[
K^* = \frac{\alpha(1-t)Y^*}{i + \delta} \quad (9.3)
\]

where \(\alpha\) 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 9.2.

The new investment function obtained above replaces our previous investment function that is determined by the interest rate:

\[
I(i) = \frac{I_0}{i} - ai \quad (9.4)
\]

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 [90], 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 9.2: 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 (8.3). 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

\[ c(P) = \frac{c}{\left(\frac{P}{P_0}\right)^e} \]  

(9.5)

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

\[ C(P) = C_0 + c(P)Y_d \]  

(9.6)

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:\n
\[ \text{Money Stock} = \text{Currency in Circulation} + \text{Deposits} \]  

(9.7)

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.

\[ ^4 \text{In our simple model, it may not be needed to classify monetary aggregates further into M1, M2 and M3.} \]
On the other hand, demand for money consists of three motives: transaction, precautionary and speculative motives, according to the standard textbooks such as \[39\]. In our previous IS-LM model (equation (8.32)), 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).

\[
\text{Cash Demand} = \frac{\text{Currency Ratio} \times \text{Deposits} - \text{Cash}}{\text{Cashing Time}}
\]

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 (8.22)\[5\].

Figure 9.3 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:

\[
\text{Money (M)} \times \text{Velocity (V)} = \text{Price (P)} \times \text{Transaction (T)},
\]

where V is called transaction velocity of money in [54, p. 82].
9.2. CHANGES FOR INTEGRATION

Figure 9.3: 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 9.4 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 9.4.

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 [83, 84]. 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.

\[
\text{Prime rate} > \text{Nominal interest rate} \quad (9.9)
\]

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. 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

\[
\text{Initial interest value} = \text{initial interest rate} + \text{discount rate} \quad (9.10)
\]

Nominal rate of interest and prime rate are assumed to be determined in our previous models as

\[
\text{Interest rate (nominal)} = \text{real interest rate} + \text{inflation rate} \quad (9.11)
\]

and

\[
\text{Prime rate} = \text{interest rate (nominal)} + \text{prime rate premium}, \quad (9.12)
\]

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.

### 9.3 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 9.5, 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 9.6, 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 9.7, 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 9.6: Transactions of Consumer
Figure 9.7: Transactions of Government
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Banks

Transactions of banks are illustrated in Figure 9.8, 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 *fractional reserve 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 9.9, 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
9.3. TRANSACTIONS AMONG FIVE SECTORS

Figure 9.8: 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.)

9.4 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:

\[ \text{Full Capacity GDP} = \text{Desired Output} \]  

(9.13)

When the economy is not in the equilibrium state, actual GDP is determined by

\[ \text{GDP} = \text{MIN} \left( \text{Full Capacity GDP}, \text{Desired Output} \right) \]  

(9.14)

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

\[ \text{GDP Gap (Full Capacity) Ratio} = \frac{\text{Full Capacity GDP} - \text{GDP}}{\text{Full Capacity GDP}}. \]  

(9.15)

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 \(\omega\) is 0.1, as illustrated in Figure 9.10.

The reader may wonder why this is a state of mostly equilibria, because growth rates and inflation rates still fluctuate as shown in Figure 9.11. Specifically, growth rates fluctuate 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 9.9: Transactions of Central Bank
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 9.12 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.
9.4. BEHAVIORS OF THE INTEGRATED MODEL

**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 9.13 portrays.

**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 9.14.
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 9.15 illustrates how supply of money shrinks and, accordingly, interest rate increases by the credit crunch caused by the central bank. Figure 9.16 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
9.4. BEHAVIORS OF THE INTEGRATED MODEL

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 bank runs arise all over. In our model this can be simulated by increasing a currency ratio by 0.15 at the year 15. Figure 9.17 illustrates how currency in circulation jumps (line 3) and deposits plummets (line 3), compared with equilibrium states (lines 2) and credit crunch (lines 1).

These changes affect overall behavior of supply of money, specifically it is decreased as indicated by the left diagram of Figure 9.18 (line 3), which in turn...
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worsens the GDP growth and causes depressions as shown by the right diagram of Figure 9.18 (line 3).

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 9.19). 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.

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 9.20). 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.
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 9.20, government debt continues to accumulate as the left diagram of Figure 9.21 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

$$
\text{Deficit} = \text{Tax Revenues} - \text{Expenditure} - \text{Debt Redemption} - \text{Interest} \quad (9.16)
$$

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 9.21. 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!

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 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 9.22, 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

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$^7$ This feedback loop from the accumulating debt to the higher interest rate is not yet fully incorporated in the model.
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(continued).

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 9.23. 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 9.22: 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 9.24 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.

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 9.24: Price Flexibility, Business Cycles and Debt Reduction

Figure 9.25: Comparison of GDP paths

Figure 9.25 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 equi-
librium 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([90]). Now is time to analyze a capitalist market economy with labor market in the next chapter.

9.5 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 10

A Macroeconomic System

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.

10.1 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 10.1 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.

10.2 Production Function

In the previous model, full capacity output level is specified as follows:

where $\kappa$ is an annual increase rate of technological progress, and $\theta$ 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:

$$Y_{full} = F(K, L, A) = AK^\alpha L^\beta$$

(10.2)

where $A$ is a factor of technological change, and $\alpha$ and $\beta$ 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

$$Y_{potential} = F(K, LF, A) = AK^\alpha LF^\beta$$

(10.3)

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 (8.42) needs to be slightly revised to reflect the gap between potential GDP and desired output $Y^D$ as

$$P^* = \frac{P}{(1 - \omega)\frac{Y_{\text{potential}}}{Y^D} + \omega\frac{I_{\text{inv}}}{I_{\text{inv}}}}$$

(10.4)

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

$$A = A_0 e^{\kappa t}$$

(10.5)

where $\kappa$ 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 [32], let us normalize this production function with the initial potential GDP at $t = 0$:

$$Y_{\text{potential}} = F(K, LF, \bar{A}) = \bar{A}K^\alpha LF^\beta \quad \text{(Initial Potential Output)}$$

(10.6)

Then, we have

$$Y_{\text{full}} = e^{\kappa t}Y_{\text{potential}} \left(\frac{K}{\bar{K}}\right)^\alpha \left(\frac{L}{LF}\right)^\beta$$

(10.7)

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 10.5), while income tax, consisting of lump-sum tax and a proportional part of income tax, is paid by consumers (Figure 10.6). With these into consideration, profits after tax $\Pi$ are now defined as

$$\Pi = ((1 - t)PY_{\text{full}} - (i + \delta)P_K K - wL)(1 - t_c)$$

(10.8)

where $t$ is an excise tax rate, $t_c$ is a corporate profit tax rate, $i$ is a real interest rate, $\delta$ 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

$$iP_K K \approx \text{Prime Rate} \times \text{Loan (or Debt by producers)}$$

(10.9)

First order condition for profit maximization with respect to capital stock is calculated by partially differentiating profits with respect to capital as
\[
\left( \frac{1}{1 - t_c} \right) \frac{\partial \Pi}{\partial K} = \alpha (1 - t) Pe^{st} \left( \frac{\bar{Y}_{full}}{K} \right) \left( \frac{K}{\bar{K}} \right)^{\alpha - 1} \left( \frac{L}{L} \right)^{\beta} - (i + \delta) P_K
\]
\[
= \frac{\alpha (1 - t) Pe^{st} \left( \frac{\bar{Y}_{full}}{K} \right) \left( \frac{K}{\bar{K}} \right)^{\alpha} \left( \frac{L}{L} \right)^{\beta}}{K} - (i + \delta) P_K
\]
\[
= \frac{\alpha (1 - t) PY_{full}}{K} - (i + \delta) P_K
\]
\[
= 0
\]
(10.10)

The demand function for capital is thus obtained as
\[
K = \frac{\alpha (1 - t) PY_{full}}{(i + \delta) P_K}
\]
(10.11)

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
\[
K^*(i) = \frac{\alpha (1 - t) Y^*}{i + \delta}
\]
(10.12)

In our model desired output \( Y^* \) is represented by the variable: Aggregate Demand Forecasting (Long-run) as illustrated in Figure 10.2 (see also [32]).

The amount of desired investment is now obtained as the difference between desired and actual capital stock such that
\[
I(i) = \frac{K^*(i) - K}{\text{Time to Adjust Capital}} + \delta K
\]
(10.13)

Furthermore, let us define desired capital-output ratio as follows:
\[
\theta^*(i) = \frac{K^*}{Y^*} = \frac{\alpha (1 - t)}{i + \delta}
\]
(10.14)

Then, the above investment function can be rewritten as
\[
I(i) = \frac{\theta^*(i) - \theta}{\text{Time to Adjust Capital}} + \delta K
\]
(10.15)

The new investment function obtained above replaces our previous investment function in equation (8.21) that is determined by the interest rate:
\[
I(i) = \frac{I_0}{i} - a \frac{\phi}{i}
\]
(10.16)

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 (10.13) is used in this model.
10.2. PRODUCTION FUNCTION

First order condition for profit maximization with respect to labor is calculated as follows:

\[
\left( \frac{1}{1-t_c} \right) \frac{\partial \Pi}{\partial L} = \beta(1-t)Pe^{\kappa t} \left( \frac{Y_{\text{full}}}{L} \right) \left( \frac{K}{K} \right)^{\alpha} \left( \frac{L}{L} \right)^{\beta-1} - w
\]

\[
= \frac{\beta(1-t)Pe^{\kappa t} \left( \frac{Y_{\text{full}}}{L} \right) \left( \frac{K}{K} \right)^{\alpha} \left( \frac{L}{L} \right)^{\beta}}{L} - w
\]

\[
= \frac{\beta(1-t)PY_{\text{full}}}{L} - w
\]

\[
= 0
\]

(10.17)

Demand for labor is thus obtained as

\[
L^d = \frac{\beta(1-t)PY_{\text{full}}}{w}.
\]

(10.18)

Specifically, it is a decreasing function of real wage rate such that \( R = \frac{w}{P} \).

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

\[
L^*(Y^*, w^e) = \frac{\beta(1-t)PY^*}{w^e}
\]

(10.19)

The expected wage rate is assumed to be determined as

\[
w^e = w(1 + \text{inflation rate})
\]

(10.20)

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

\[
E(Y^*, w^e) = \frac{L^*(Y^*, w^e) - L}{\text{Time to Adjust Labor}}
\]

(10.21)

Net employment thus defined has a downward-sloping shape such that

\[
\frac{\partial E}{\partial w^e} = -\frac{\beta(1-t)Y^*}{\text{Time to Adjust Labor}} \frac{1}{(w^e)^2} < 0.
\]

(10.22)

The amount of wages to be paid by producers is determined by

\[
W = wL
\]

(10.23)

as illustrated in Figure 10.5.

With the above first-order conditions, profits after tax are now rewritten as

\[
\Pi = \left( (1-t)PY_{\text{full}} - (i + \delta)P_{Pe}K - wL \right)(1-t_c)
\]

\[
= \left( (1-t)PY_{\text{full}} - \alpha(1-t)PY_{\text{full}} - \beta(1-t)PY_{\text{full}} \right)(1-t_c)
\]

\[
= (1-t)(1-t_c)(1-\alpha - \beta)PY_{\text{full}}
\]

(10.24)
Figure 10.2: Real Production of GDP
10.3 Population and Labor Market

Labor Market and Wage Rate Adjustment

So far labor demand is assumed to be fully met as the equation (10.21) 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 10.3. 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:

\[
\frac{dw}{dt} = \phi(L^* - L^s) \tag{10.25}
\]

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 (10.18).

Let us further specify the wage rate equation, as in the interest rate and price equations, as follows:

\[
\frac{dw}{dt} = \frac{w^* - w}{\text{DelayTime}} \tag{10.26}
\]

where the desired wage rate \(w^*\) is obtained as

\[
w^* = \frac{w}{(L^e)^e} \tag{10.27}
\]

where \(e\) is a labor ratio elasticity.

These features are reflected in Figure 10.4.

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\(^3\) Vensim version of the World3 model is provided in the vendor’s sample models by Ventana Systems, Inc.
Figure 10.3: Population and Labor Market
10.4. TRANSACTIONS AMONG FIVE SECTORS

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

\[
\frac{dP}{dt} = \Psi(Y^D - Y_{potential}, I_{inv}^* - I_{inv}). \quad (10.28)
\]

With the introduction of wage determination in equation (10.26), it now becomes possible to add cost-push forces to the price adjustment process. These forces are represented by a change in the nominal wage rate such that

\[
w_g = \frac{d \log(w)}{dt}. \quad (10.29)
\]

The price adjustment process is now influenced by demand-pull and cost-push forces as well such that

\[
\frac{dP}{dt} = \Psi_1(Y^D - Y_{potential}, I_{inv}^* - I_{inv}) + \Psi_2(w_g) \quad (10.30)
\]

Figure 10.4 illustrates our revised model for adjustment processes of price and wage rate as well as interest rate.

10.4 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 10.5, 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 10.4: Interest Rate, Price and Wage Rate
10.4. TRANSACTIONS AMONG FIVE SECTORS

Figure 10.5: Transactions of Producers
Figure 10.6: Transactions of Consumer
10.4. TRANSACTIONS AMONG FIVE SECTORS

Consumers
Transactions of consumers are illustrated in Figure 10.6, 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 10.7, 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 10.8, some of which are summarized as follows.

- Banks receive deposits from consumers, against which they pay interests.
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Figure 10.7: Transactions of Government
10.4. TRANSACTIONS AMONG FIVE SECTORS

- 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 10.9, 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 10.8: 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.)

10.5 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:

\[ \text{Full Capacity GDP} = \text{Desired Output} \]  
(10.31)

When the economy is not in the equilibrium state, actual GDP is determined by

\[ \text{GDP} = \text{MIN} (\text{Full Capacity GDP, Desired Output}) \]  
(10.32)

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

\[ \text{Potential GDP} = \text{Full Capacity GDP} \]  
(10.33)

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

\[ \text{GDP Gap Ratio} = \frac{Y_{\text{potential}} - \text{GDP}}{Y_{\text{potential}}} \]  
(10.34)

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 10.10.

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 10.11 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 10.9: Transactions of Central Bank
10.5. BEHAVIORS OF THE COMPLETE MACROECONOMIC MODEL

**Figure 10.10:** Mostly Equilibrium States

**Figure 10.11:** 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 10.12 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.
CHAPTER 10. A MACROECONOMIC SYSTEM

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 10.13 portrays.

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 10.14.

![Figure 10.14: Business Cycles caused by Elastic Price Fluctuation](image1)

**Business Cycles by Cost-push Price**

Since price adjustment process is revised in equation (10.30), 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 10.15.

![Figure 10.15: Business Cycles caused by Cost-push Price](image2)

It would be worth examining this case of business cycle furthermore. Figure 10.16 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 vice 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...
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Price-Wage-Unemployment Rate

Figure 10.16: 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 10.17).

Figure 10.17: 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”.

10.5. **BEHAVIORS OF THE COMPLETE MACROECONOMIC MODEL**

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.

![Diagram of Money Supply and Interest Rate](image1)

Figure 10.18: Supply of Money and Interest Rate by Credit Crunch

![Diagram of GDP Gap Ratio and Unemployment Rate](image2)

Figure 10.19: Economic Recessions caused by Credit Crunch

10.19 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 10.20 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 10.20: 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 10.21 (line 3), which in turn worsens the GDP growth and causes depressions as shown by the right diagram of Figure 10.21 (line 3).

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 10.22 (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


10.5. BEHAVIORS OF THE COMPLETE MACROECONOMIC MODEL

Diagram of Figure 10.22 (line 3). Indeed, these recessions are appropriately called Depression.

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 10.23). 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%,
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 10.24).

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 10.24, government debt continues to accumulate as the left diagram of Figure 10.25 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

\[
\text{Deficit} = \text{Tax Revenues} - \text{Expenditure} - \text{Debt Redemption} - \text{Interest} \tag{10.35}
\]
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 10.25. 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\textsuperscript{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 10.26, debt-GDP ratio will be reduced to around one (right diagram) and the accumulation of debt will be eventually curved (left diagram).

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

\textsuperscript{4} This feedback loop from the accumulating debt to the higher interest rate is not yet fully incorporated in the model.
10.5. BEHAVIORS OF THE COMPLETE MACROECONOMIC MODEL

the economy fails to sustain a full capacity and full employment equilibrium as illustrated by line 1 in Figure 10.27. 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%.

![GDP Gap Ratio and Unemployment Rate](image)

Figure 10.27: 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 10.28 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.

![GDP Gap Ratio and Unemployment Rate](image)

Figure 10.28: 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 10.29 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 10.29: Comparison of GDP paths

10.6 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 IV

Open Macroeconomic Systems of Debt Money
Chapter 11

Balance of Payments and Foreign Exchange

This chapter 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.

11.1 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.

---

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 [50] and [54], 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 11.2 below), while the same amount is reduced from the inventory of foreign exporters (a red disk numbered 4 in Figure 11.3 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 11.2 and 11.5 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 11.6 and 11.3 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 11.1 expresses our image of modeling open macroeconomy by the principle of accounting system dynamics.

![Diagram](image)

**Figure 11.1:** Foreign Sector as a Mirror Image of Domestic Macroeconomy

### 11.2 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
11.2. OPEN MACROECONOMIC TRANSACTIONS

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 11.2, 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 11.3.

\(^{2}\)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 11.2: Transactions of Producers
Figure 11.3: Transactions of Foreign Producers
Consumers and Government

Transactions of consumers and government are illustrated in Figure 11.4, 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 11.4: Transactions of Consumers and Government](image)

Banks

Transactions of banks are illustrated in Figure 11.5, 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 11.6.

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 11.7, 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.

11.3 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 [50] 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 11.5: Transactions of Banks
Figure 11.6: Transactions of Foreign Banks
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 11.8 illustrates all transactions which enter into the balance of payments account.

Figure 11.9, 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.
11.3. THE BALANCE OF PAYMENTS

![Diagram of the Balance of Payments]

Figure 11.8: The Balance of Payments
11.4 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

$$M = M(Y, P_M), \quad \frac{\partial M}{\partial Y} > 0 \quad \text{and} \quad \frac{\partial M}{\partial P_M} < 0. \tag{11.1}$$

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 11.10 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:

\[ M = M(Y, P_M) = M(Y, P_f E), \quad (11.2) \]

\[ \frac{\partial M}{\partial P_f} = \frac{\partial M}{\partial P_M} \frac{\partial P_M}{\partial P_f} = \frac{\partial M}{\partial P_M} E < 0 \quad (11.3) \]

\[ \frac{\partial M}{\partial E} = \frac{\partial M}{\partial P_M} \frac{\partial P_M}{\partial E} = \frac{\partial M}{\partial P_M} P_f < 0 \quad (11.4) \]

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

\[ M = M(Y, P_M) = M(Y)D(P_M) = mYD(P_f E) \quad (11.5) \]

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

\[ X = X(Y_f, P_{M,f}), \text{ where } \frac{\partial X}{\partial Y_f} > 0 \text{ and } \frac{\partial X}{\partial P_{M,f}} < 0. \quad (11.6) \]

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:

\[ X = X(Y_f, P_{M,f}) = X(Y_f, P/E), \quad (11.7) \]

\[ \frac{\partial X}{\partial P} = \frac{\partial X}{\partial P_{M,f}} \frac{\partial P_{M,f}}{\partial P} = \frac{\partial X}{\partial P_{M,f}} \frac{1}{E} < 0 \quad (11.8) \]

\[ \frac{\partial X}{\partial E} = \frac{\partial X}{\partial P_{M,f}} \frac{\partial P_{M,f}}{\partial E} = \frac{\partial X}{\partial P_{M,f}} (-\frac{P}{E^2}) > 0. \quad (11.9) \]

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.

\[ X = X(Y_f, P_{M,f}) = X(Y_f)D(P_{M,f}) = m_f Y_f D(P/E) \quad (11.10) \]

where \( m_f \) is a constant import coefficient of a foreign country.
CHAPTER 11. BALANCE OF PAYMENTS AND FOREIGN EXCHANGE

Let us define trade balance as

$$TB(E; Y, Y_f, P, P_f) = X(E; Y_f, P) - M(E; Y, P_f)$$  \hspace{1cm} (11.11)

Then we have

$$\frac{\partial TB}{\partial Y} = -\frac{\partial M}{\partial Y} < 0, \quad \frac{\partial TB}{\partial Y_f} = \frac{\partial X}{\partial Y_f} > 0,$$  \hspace{1cm} (11.12)

$$\frac{\partial TB}{\partial P} = \frac{\partial X}{\partial P} < 0, \quad \frac{\partial TB}{\partial P_f} = -\frac{\partial M}{\partial P_f} < 0.$$  \hspace{1cm} (11.13)

$$\frac{\partial TB}{\partial E} = \frac{\partial X}{\partial E} - \frac{\partial M}{\partial E} > 0.$$  \hspace{1cm} (11.14)

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 11.11 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 11.11: Trade Balance vs Foreign Exchange Rate](image)

**National Income Identity**

Let us now briefly summarize our model in terms of national income account as follows:

$$Y = C(Y - T) + I + G + TB(E)$$  \hspace{1cm} (11.15)

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

$$S = S_p + S_g = Y - C - G,$$  \hspace{1cm} (11.16)
which reduces to
\[ S - I = TB(E). \] (11.17)

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.

### 11.5 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 [50] and [67].

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:

\[ R = i \] (11.18)

An expected return from a deposit with a foreign bank is calculated as

\[ R_f = (1 + i_f) \frac{E^e}{E} \] (11.19)

Thus we obtain

\[ \frac{\partial R_f}{\partial E} = -\frac{(1 + i_f)E^e}{E^2} < 0 \] (11.20)

\[ \frac{\partial R_f}{\partial E^e} = \frac{(1 + i_f)}{E} > 0 \] (11.21)

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

\[ A(E, E^e; i, i_f) = R_f(E, E^e; i_f) - R(i) \] (11.22)

and net capital flow (NCF) as

\[ NCF = \text{Foreign Investment Abroad} - \text{Investment Abroad} \] (11.23)

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:

\[
\begin{align*}
NCF < 0 & \quad \text{if } A > 0 \\
NCF > 0 & \quad \text{if } A < 0
\end{align*}
\] (11.24)

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 11.12 illustrates
table functions of investment levels that are assumed in our model in terms of
expected return arbitrage.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{fig11.12.png}
\caption{Direct and Financial Investment Indices}
\end{figure}

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 in-
vestment 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 as-
sumptions are made to reflect 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

\[
NCF = NCF(A(E, E^*)), \quad \text{where } \frac{\partial NCF}{\partial A} < 0 \quad (11.25)
\]

It is important to note, however, that this functional relation holds only in the
neighborhood of equilibrium, so do the following relations as well.

\[
\frac{\partial NCF}{\partial E} = \frac{\partial NCF}{\partial A} \frac{\partial A}{\partial E} = \frac{\partial NCF}{\partial R_f} > 0 \tag{11.26}
\]

\[
\frac{\partial NCF}{\partial E^e} = \frac{\partial NCF}{\partial A} \frac{\partial A}{\partial E^e} = \frac{\partial NCF}{\partial R_f} < 0 \tag{11.27}
\]

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 11.13, net capital flow is shown to be an 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.

![Figure 11.13: Net Capital Inflow vs Foreign Exchange Rate](image)

11.6 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 11.8, 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:

\[
\text{Excess Demand for Foreign Exchange} = \text{Imports} - \text{Exports} + \text{Investment Abroad} - \text{Foreign Investment Abroad} + \text{Foreign Investment Income} - \text{Investment Income} + \text{Foreign Exchange Purchase} - \text{Foreign Exchange Sale}
\]

\[= - \text{Trade Balance (TB)} - \text{Net Capital Flow (NCF)} - \text{Net Investment Income (NII)} + \text{Net Exchange Reserves (NER)}
\]

(11.28)

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:

\[
\frac{dE}{dt} = \Psi(-TB(E) - NCF(E, E^e) - NII + NER) = \Psi(E, E^e)
\]

(11.29)

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 \(N \text{random}(m, sd)\) 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

\[
\frac{dE^e}{dt} = \Phi(N \text{random}(m, sd)E - E^e) = \Phi(E, E^e)
\]

(11.30)

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 11.14 illustrates how foreign exchange rate and its expectation are modeled in our economy.
Now dynamic modeling of foreign exchange rate in our open macroeconomy is complete. It consists of three equations: (11.15), (11.29), and (11.30), out of which three variables \( E, E^c \) 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

\[
(Y, Y_f, P, P_f, i, i_f, N_{random}) \implies (E, E^c, TB) \tag{11.31}
\]

Figure 11.15 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.
11.7 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 11.16 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.
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

$$\frac{dE}{dt} = \Psi(-TB(E))$$ (11.32)

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 wholly 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 11.17. 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 11.17: 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 11.18.

![Figure 11.18: Foreign Inflation and Restoring Trade Balance (S2)](image)

11.8 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 \( E, E^c \) and \( TB \) are fully analyzed under the three equations: (11.15), (11.29), and (11.30).

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 11.12 above.

Figure 11.19 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 11.19: Random Expectations and Foreign Investment (S3)](image)

### 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 11.20 illustrates how a plummet of interest rate appreciates foreign exchange rate and improve a trade balance.

Figure 11.20: Interest Plummet under Random Expectations (S4)

Left-hand diagram of Figure 11.21 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.
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 11.22 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.

![Comparison of the Balance of Payments between S3 and S4](image)

Figure 11.21: Comparison of the Balance of Payments between S3 and S4

![Foreign GDP Plunge and Foreign Investment (S5)](image)

Figure 11.22: 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.

11.9 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 11.23 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 11.24 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
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 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 11.25 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.
11.10 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 (11.31) has to be made two-way such that

\[(Y, Y_f, P, P_f, i, i_f, N_{random}) \leftrightarrow (E, E^*, TB)\]  \hspace{1cm} (11.33)

Mundell-Fleming Model

Compared with our model, one of the repeatedly used open macroeconomic model in standard international economics textbooks is the Mundell-Fleming
model that is described, according to [54], as

\[ Y = C(Y - T) + I(i) + G + TB(E) \]  \hspace{1cm} (11.34)

\[ \frac{M^*}{P} = L(i, Y) \]  \hspace{1cm} (11.35)

\[ i = i_f \]  \hspace{1cm} (11.36)

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: (11.15), (11.29), and (11.30), determines only three variables \( E, E^* \) 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 \( M^* \) 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 11.15, then we can obtain a complete feedback loop diagram as illustrated in Figure 11.26.

Figure 11.26: Missing Feedback Loops Added to the Foreign Exchange Dynamics
11.11. Conclusion

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.

### 11.11 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 12

Open Macroeconomies as A Closed System

This chapter 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.

12.1 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.

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 12.1.

Figure 12.1: 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.

### 12.2 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 \( \text{GDP}_f \).

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 \( \text{Yen/Dollar} \). 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.
12.2. TRANSACTIONS IN OPEN MACROECONOMIES

Real foreign exchange rate (RFE) is the amount of real goods worth per unit of the equivalent foreign real goods such that

\[ RFE = \frac{FE \times Pf}{P} \]  

which has a unit of \( \text{YenReal/DollarReal} \).

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 12.6 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.

- Producers 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 12.7 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.
12.2. TRANSACTIONS IN OPEN MACROECONOMIES

Government
Transactions of the government are illustrated in Figure 12.8, 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 12.9 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 12.10 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 12.2 illustrates newly fixed feedback loops.
Figure 12.3: Population and Labor Force
12.2. TRANSACTIONS IN OPEN MACROECONOMIES

Figure 12.4: GDP Determination
Figure 12.5: Interest Rate, Price and Wage Rate
Figure 12.6: Transactions of Producers
CHAPTER 12. OPEN MACROECONOMIES AS A CLOSED SYSTEM

Figure 12.7: Transactions of Consumers
Figure 12.8: Transactions of Government
12.2. TRANSACTIONS IN OPEN MACROECONOMIES

Figure 12.10: Transactions of Central Bank
Figure 12.11: Foreign Exchange Market
Figure 12.12: Balance of Payment
Figure 12.13: Simulation Panel of GDP
12.2. TRANSACTIONS IN OPEN MACROECONOMIES

Figure 12.14: Simulation Panel of Trade and Investment Abroad
12.3 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 12.15 demonstrates that our open macroeconomies can attain mostly equilibrium states.

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 12.16. Moreover, alternating interest arbitrages generate very small amounts of capital inflows and outflows as illustrated in Figure 12.17 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
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 12.18.

Does this business cycle affect a foreign economy? Figure 12.19 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
be said to be mutually interdependent and constitute indeed a closed economic system as a whole.

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 12.20.

Does this domestic recession affect the foreign economy? Figure 12.21 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.
12.4. 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 [95] 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 [90]. 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

$$C = C(C_0,Y,P,i,W_e)$$

(12.2)

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 is, Japanese macroeconomy as a domestic economy and US macroeconomy as a foreign economy along the framework of our open macroeconomies.

\(^2\)Chinese GDP surpassed Japanese GDP in 2010, and Japan is now the third largest economy.
12.4. WHERE TO GO FROM HERE?

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” [96], which was based on my step-by-step definition of sustainability in terms of physical, social and ecological reproducibilities [99], 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.
12.5 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 V

Macroeconomic Systems of Public Money
Chapter 13

Designing A Public Money System

This chapter 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.

13.1 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 [74], 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.

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1This 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”.

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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 [17, p.1].

Being enlightened by the books such as [38] and [114], 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 [54], [55], [59], [39], 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.

13.2 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 13.1 shows that, among 33 OECD countries,
13.2. DEBT CRISIS AS A SYSTEMIC FAILURE

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%. This implies that developed countries are facing debt crises more seriously than many developing countries.

<table>
<thead>
<tr>
<th>Country</th>
<th>Ratio(%)</th>
<th>Country</th>
<th>Ratio(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japan</td>
<td>196.4</td>
<td>Israel</td>
<td>77.3</td>
</tr>
<tr>
<td>Greece</td>
<td>144.0</td>
<td>Germany</td>
<td>74.8</td>
</tr>
<tr>
<td>Iceland</td>
<td>123.8</td>
<td>Hungary</td>
<td>72.1</td>
</tr>
<tr>
<td>Italy</td>
<td>118.1</td>
<td>Austria</td>
<td>68.6</td>
</tr>
<tr>
<td>Belgium</td>
<td>102.5</td>
<td>United Kingdom</td>
<td>68.1</td>
</tr>
<tr>
<td>Ireland</td>
<td>98.5</td>
<td>Netherlands</td>
<td>64.6</td>
</tr>
<tr>
<td>United States</td>
<td>96.4</td>
<td>Spain</td>
<td>63.4</td>
</tr>
<tr>
<td>France</td>
<td>83.5</td>
<td>Poland</td>
<td>50.5</td>
</tr>
<tr>
<td>Portugal</td>
<td>83.2</td>
<td>OECD</td>
<td>66.7</td>
</tr>
<tr>
<td>Canada</td>
<td>82.9</td>
<td>World</td>
<td>58.3</td>
</tr>
</tbody>
</table>

Table 13.1: 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’ 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 13.1 (line 2) illustrates how fast US national debt has been accumulating almost exponentially. 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 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%.

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3 Data illustrated in the Figure are obtained from TreasuryDirect Web page, http://www.treasurydirect.gov/govt/reports/pd/histdebt/histdebt.htm
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 13.2, let us now explore a conceivable systemic failure of the current debt money system.

Figure 13.2: 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 con-
fronted 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. 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 intro-
duce 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
[88]. 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 13.2.

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, de-
mand 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

\footnote{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.

13.3 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* [46], and Irving Fisher’s book: *100% Money* [13].

Keynes proposed that the Great Depression was caused by the deficiency in the effective demand of macroeconomy 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

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\(^5\) 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." [13, 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 [63, 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* [13, 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 [13, 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 demuded. 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 [13, 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 [13, p. 182].

In the United State, the American Monetary Act has been endeavoring to restore the proposal of the Chicago Plan and monetary reform by replacing the

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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 [114, Chap. 24] and [115].

- 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 de-
sign 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 macroeco-
nomic 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* [115,
p.12].

In Japan, the government owns 55% of the shares of the Bank of Japan. Ac-
cordingly, 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 Eu-
rpean 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.

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2011 as H.R. 2990 by the congressman Dennis Kucinich. Its full text is available at

On July 26, 2011, about two months before its submission, I was invited to the US Congress-
ional 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 [115, p.12].

When full reserve system is implemented by the Act, bank reserves become equal to deposits so that we have

\[
\text{Money Stock} = \text{Currency in Circulation} + \text{Deposits} = \text{Currency in Circulation} + \text{Reserves} = \text{High-Powered Money} \tag{13.1}
\]

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

\[
\text{Money Stock} = m \times \text{High-Powered Money} \tag{13.2}
\]

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
\[(N - 1) + \text{Gold}\]

Debt Money
\[N + \text{Currency in Circulation} + \text{Credits (Deposits)}\]

Public Money
\[N + \text{Money}\]

**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:

\[MV = PT = kPY\]  \quad (13.3)

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

\[
\frac{\dot{M}}{M} = \frac{\dot{P}}{P} + \frac{\dot{Y}}{Y} \tag{13.4}
\]

Thus, to sustain a monetary value by avoiding inflation or deflation, we have to attain \(\frac{\dot{P}}{P} = 0\). This implies that \(\frac{\dot{M}}{M} = \frac{\dot{Y}}{Y}\); 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 [115, p.12].
13.4 MACROECONOMIC SYSTEM OF DEBT MONEY

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 [114], 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 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. · · · 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) [115, 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 [38]. 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.

13.4 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. According to the discussions above, the model is classified as a macroeconomic system of debt money, in which five macroeconomic sectors are assumed to play

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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 [90]. 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.
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 13.3, 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 13.4, 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 13.3: Transactions of Government
Figure 13.4: 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 13.5, 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.)

13.5 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:

\[
\text{Full Capacity GDP} = \text{Desired Output} = \text{Aggregate Demand} \quad (13.5)
\]
CHAPTER 13. DESIGNING A PUBLIC MONEY SYSTEM

Figure 13.5: 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 $\omega$ is 0.1, as illustrated in Figure 13.6.

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 13.7 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 13.7.

![Figure 13.7: Lending by the Central Bank and its Growth Rate](image)

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 [83] and [84].

**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 13.6 government debt continues to accumulate as the line 1 in the left diagram of Figure 13.8 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 defined as

\[
\text{Deficit} = \text{Tax Revenues} - \text{Expenditure} - \text{Debt Redemption} - \text{Interest} \quad (13.6)
\]

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 13.8. 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.\(^\text{10}\)

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 13.9 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 13.8. Accordingly, the accumulation of debt will be eventually curved as shown in line 2 in the left diagram.

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
13.5. BEHAVIORS OF A DEBT MONEY SYSTEM

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 13.9 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 13.9. 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 13.8. 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 13.10. 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.
13.6 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 13.11. 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 13.11: Transactions of Government
Line 1 in Figure 13.12 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.

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 [83]. 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 13.13. Green stock boxes of seigniorage assets and government reserves are newly added.
Figure 13.13: Transactions of the Public Money Administration
13.7 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 13.14, which is the same as Figure 13.8 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 13.14: Liquidation of Government Debt and Debt-GDP Ratio

Figure 13.15 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 13.16 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
money than necessary, which tends to bring about inflation eventually, though history shows the opposite [114].

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 13.17, 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 13.18, 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 13.19 shows
business cycles caused by the mismanagement of the increase in money stock when no GDP gap exists.

Figure 13.17: No Inflation under GDP Gap

Figure 13.18: Inflation under No GDP Gap

Figure 13.19: 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 [59, 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 [115, p.27].

From the following relation,

\[ \text{Nominal interest rate} = \text{Real interest rate} + \text{Inflation rate} \quad (13.7) \]

we have, for non-negative real interest rate \( \geq 0 \),

\[ \text{Maximum Nominal interest rate} \ (= 8\%) \geq \text{Inflation rate} \quad (13.8) \]

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.

13.8 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 14

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.

14.1 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 macroeconomic 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 14.12 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.
14.1. MODELING A DEBT MONEY SYSTEM

- 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 14.14 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.

14.2 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:

\[
\text{Full Capacity GDP} = \text{Desired Output} = \text{Aggregate Demand} \quad (14.1)
\]

If the economy is not in the equilibrium state, then actual GDP is determined by

\[
\text{GDP} = \min (\text{Full Capacity GDP}, \text{Desired Output}) \quad (14.2)
\]

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:

\[
\text{Potential GDP} = \text{Full Capacity GDP} \quad (14.3)
\]

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

\[
\text{GDP Gap Ratio} = \frac{\text{Potential GDP} - \text{GDP}}{\text{Potential GDP}} \quad (14.4)
\]

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 14.1.

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
unemployment rate. Figure 14.2 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.

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
[99]. 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 created 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 14.3 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 14.3, in which line 1 is a growth rate of 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 14.1 government debt continues to accumulate as the line 1 in the left diagram of Figure 14.4.
14.2. BEHAVIORS OF A DEBT MONEY SYSTEM

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

\[ \text{Deficit} = \text{Tax Revenues} - \text{Expenditure} - \text{Debt Redemption} - \text{Interest} \quad (14.5) \]

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 14.4. 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 14.5 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 14.4. Accordingly, the accumulation of debt will be eventually curved as shown by line 2 in the left diagram of Figure 14.4.

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 14.5 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 14.5. Accordingly the government needs not be forced to reduce the equilibrium level of budget.
As a result, this policy can also successfully reduce 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 14.4.

**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 14.6. 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.

![GDP (real)](image)

**Figure 14.6: Recessions triggered by Debt Liquidation**

Figure 14.7 (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 gap triggered by Policy B.

In the previous paper [103], 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.
CHAPTER 14. WORKINGS OF A PUBLIC MONEY SYSTEM

Figure 14.7: GDP Gap and Unemployment

Figure 14.8 illustrates how fast wage rate plummets (line 2 in the left diagram) - another finding in this paper. Concurrently inflation rate plummets 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 14.8: 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 14.9 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 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.
14.3 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.

Revised transaction of the government is illustrated in Figure 14.12 where green stock box of deposits is newly added to the assets.

**Banks**

Revised transactions of commercial banks are summarized as follows.
Figure 14.12: Transactions of Government
• 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 14.13 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 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.

**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.
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 pur-
chases 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 [83]. 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 14.14 where green stock boxes of seigniorage assets and government reserves are newly added.

14.4 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 14.15, which is the same as the left diagram of Figure 14.4 except the line 4. Recollect that line 1 is a benchmark debt accumulation of 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 14.16 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 14.17, 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
14.4. BEHAVIORS OF A PUBLIC MONEY SYSTEM

Figure 14.16: No Recessions Triggered by A Public Money System

better performed than the current debt system because of its accomplishment without recession and unemployment.

Figure 14.17: GDP Gap and Unemployment

Figure 14.18: Wage Rate and Inflation
Moreover, Figure 14.18 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 14.19. That is, GDP gap and unemployment in a foreign country (lines 4) remain closer to their almost equilibria states (lines 1).

![Figure 14.19: Foreign Recessions are Not Triggered](image)

**Debt Crises can be Subdued!**

In sum, the public 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.

### 14.5 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
14.5. 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 14.20. 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 14.21.

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 14.21 confirms that the GDP gap now gets completely filled in. More specifically, Figure 14.22 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.
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 14.23 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 14.23 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 14.24.

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
history shows the opposite [114]. 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 [103], 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 [59, p.353].” Indeed Figure 14.25, 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 14.25: 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 14.20. 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 15

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.

15.1 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 [103] and [114, 115].

- 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 [104], 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 [103]. 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 [104]. 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 [13, 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.” [14, 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.” [35, 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 [35, 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.

15.2 Debt vs Public Money Systems Simplified

I have already presented two macroeconomic models of the American Monetary Act in [103] and [104] based on the method of accounting system dynamics developed in [95]. To focus on our main concern of the monetary and financial stability in this chapter, a simplified model is constructed here [105], 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 15.1, 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.

- Out of the income thus realized, capital depreciation is subtracted first and interests of their debt are paid to the banks.

\(^2\) The model is also motivated by the work of Steve Keen [45, 2011], specifically his monetary model of capitalism in chapter 14.
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 15.2, 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 15.3. 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.
- 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
Figure 15.1: Transactions of Producers
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 rule3.

- Banks receive income as prime rate interests against their loans. 80% of the income is assumed to be spent on consumption, and the remaining will be retained as equity.

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3 This limit is not explicitly considered in our model
15.2 DEBT VS PUBLIC MONEY SYSTEMS SIMPLIFIED

**Figure 15.3: Transactions of Banks**

- **Vault Cash (Banks)**
  - Initial Vault Cash
  - Desired Borrowing (Banks)
  - Credit Creation Switch
  - Time for Credit Creation

- **Deposits (Savings)**
  - Deposits (Credits)
  - Interest Income (Consumers)
  - Cash Demand
  - Deposit Withdrawals
  - Loans (Credit Disbursement)
  - Lending

- **Loans**
  - Lending
  - Desired Borrowing
  - Credit Creation
  - Credit Creation 1
  - Credit Crunch 1
  - Credit Crunch 2
  - Credit Creation 2

- **Equity (Banks)**
  - Interest Income (Bankers)
  - Interest Rate
  - Prime Rate

- **Public Money System**
  - Debt Creation
  - Public Money Creation
  - Time for Public Money Creation
  - Desired Borrowing (Banks)
  - Prime Rate
  - Interest Rate

- **Net Interest Income (Bankers)**
  - Interest Paid (Banks)
  - Interest Income (Bankers)

- **MPC (Bankers)**
  - Consumption (Bankers)
  - Maximum Loans by BIS Ruls

- **Deposit (Credit)**
  - Deposits (Savings)
  - Lending (Credits)
  - Interest Paid (Banks)

- **Net Cash Flow (Banks)**
  - Loans (Credit Disbursement)
  - Savings
  - Loan Disbursement

- **BIS Rules of Equity Ratio**
  - Equity-Loans Ratio
  - Equity Ratio

- **Interest (Prime) Rate**
  - Interest Rate
  - Credit Crunch 2 Level

- **Credit Crunch 1**
  - Credit Crunch 1
  - Credit Crunch 2

- **Credit Crunch 2**
  - Credit Crunch 2
  - Credit Crunch 2 Level

- **Credit Crunch Switch 2**
  - Credit Crunch Switch 2

- **Credit Crunch Switch 1**
  - Credit Crunch Switch 1

- **Desired Borrowing (Banks)**
  - Desired Borrowing (Banks)
  - Credit Creation Switch

- **Time for Credit Creation**
  - Time for Credit Creation

- **Initial Vault Cash**
  - Initial Vault Cash
  - Initial Vault Cash

- **Debt (Banks)**
  - Debt Creation
  - Public Money Creation
  - Time for Public Money Creation
  - Desired Borrowing (Banks)

- **Public Money into Circulation**
  - Public Money into Circulation

- **Credit Crunch 2 Level**
  - Credit Crunch 2 Level

- **Credit Crunch Switch 2**
  - Credit Crunch Switch 2
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.

15.3 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.

\[
AD = C + I \quad (15.1)
\]

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).

\[
C = cY \quad (15.2)
\]

Keynesian model claims that GDP is determined by the level of aggregate demand;

\[
Y = AD. \quad (15.3)
\]

From these three equations, Keynesian equilibrium of GDP is determined by the following equation:

\[
Y = \frac{1}{1 - c} I. \quad (15.4)
\]

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 a dynamic process of GDP determination as follows:

Figure 15.4: Keynesian GDP Determination
15.3. BEHAVIORS OF A DEBT MONEY SYSTEM

\[
\frac{dY}{dt} = \frac{AD - Y}{AT} \quad (15.5)
\]

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 15.5, such that

\[
\frac{dY}{dt} = \frac{AD - Y}{AT} - \frac{I_{\text{inv}}}{AT_{\text{inv}}} \quad (15.6)
\]

where \(AT_{\text{inv}}\) is an adjustment time of inventory.

Figure 15.6 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.

![GDP (No Monetary Constraints)](image)

Figure 15.6: 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 15.5, assumed to be adjusted by the following dynamics:

\[
\frac{dP}{dt} = \frac{P^* - P}{AT}
\]

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 macroeconomic model, though simplified, is based on micro-foundation behaviors, it would be appropriate to use monetary and financial stability inseparably here.

\(^4\) This is a simplified equation of price flexibility presented in [103].
Monetary Constraints

Dynamical equilibria in Figure 15.6 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 15.1. Thus, it is calculated as follows:

\[
\text{Net Cash Flow} = \text{Cash Inflow} - \text{Cash Outflow} = \text{Consumption (Consumers and Bankers)} + \text{Investment} - \text{Factor Income} - \text{Interest Income (Banks)} - \text{Investment} - \text{Loan Payments} = - \text{Savings (Consumers and Bankers)} - \text{Loan Payments}
\]

(15.9)

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 15.6. 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 15.7. 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, producers 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 15.7 illustrates how GDP gets reduced, while that of the right-hand diagram indicates that producers’ cash is getting depleted to zero.

![Diagram](Image)

Figure 15.7: 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 15.8 illustrates how money is created and put into circulation as credit creation.

In this way, whenever producers can raise desired borrowing amount successfully, the equilibrium GDP is attained. Figure 15.9 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
15.3. BEHAVIORS OF A DEBT MONEY SYSTEM

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.

Figure 15.9: Equilibrium GDP by Credit Creation(100%)
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. Hence,

\[ \text{Initial Base Money} = \text{Initial Cash (Producers)} + \text{Initial Vault Cash (Banks)} \]

(15.10)

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,

\[ \text{Base Money (M0)} = \text{Initial Base Money} + \text{Debt (Banks)} \]

(15.11)

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

\[ \text{Money Stock (M1)} = \text{Currency in Circulation} + \text{Demand Deposits} \]

(15.13)

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 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

\[ \text{Money Stock} = m \times \text{Base Money} \]

(15.12)

where \( m \) is a money multiplier.

---

5 Money stock is also defined in terms of base money (M0) as

\[ \text{Money Stock} = m \times \text{Base Money} \]
15.3. BEHAVIORS OF A DEBT MONEY SYSTEM

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

\[
\text{Money Stock (M1)} = \text{Currency in Circulation} \\
= \text{Cash/Deposits(Producers)} \\
+ \text{Cash/Deposits (Consumers)} \\
+ \text{Vault Cash (Banks)}. \tag{15.14}
\]

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):

\[
\text{Money out of Nothing} = \text{Money Stock (M1)} - \text{Base Money (M0)} \tag{15.16}
\]

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

\[
\text{Money Stock (M2)} = \text{Money Stock (M1)} + \text{Time Deposits} \tag{15.17}
\]

With these denotations of money in mind, let us examine how money is created. In Figure 15.10, 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

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{image}
\caption{Money Stock: M0, M1 and M2}
\end{figure}
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 [99]. This amount is denoted in our analysis by the file name of Credit Creation (100%). What 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 15.11: Changes in Money Stock and Net Interest Income of Bankers](image)

Left-hand diagram of Figure 15.11 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 15.12 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.

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 15.13 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%.

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 15.14 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).

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 15.12. 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 15.14.

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 15.14; that is, a start of credit crunch of 20%. Left-hand diagram of Figure 15.15 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 15.16 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.

### 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 15.17. 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.

From the left-hand diagram of wage distribution in Figure 15.14, 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

Figure 15.15: Reduction of M1 and Deflation by Credit Crunch

Figure 15.16: Recession (GDP and Growth Rate) triggered by Credit Crunch
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 15.18 illustrates how economic growth rates are affected by the moni-
15.4. 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 [103] and [104]).

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 15.20 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 system is implemented in the public money system, bank reserves become equal to deposits so that we have

$$\text{Money Stock (M1)} = \text{Currency in Circulation} + \text{Demand Deposits}$$

$$= \text{Currency in Circulation} + \text{Reserves}$$

$$= \text{Base Money (M0)}$$

(15.18)
Accordingly, under the public money system, money stock (M1) becomes equivalent to base money (M0). With these in mind, let us examine the effect of over-supply of money on monetary stability. Left-hand diagram of Figure 15.21 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 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

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6 Money stock is also defined in terms of base money as

\[
\text{Money Stock (M1)} = m \times \text{Base Money (M0)}
\]  

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.
CHAPTER 15. MONETARY AND FINANCIAL STABILITY

Inflation Rates

0.02
0.0135
0.007
0.0005
-0.006

Figure 15.21: Money Stock and Inflation under Debt vs Public Money

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 15.22. 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.

Figure 15.22: Interest Income and Wage Distribution under Debt vs Public Money

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 dis-
tributions do not so seriously get worsened for a higher level of public money creation under the public 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 \((M_0=M_1)\) created by the PMA never get crunched, and continue to stay in circulation, and be efficiently used for higher 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 [14, 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 15.23. Compared with the causal loop diagram of the debt money system in Figure 15.17, 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.

![Causal Loop Diagram of Public Money System](image)

Figure 15.23: Causal Loop Diagram of 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:

\[ 20\% \leq \text{Level of Desired Borrowing(Banks)} \leq 180\% \quad (15.20) \]

Figure 15.24 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 15.25 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% 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 15.26 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.

Figure 15.26: Debt-vs-Public System Sensitivity: GDP

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% system would be no cure-all for business fluctuations though it would help reduce them [13, p.216].” Yet, as I have demonstrated in [104], 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 16

Public Money and Sustainability

This chapter 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.

16.1 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

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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 Sheraton 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 16.1 compares system structures of these two systems. Let us examine their structural differences one by one.

<table>
<thead>
<tr>
<th></th>
<th>Public Money System</th>
<th>Debt Money System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Money Issuer</td>
<td>Public Money Administration</td>
<td>Central Bank</td>
</tr>
<tr>
<td>Its Owner</td>
<td>Government (Public)</td>
<td>Private Banks and Financiers</td>
</tr>
<tr>
<td>Bank Reserves</td>
<td>100% Reserve</td>
<td>Fractional Reserve</td>
</tr>
<tr>
<td>Money Stock</td>
<td>Public Money directly put into</td>
<td>Base Money: by Central Bank</td>
</tr>
<tr>
<td></td>
<td>Circulation as Economy grows</td>
<td>Deposits: by Bank Loans</td>
</tr>
<tr>
<td></td>
<td>Private Banking unaffected</td>
<td>Money in Circulation: by Public</td>
</tr>
<tr>
<td>Interest</td>
<td>Interest-free</td>
<td>Interest-bearing Debt</td>
</tr>
<tr>
<td>Economic Policies</td>
<td>Public Money Policy</td>
<td>Monetary Policy: Central Bank</td>
</tr>
<tr>
<td></td>
<td>(Public Money Financing)</td>
<td>Fiscal Policy: Government</td>
</tr>
</tbody>
</table>

Table 16.1: 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.
16.1. PUBLIC VS DEBT MONEY SYSTEM STRUCTURES

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 bor-
row 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.
16.2 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.

<table>
<thead>
<tr>
<th></th>
<th>Public Money System</th>
<th>Debt Money System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monetary Stability</td>
<td>Stable Money Stock</td>
<td>Bubbles and Credit Crashes</td>
</tr>
<tr>
<td></td>
<td>Stable Price Level</td>
<td>Inflation &amp; Deflation</td>
</tr>
<tr>
<td>Financial Stability</td>
<td>No Bank-runs</td>
<td>Business Cycles</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Booms and Depressions)</td>
</tr>
<tr>
<td>Employment</td>
<td>Full Employment</td>
<td>Involuntary Unemployment</td>
</tr>
<tr>
<td>Government Debt</td>
<td>No Government Debt</td>
<td>Built-in Debt Accumulation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>→ Recession &amp; Unemployment</td>
</tr>
<tr>
<td>Inequality</td>
<td>Income Inequality between</td>
<td>Income Inequality between</td>
</tr>
<tr>
<td></td>
<td>Workers and Capitalists</td>
<td>Financiers and Non-financiers</td>
</tr>
<tr>
<td>Sustainability</td>
<td>Sustainability is Possible</td>
<td>Accumulated Debt</td>
</tr>
<tr>
<td></td>
<td></td>
<td>→ Forced Growth</td>
</tr>
<tr>
<td></td>
<td></td>
<td>→ Environmental Destruction</td>
</tr>
</tbody>
</table>

Table 16.2: 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

\[
\text{Money Stock} \ (M_1) = \frac{\alpha + 1}{\alpha + \beta} \times M_0 \quad (16.1)
\]

where \( \alpha \) is the currency ratio and \( \beta \) 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 ($= 1.82 \times 200$), 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 [15, 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

$$\text{Money Stock } (M_1) = \frac{\alpha + 1}{\alpha + \beta} \star M_0 = M_0. \quad (16.2)$$

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’
16.2. PUBLIC VS DEBT MONEY SYSTEM BEHAVIORS

Greed” and the balancing loop of credit crunch 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. Moreover, 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 [15, 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 [15, pp.39,40].
CHAPTER 16. PUBLIC MONEY AND SUSTAINABILITY

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 16.1 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 [75].

This type of income inequality is completely eliminated under the public money system. However, the inequality between workers 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 [90].

**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!

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 en-

Figure 16.1: Inequality under Debt Money System
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 be-
tween 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.

16.3 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 [90].

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. [90, 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 [90, 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 16.2 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 [90, 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

**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
16.4. THE GREEN VILLAGE(MURATOPIA) ECONOMY

Why Didn’t the MuRatopian Economy Emerge?

The MuRatopian economy was proposed in the book [90] 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.

16.4 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
16.4. THE GREEN VILLAGE(MURATOPIA) ECONOMY

The Green Village(Muratopia) Economy: Structures

| Economy                      | • Public Money System (against Debt Money System)  
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<td>→ Self-investor (Savers = Investors)</td>
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<td>(⇒ Localization against Globalization)</td>
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The Green Village(Muratopia) Economy: Behaviors

| Monetary & Financial Stability | Stable Money Stock  
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<td>Sustainability</td>
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</table>

Table 16.3: 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 [78]. 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:

Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. [62, 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.

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.

\[
\text{Public Money Index} = \frac{\text{Public Ownership} \times \% + \text{Reserve Ratio} \times \%}{200 \times \%}
\]  

(16.3)

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.

\[
\text{Co-worker Index} = \frac{\text{Co-Workers}}{\text{Total Labor Force}}
\]  

(16.4)

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 17

A Transition to the Public Money System

This chapter 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.

17.1 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

---

In Chapter 16, the comparative analyses of these two system structures and their behaviors are succinctly summarized in Tables 16.1 and 16.2. 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.vpwx]. 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 17.1 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.

<table>
<thead>
<tr>
<th>Assets</th>
<th>Liability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Base Money</td>
<td>180</td>
</tr>
<tr>
<td>Currency Outstanding</td>
<td>180</td>
</tr>
</tbody>
</table>

Figure 17.1: (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 17.2.

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.
17.1. VOLATILE BEHAVIORS OF DEBT MONEY SYSTEM

Figure 17.2: 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:

\[ \text{Credits (Banks)} = \frac{1 - \beta}{\beta} \text{Reserves (Banks)} \quad (17.1) \]

where \( \beta \) 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 $900 (= \frac{(1 - 0.1)}{0.1} \times 100 )$.

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 17.4 and 17.12 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 [15, 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 17.5 and 17.12 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 $90=(1 - 0.1)/0.1 \times 10$, and money supply to $990$ from $1,080$. Figures 17.6 and 17.12 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). [13, 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 17.3. 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 17.3: 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 [48]. 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 17.3. 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 17.7 and 17.12.

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 Securities (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 17.3. 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 17.8 and 17.12.

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.
17.1. VOLATILE BEHAVIORS OF DEBT MONEY SYSTEM

Figure 17.4: (1) Fractional Reserve Banking System
CHAPTER 17. A TRANSITION TO THE PUBLIC MONEY SYSTEM

Figure 17.5: (2) Making Bubbles

Public Money System: We Are All Happy 120%
Debt Money System: We Are Unhappy 99%

Credit Creation = \((1 - \text{Reserve Ratio}) / \text{Reserve Ratio} \times \text{Reserves (Banks)}\)

Producers Balance Sheet

Bank Balance Sheet

Government Balance Sheet

Central Bank Balance Sheet

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Figure 17.6: (3) Bubble Burst and Bank-runs
Figure 17.7: (4) Credit Crunch → Depressions
17.1. VOLATILE BEHAVIORS OF DEBT MONEY SYSTEM

Credit Creation = (1 - Reserve Ratio) x Reserve (Banks)

Producers Balance Sheet

Bank Balance Sheet

Government Balance Sheet

Central Bank Balance Sheet

MV = PT \rightarrow M = kY (\text{GDP})

Deposit (Investment)

Credit Creation = (1 - Reserve Ratio) x Reserve (Banks)

Initial Base Money

Figure 17.8: (5) Issuing Securities → Restore Money Supply

Public Money System: We Are All Happy 128%

Debt Money System: We Are Unhappy 99%
(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 17.9 and 17.12 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 reserve 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 [15, 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 17.10 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 decades in Japan is called the “Balance Sheet Recession” by Richard Koo [48], as already pointed out in the step 4 above.
17.1. VOLATILE BEHAVIORS OF DEBT MONEY SYSTEM

Debt Money System: We Are Unhappy

Public Money System: We Are All Happy

Figure 17.9: (6) Bailout → Accumulated Debt

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Figure 17.10: (7) Collapse of Securities
17.1. VOLATILE BEHAVIORS OF DEBT MONEY SYSTEM

Figure 17.11: (8) Financial Quantitative Easing (QE)
CHAPTER 17. A TRANSITION TO THE PUBLIC MONEY SYSTEM

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 17.3.

In Figure 17.11, 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 producers, 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 17.3 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 17.12, 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 17.12 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 17.13. 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.
17.1. VOLATILE BEHAVIORS OF DEBT MONEY SYSTEM

Monetary Base and Money Supply

Figure 17.12: Monetary Instability 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

\[
\text{Money Supply (Base)} = m \ast \text{Monetary Base} \tag{17.2}
\]

where money multiplier \((m)\) is defined by the equation (5.14) as

\[
\text{Money Multiplier (} m \text{) } = \frac{\alpha + 1}{\alpha + \beta} . \tag{17.3}
\]

Currency ratio \((\alpha)\) and reserve ratio \((\beta)\) are a little bit differently defined here from Chapter 5, according to our model definitions in Figure 17.14, 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.
Values of Money Supply (Base) thus obtained are confirmed to be the same as those of Money Supply in Figure 17.12, that is, Money Supply = Money Supply (Base). Behaviors of money multiplier, currency ratio and reserve ratio are shown in Figure 17.15 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 17.15 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 17.14: Definition of Money Multiplier

\[
\text{Currency Ratio } (\alpha) = \frac{\text{Currency Outstanding}}{\text{Deposits} + \text{Deposits (Credits)}} \quad (17.4)
\]

\[
\text{Reserve Ratio } (\beta) = \frac{\text{Reserves (Central Bank)}}{\text{Deposits} + \text{Deposits (Credits)}} \quad (17.5)
\]
17.2 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

\[
10 \ (\text{Debt Money}) = 11 \ (\text{Public Money}).
\]  

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 17.16 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 [13]. 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. [13, 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 assets 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 17.17. 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.” [13, 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 17.18 and 17.22.

(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 17.19. 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 17.22. 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 [15, 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 17.20. This conversion surely does not change public money supply.
Figure 17.16: (T1) Conversion to the Public Money
Figure 17.17: (T2) Securities as Reserves Collateral
17.2. A TRANSITION TO THE PUBLIC MONEY SYSTEM

Figure 17.18: (T3) Public Money Issued
CHAPTER 17. A TRANSITION TO THE PUBLIC MONEY SYSTEM

Figure 17.19: (T4) Debt Liquidation: Money Supply Unchanged
17.2 A TRANSITION TO THE PUBLIC MONEY SYSTEM

Figure 17.20: (T5) Public Money Converted to Time Deposits

Debt/Money System: We Are Unhappy 99%

Public Money System: We Are All Happy 120%

NM = FT \rightarrow M = \frac{1}{1-R} G(Y)

M = kY (\approx GDP)

\text{Public Money Issued}

\text{Securities Issued}

\text{Debt Repayment}

\text{Bubble Burst}

\text{Bailout}

\text{Operation Revenues}

\text{Demand Deposits}

\text{Loans (Securities)}

\text{Loans (Credit)}

\text{Deposits (Credit)}

\text{Currency Outstanding}

\text{Deposits (Time)}

\text{Loans (Investment)}

\text{Government Securities}

\text{Government Securities Issued}

\text{Public Money for Time Deposits}

\text{Reserves (Central Bank)}

\text{Net Assets (Government)}

\text{Net Assets (Banks)}

\text{Reserves (Banks)}

\text{Credit Creation} = \frac{1-\text{Reserve Ratio}}{\text{Reserve Ratio}} \times \text{Reserves (Banks)}

\text{Required Reserve Ratio}

\text{Quantitative Easing}

\text{Bailout Ratio}

\text{Deposits (Government)}

\text{Cash (Time Deposits)}

\text{Lending (Stocks and Real Estates)}

\text{Lending (Financial Investment (Bubbles))}

\text{Demand Deposits for Repayment}

\text{Bank-run Amount}

\text{Public Money Conversion
Figure 17.21: (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 17.21 only illustrates the final process of putting the additional amount of public money into circulation under the PMA balance sheet. Figure 17.22 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 17.22 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 \( (t=0\sim30) \) 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 \( (t=31\sim37) \) 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 \( (t=38\sim50) \) 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 \( M1=M2=790 \).
CHAPTER 17. A TRANSITION TO THE PUBLIC MONEY SYSTEM

Monetary Base and Money Supply

As the reader can easily identify in Figure 17.22, 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 17.22: From Debt Money to Public Money System

Money Multiplier

Figure 17.23: 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:

\[
\text{Currency Ratio } (\alpha) = \frac{\text{Currency Outstanding}}{\text{Demand Deposits}}
\]

(17.7)

\[
\text{Reserve Ratio } (\beta) = \frac{\text{Reserves (Central Bank)} + \text{Reserves (Government)}}{\text{Demand Deposits}}
\]

(17.8)

Figure 17.23 shows that except the transition period of $t = 34$ and 35, the reserve ratio \((\beta)\) becomes 1, and, from the equation (17.3), 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 17.24 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 17.3, such as credit crunches of lenders and borrowers, balance sheet recessions, monetary and fiscal policies and QE policy.

Figure 17.24: Monetary Stabilization under the Public Money System

---

\(^6\) 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 VI

Electronic Public Money
Chapter 18

Electronic Public Money

This chapter 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 [60, 2008] inspired various blockchain-based money, including the proposal of electronic public money (EPM) system [113, 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" [113, 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" [110, 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 27, 2017 at his home in Chicago. Without his vision on monetary reform and guidance through his work [114, 2002], our present research on the public money system would not have gotten started.
CHAPTER 18. ELECTRONIC PUBLIC MONEY

18.1 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 [101, 2008], which later became a theoretical foundation of the proposal of Public Money System [104, 2011], and a paper on Bitcoin by Nakamoto [60, 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 [95, 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; [98, 2005], [99, 2006], [100, 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; [102, 2009], [103, 2010], [104, 2011], [105, 2012], [107, 2014], [109, 2015], [112, 2016]. My research has been led by the so-called Chicago Plan of monetary reform [15, 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 [108, 2015].
The upper part of Figure 18.1 briefly illustrates how the proposal of the public money system has evolved since the year 2008.

Figure 18.1: 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" [60, 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 [60, 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,
CHAPTER 18. ELECTRONIC PUBLIC MONEY

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 18.1 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 18.1, 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 [13, 1935] and [15, 1939], and government debt crises by our joint paper in [112, 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.

18.2 Money Creation Revisited

18.2.1 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 18.1, 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.

<table>
<thead>
<tr>
<th>Classification of Money</th>
</tr>
</thead>
<tbody>
<tr>
<td>Front: Issuance</td>
</tr>
<tr>
<td>Back: Fiat Status</td>
</tr>
<tr>
<td>Non-metal Commodities</td>
</tr>
<tr>
<td>Metal Coinage</td>
</tr>
<tr>
<td>Paper Notes</td>
</tr>
<tr>
<td>Digital Cards &amp; Accounts</td>
</tr>
</tbody>
</table>

Table 18.1: Public Money vs Debt Money
18.2. Money as Legal Tender

Table 18.1 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 it and make it useless [114, 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 18.1, 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 [114, 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.

18.2.3 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

\[ \text{Money Stock} = \text{Currency} + (\text{Commercial Bank) Deposits} \quad (18.1) \]
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

\[ \text{Currency} = \text{Coins} + (\text{Central Bank}) \text{ Notes} \quad (18.2) \]

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:

\[ \text{Base Money} = \text{Currency} + (\text{Central Bank}) \text{ Reserves} \quad (18.3) \]

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 \[69, \text{p.13} \] (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 18.1 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.

18.3 Debt Money System Revisited

18.3.1 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 \[15, 1939\]. 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
18.3. DEBT MONEY SYSTEM REVISITED

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. 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.

18.3.2 Structure of Debt Money System

Since the financial crisis in 2008, enormous amount of regulations and supervi-
sory mechanisms have been implemented. However, they made the existing reg-
ulatory 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 18.2, which
is slightly modified from the original Table 16.1 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.

<table>
<thead>
<tr>
<th></th>
<th>Public Money System (Proposed)</th>
<th>Debt Money System (Current)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Money Issuer Its Owner</td>
<td>Public Money Administration</td>
<td>Central Bank &amp; Commercial Banks</td>
</tr>
<tr>
<td>Required Reserves</td>
<td>100% (for Demand Deposits)</td>
<td>Fractional</td>
</tr>
<tr>
<td>Role of Banks</td>
<td>Intermediaries of Money</td>
<td>Creators of Deposits</td>
</tr>
<tr>
<td>Money Stock</td>
<td>Base Money = Money Stock</td>
<td>Base Money: by Central Bank</td>
</tr>
<tr>
<td></td>
<td>(Financial system unaffected)</td>
<td>Deposits: by Bank Loans</td>
</tr>
<tr>
<td>Issuance of Money</td>
<td>Interest-free</td>
<td>Interest-bearing Debt</td>
</tr>
<tr>
<td>Economic Policies</td>
<td>Public Money Policy</td>
<td>Monetary Policy: Central Bank</td>
</tr>
<tr>
<td></td>
<td>(Direct Public Money Injection)</td>
<td>Fiscal Policy: Government</td>
</tr>
</tbody>
</table>

Table 18.2: System Structures of Public Money and Debt Money

18.3.3 System Behaviors: Four Built-in Failures

Behaviors of the debt money system are summarized in the last column of Ta-
ble 18.3, which is slightly modified from the original Table 16.2 in Chapter

---

\(^2\) The central banks were accustomed to maintain a reserve of upwards of forty per cent in
gold or gold exchange behind their note issuances [15, 1939].
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 [112, 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.

<table>
<thead>
<tr>
<th></th>
<th>Public Money System (Proposed)</th>
<th>Debt Money System (Current)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monetary Stability</td>
<td>Stable Supply of Money</td>
<td>Excessive Credit Creation &amp; Crunches</td>
</tr>
<tr>
<td></td>
<td>Stable Price Level</td>
<td>Inflation &amp; Deflation</td>
</tr>
<tr>
<td>Financial Stability</td>
<td>No Bank-runs</td>
<td>Business Cycles, Banking Crisis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Booms and Depressions)</td>
</tr>
<tr>
<td>Employment</td>
<td>Full Employment</td>
<td>Involuntary Unemployment</td>
</tr>
<tr>
<td>Government Debt</td>
<td>No Government Debt</td>
<td>Built-in Debt Accumulation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>→ Recession &amp; Unemployment</td>
</tr>
<tr>
<td>Inequality</td>
<td>Income Inequality between</td>
<td>Income Inequality between</td>
</tr>
<tr>
<td></td>
<td>Workers and Capitalists</td>
<td>Financiers and Non-financiers</td>
</tr>
<tr>
<td>Sustainability</td>
<td>Sustainability is Possible</td>
<td>Debt Accumulation (Private and Public)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>→ Forced Growth</td>
</tr>
<tr>
<td></td>
<td></td>
<td>→ Environmental Destruction</td>
</tr>
</tbody>
</table>

Table 18.3: 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 endogenously 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 [13, 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 [109, 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 phenomenon 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.

**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

\(^3\) The simulation experiment using simple ASD model in [112, 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.
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 18.2: Income Inequality between Financiers and Non-financiers

Figure 18.2 is produced by running "the payment system model through nonbank intermediaries and multiple banks", illustrated in Figure 18.10 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.

18.4 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 18.3 illustrates overview of all payment methods, including Bitcoin\(^4\), under the current debt money system. Figure 18.4 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, respectively.

18.4.1 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 18.5 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 18.6.2 below
Figure 18.3: Overview of Payment System under Public and Debt Money
18.4. PAYMENTS 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 18.6 presents a simulation model of this payment method.

18.4.2 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 online 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 18.7.
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Figure 18.5: Payment System (i) 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 18.8.

18.4.3 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
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 18.9.

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 18.10.
Figure 18.7: Payment System with Bank Deposits
Figure 18.8: Payment System with Multiple Bank Deposits
Figure 18.9: Payment System through Nonbank Intermediaries (Credit Cards)
Figure 18.10: Payment System © through Nonbank Intermediaries and Multiple Banks
18.5 Public Money System Revisited

18.5.1 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 Money [108, 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 \(^6\). 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.\(^7\) Then, the Chicago Plan was vehemently carried on by Irving Fisher from Yale University \(^8\) and his group of five economists\(^7\) as "A PROGRAM FOR MONETARY REFORM" \(^9\), and later by Milton Friedman \(^10\), \(^11\). Gradually, the Chicago Plan and similar sort of proposals began to be neglected and made a taboo subject \(^12\) 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

\[
\text{Money Stock} = \text{Base Money} \tag{18.4}
\]

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. Based on the Chicago Plan, we have proposed Public Money System in Part IV

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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 Gramm-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. \([52, 2012, pp.129-130]\)
of this book as an alternative system design to overcome structural flaws of the debt money system.

Figure 18.11: From Debt Money to Public Money System

Figure 18.11 illustrates how two great economists learned important lessons independently from the Great Depression in 1930’s; that is, 100% Money by Irving Fisher [13, 1935] and The General Theory of Employment, Interest and Money by John M. Keynes [46, 1935]. It also shows that a new macroeconomic theory of public money system developed with Accounting System Dynamics (ASD) modeling approach [106, 2013, First Edition] is an integration of the above two lessons proposed in 1935 in the wake of the Great Depression in 1930’s.

18.5.2 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 18.2 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.
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- 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. [47, 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 [108, 2015] as illustrated in Figure 18.12 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 18.12: 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 [108, 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.

18.5.3 System Behaviors: Four Failures Getting Fixed

Second column of Table 18.3 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 [112, 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 [103, 2010], [104, 2011], [105, 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.

18.5.4 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 [108, 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 [104, 2011]. With our present proposal of electronic public money (EPM) system as in [113, 2017], the public money system discussed in this section will be referred to as the original public money system in comparison to the EPM.

18.5.5 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 [103, 2010], [106, 2013] [112, 2016]. Yet, payment methods do not change drastically; that is, payment methods 1 through 6 discussed in Section 18.4 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 [60, 2008].
18.6 Bitcoin and Blockchain Technology

18.6.1 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 [1, 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.

18.6.2 Payments with Bitcoin

Payments with Bitcoin

It is pointed out in Section 18.2 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 18.13 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 18.13 demonstrates how it is constrained
as a means of exchange. Figure 18.3 in Section 18.4 illustrates overview of all payment systems we have discussed so far; that it, ① through 7.

Figure 18.14 presents its detailed payment system. Even though Bitcoin payments are peer-to-peer and in this sense the same as cash payments in Figure 18.5, it requires additional Bitcoin exchangers, similar to gold traders.

<table>
<thead>
<tr>
<th>①</th>
<th>Electronic Cash</th>
</tr>
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<tbody>
<tr>
<td>②</td>
<td>Proprietary Database of Banks</td>
</tr>
<tr>
<td>③</td>
<td>Interbank Database of Central Bank</td>
</tr>
<tr>
<td>④</td>
<td>Cheques</td>
</tr>
<tr>
<td>⑤</td>
<td>Debit Cards</td>
</tr>
<tr>
<td>⑥</td>
<td>ATM</td>
</tr>
<tr>
<td>⑦</td>
<td>Bitcoin (P2P Payment)</td>
</tr>
</tbody>
</table>

Figure 18.13: Overview of Debt Money and Bitcoin Payments

### 18.6.3 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 18.6. 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.

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 18.15.
18.6. BITCOIN AND BLOCKCHAIN TECHNOLOGY

Figure 18.14: Payment System with Bitcoin: Peer-to-Peer
Dynamic equations of this stock-flow diagram can be written as follows:

\[
\begin{align*}
\text{Inflow}_t &= \text{Receipt from } A_t + \text{Receipt from } B_t \\
\text{Outflow}_t &= \text{Payment to } C_t + \text{Payment to } D_t \\
\text{Stock}_{t+1} &= \text{Stock}_t + \text{Inflow}_t - \text{Outflow}_t, \quad t = 0, 1, 2, \cdots
\end{align*}
\]  

(18.5)

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

\[
\begin{align*}
\text{Inputs}_t \left\{ \begin{array}{l}
\text{Stock(unspent)}_t \\
\text{Receipt from } A_t \\
\text{Receipt from } B_t
\end{array} \right\} & \implies \text{Outputs}_t \left\{ \begin{array}{l}
\text{Payment to } C_t \\
\text{Payment to } D_t \\
\text{Stock(unspent)}_{t+1}
\end{array} \right\}
\end{align*}
\]  

(18.6)

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.

18.7 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:

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.

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.

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. 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.
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 [57, 2016], and *Elixxir* (Scalable Digital Sovereignty) by Chaum [6, 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 ... that can be expressed in code [77, page 7]."

![Image of Japanese Yen, United States Dollar, and Chinese Yuan]  

**Figure 18.16: Collapsing Debt Money Systems**

However, as pointed out in Section 18.1, the blockchain technology is currently applied to improve financial services of the debt money system by mini-
Electronic Public Money System

18.8.1 Integrated Public Money and Blockchain

The public money system revisited in Section 18.5 is shown to fix system design failures of the debt money system revisited in Section 18.3. Yet its implementation has been difficult since its birth [104, 2011] because its predecessor, the Chicago Plan in 1933, has been made "taboo" in economics as discussed in Subsection 18.5.1. In Section 18.6, 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 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 [113, 2017].

Figure 18.17 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.

18.8.2 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 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 18.5.2 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 18.5.2. 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 18.5.2.

18.8.3 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 18.5.3 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. Hence, system behaviors will be summarized as follows.

a. Stabilization of monetary system and its increased resiliency to the internal and external financial shocks

b. Liquidation of government debt within each EPM region.

c. Elimination of income inequality between financiers and non-financiers.

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11 This point will be further discussed in the last Section 18.10.

12 As shown in Figure 18.19 below, EPM regions based on different currency are expected to emerge.
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.

18.9 Blockchain-based Money Classified

18.9.1 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 \[60, 2008\]. 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 18.1, 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 another type of blockchain-based money. These two types are positioned in the functional-money and public money columns, respectively, in our extended classification of Table 18.4 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 18.4. Let us now explore these blockchain-based money in more detail.

<table>
<thead>
<tr>
<th>Classification of Money (after the Year 2008)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Front: Issuance</strong></td>
</tr>
<tr>
<td>Public Money</td>
</tr>
<tr>
<td>Debt Money (at interest)</td>
</tr>
<tr>
<td><strong>Back: Fiat Status</strong></td>
</tr>
<tr>
<td>Money as Legal Tender</td>
</tr>
<tr>
<td>Functional-Money</td>
</tr>
<tr>
<td><strong>Non-metal Commodities</strong></td>
</tr>
<tr>
<td>Shell, Cloth (Silk)</td>
</tr>
<tr>
<td>Woods, Stones, etc</td>
</tr>
<tr>
<td><strong>Metal Coinage</strong></td>
</tr>
<tr>
<td>Non-precious Metal Coins</td>
</tr>
<tr>
<td>Gold, Silver &amp; Copper Coins</td>
</tr>
<tr>
<td>Metal Ingots</td>
</tr>
<tr>
<td>(such as Gold)</td>
</tr>
<tr>
<td><strong>Paper Notes</strong></td>
</tr>
<tr>
<td>Public Money Notes</td>
</tr>
<tr>
<td>by PM Admin.</td>
</tr>
<tr>
<td>Goldsmith Certificates</td>
</tr>
<tr>
<td>Central Bank Notes</td>
</tr>
<tr>
<td><strong>Digital Accounts &amp; Cards</strong></td>
</tr>
<tr>
<td>Public Money</td>
</tr>
<tr>
<td>Deposits</td>
</tr>
<tr>
<td>Central Bank Reserves</td>
</tr>
<tr>
<td>Bank Deposits (Credits by Loans)</td>
</tr>
<tr>
<td><strong>Digital Tokens (Blockchains &amp; Distributed Ledgers, etc.)</strong></td>
</tr>
<tr>
<td>Electronic</td>
</tr>
<tr>
<td>Central Bank Digital Currency (issued as Base Money)</td>
</tr>
<tr>
<td>Bitcoin and approx. 1,000 Altcoins</td>
</tr>
<tr>
<td>&lt; Crypto-token (as Notes) (as Deposits) &gt;</td>
</tr>
<tr>
<td><strong>(After 2008)</strong></td>
</tr>
<tr>
<td>&lt; EPM &gt;</td>
</tr>
<tr>
<td>&lt; CBDC &gt;</td>
</tr>
<tr>
<td>&lt; Crypto-Coins &gt;</td>
</tr>
</tbody>
</table>

Table 18.4: Classification of Digital token-based Public and Debt Money

### 18.9.2 Crypto-Coins

#### Bitcoin as Functional-Money

Crypto-coins, consisting of Bitcoin and Altcoins, 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. From our strict definition of currency and money discussed in Section 18.2, 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 18.4, since it functions as money similar to bank deposits under the debt money system. Other crypto-coins (Altcoins),

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13 Crypto-coins could further be classified into permission or permission-less (public) types, depending on whether a validating node is required 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.
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 18.6, 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 18.6, 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 18.5 lists top 10 crypto-coins, as of Sept. 2, 2017, according to their scales of market capitalization. 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.

<table>
<thead>
<tr>
<th>Rank</th>
<th>Name</th>
<th>Market Capitalization</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bitcoin</td>
<td>$76,561,792,510</td>
<td>$4629.09</td>
</tr>
<tr>
<td>2</td>
<td>Ethereum</td>
<td>$33,622,114,919</td>
<td>$356.22</td>
</tr>
<tr>
<td>3</td>
<td>Bitcoin Cash</td>
<td>$9,769,799,507</td>
<td>$590.08</td>
</tr>
<tr>
<td>4</td>
<td>Ripple</td>
<td>$8,872,381,573</td>
<td>$0.23</td>
</tr>
<tr>
<td>5</td>
<td>Litecoin</td>
<td>$4,196,792,392</td>
<td>$79.56</td>
</tr>
<tr>
<td>6</td>
<td>NEM</td>
<td>$2,770,884,000</td>
<td>$0.31</td>
</tr>
<tr>
<td>7</td>
<td>Dash</td>
<td>$2,689,302,539</td>
<td>$357.20</td>
</tr>
<tr>
<td>8</td>
<td>Ethereum Classic</td>
<td>$1,927,363,497</td>
<td>$20.26</td>
</tr>
<tr>
<td>9</td>
<td>Monero</td>
<td>$1,925,085,092</td>
<td>$128.13</td>
</tr>
<tr>
<td>10</td>
<td>IOTA</td>
<td>$1,839,117,905</td>
<td>$0.66</td>
</tr>
</tbody>
</table>

Table 18.5: Ranking By Market Capitalization

15 Source: https://coinmarketcap.com/currencies/
18.9.3 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)[8, 2015].

<Public Money vs CBDC>

From the extended classification Table 18.4 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: 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.\(^\text{16}\)

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 18.5.2. Ironically, this reform turns out to be the same mechanism incorporated into the public money system for maintaining price stability.

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.

18.9.4 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 18.4, this type of crypto-token with stability of real money is 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 MUGF 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). 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,


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 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.

$M_0$-backed EPM token

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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
20 According to: http://bccc.global/ja/articles/20170705.html (last access on Sep 2, 2017).
$M_0$-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 (18.3), 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 18.8; 100% reserve ratio for demand deposits or "100% money" as described by Fisher [13, 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.

18.10 EPM as Money of the Futures

18.10.1 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 18.5.5, 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 18.4 remain the same under the public money system. Bitcoin payment is additionally added as peer-to-peer (p2p) payment method ⑦ in Figure 18.13.

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 indistinguishable 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.
18.10.2 Design Configuration of EPM Protocol

(A) As Monetary System

To implement EPM world-wide as money of the future, new EPM protocol needs to be developed. Since the introduction of Bitcoin [60, 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 18.5.2. In other words, PMA has to be the sole issuer of money, and any other network participants should not be allowed to create additional units 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 18.5. 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 18.5.2). Thus, the EPM protocol must be carefully designed both as monetary and payment systems. For this purpose, the above

![A Network within a Single EPM Region](image-url)

Figure 18.18: A Network within a Single EPM Region

proposed protocol may not be enough, especially when it is to be used across
EPM regions. Figure 18.18 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 18.19 illustrates how each EPM region starts to emerge and begin to overlap as if diverse colors of floral petals open up internationally.

![Figure 18.19: A Network of Worldwide EPM systems](image)

**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
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