Part III

Macroeconomic Systems of Debt Money

Chapter 8

Aggregate Demand Equilibria

This chapter [1] discusses a dynamic determination processes of GDP, interest rate and price level on the same basis of the principle of accounting system dynamics. For this purpose, a simple Keynesian multiplier model is constructed as a base model for examining a dynamic determination process of GDP. It is then expanded to 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, produces and government. And government is separated in a later analysis. For the analysis of aggregate demand and supply in this chapter, we need at least four sectors such as producers, consumers, banks and government. Since money supply is assumed to be exogenously determined in this chapter, central bank is excluded. Our analysis is also

[1] This chapter is based on the paper: Aggregate Demand Equilibria and Price Flexibility – SD Macroeconomic Modeling (2) – in "Proceedings of the 23rd International Conference of the System Dynamics Society", Boston, USA, July 17 - 21, 2005. ISBN 0-9745329-3-2.

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

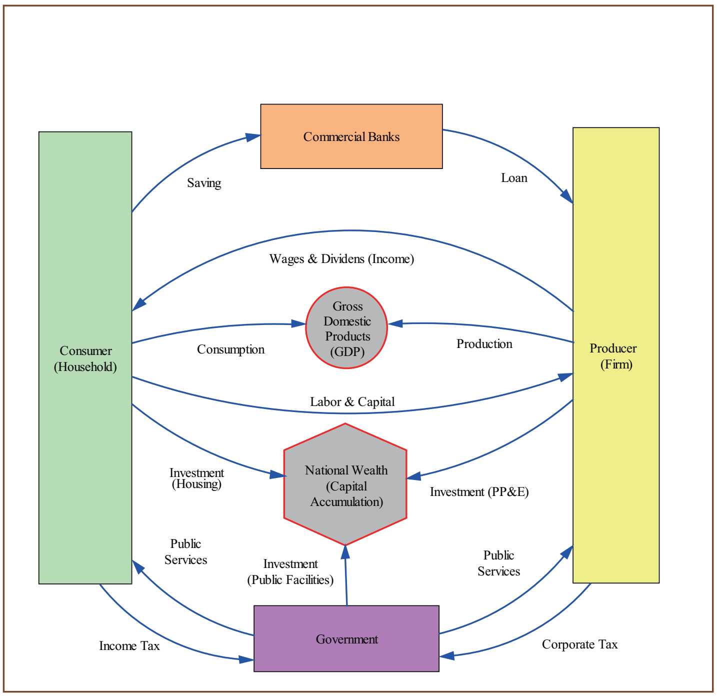

Figure 8.1: Macroeconomic System Overview

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 [10], [53], [54], and [58] are occasionally used to examine a standard approach to macroeconomics.

A simple Keynesian macroeconomic model is described as follows.

$$Y = AD \quad \text{(Determination of GDP)} \tag{8.1}$$

$$AD = C + I + G \quad \text{(Aggregate Demand)} \tag{8.2}$$

$$C = C_0 + cY_d \quad \text{(Consumption Decisions)} \tag{8.3}$$

$$Y_d = Y - T - \delta K \quad \text{(Disposable Income)} \tag{8.4}$$

$$T = \bar{T} \quad \text{(Tax Revenues)} \tag{8.5}$$

$$I = \bar{I} \quad \text{(Investment Decisions)} \tag{8.6}$$

$$G = \bar{G} \quad \text{(Government Expenditures)} \tag{8.7}$$

$$\frac{dK}{dt} = I - \delta K \quad \text{(Net Capital Accumulation)} \tag{8.8}$$

$$Y_{full} = F(K, L) \quad \text{(Production Function)} \tag{8.9}$$

$$Y_{full} = Y \quad \text{(Equilibrium Condition)} \tag{8.10}$$

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 $(L, C_0, c, \bar{T}, \bar{I}, \delta, \bar{G})$.[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 [3]

$$\frac{dP}{dt} = \Psi(AD/P - Y_{full}). \tag{8.11}$$

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.

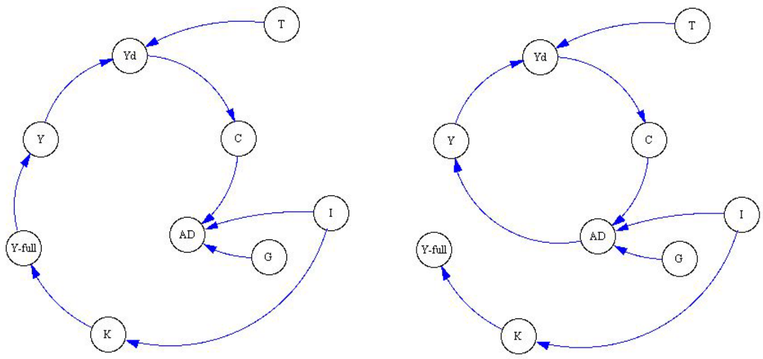

Figure 8.2: Causal loops of Neoclassical and Keynesian Models

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[4]? 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 $(C_0, c, \bar{T}, \bar{I}, \delta, \bar{G}, L)$.

[4]I once posed this question in the book [89]. At that time, I was unaware of system dynamics and unable to model my general equilibrium framework for simulation.

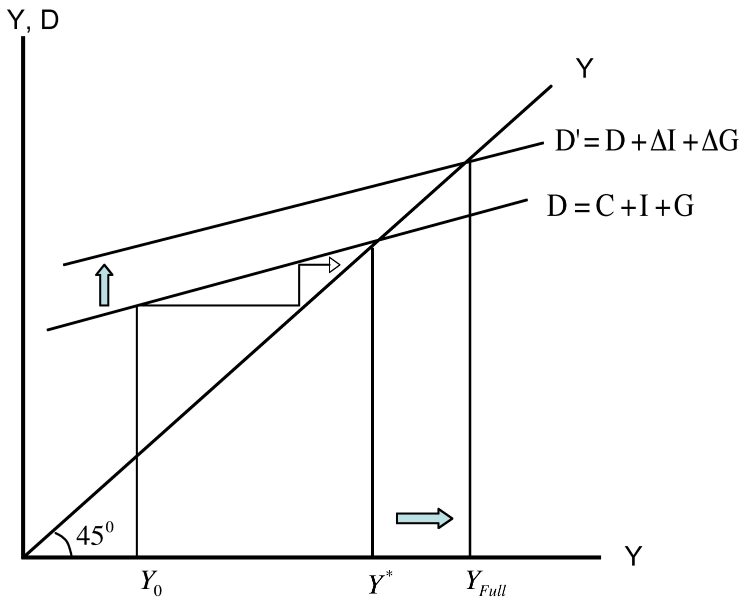

Figure 8.3: Keynesian Comparative Static Determination of GDP

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

$$Y^* = \frac{C_0 - c\bar{T} + \bar{I} + \bar{G}}{1 - c} \tag{8.12}$$

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

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:

$$\frac{d\,Y}{dt} = (AD - Y)/AT \tag{8.13}$$

where AT is an adjustment time.

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.vpm].

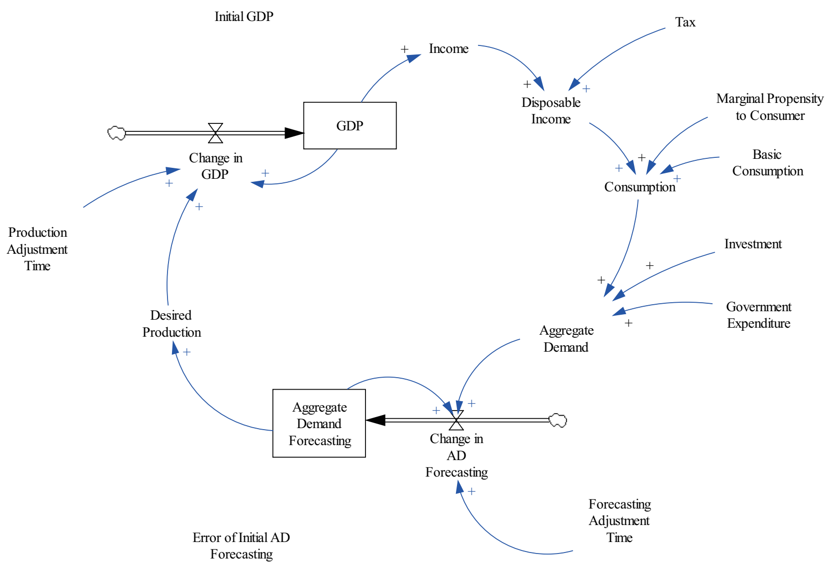

Figure 8.4: Keynesian SD Model of GDP

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.

$$Y_{full} = Y(K, L) \tag{8.14}$$

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.

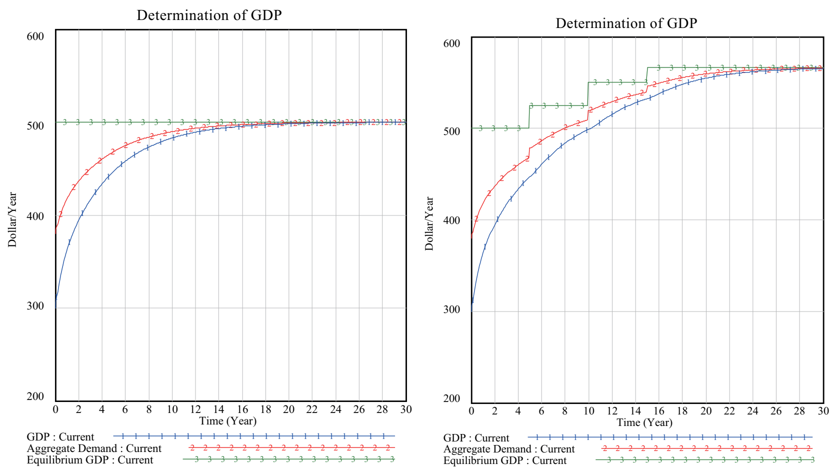

Figure 8.5: Keynesian SD Determination of GDP

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

$$\Delta Y = \frac{-c\Delta T + \Delta I + \Delta G}{1-c} \tag{8.15}$$

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

$$\frac{\Delta Y}{\Delta I} = \frac{\Delta Y}{\Delta G} = \frac{1}{1-c} = 2.5 \ ; \ \frac{\Delta Y}{\Delta T} = \frac{-c}{1-c} = -1.5 \tag{8.16}$$

Suppose that $Y_{full} = 560$. Then, to attain a full capacity level of GDP, we need to increase $\Delta Y = Y_{full} - Y^* = 60$. This could be done by increasing the investment or government expenditure by 24 (that is, $\Delta Y = 2.5 \cdot 24$), or decreasing tax by 40 (that is, $\Delta Y = (-1.5) \cdot (-40)$). Figure 8.3 illustrates how Y_{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 [72]. 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).vpm]. 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

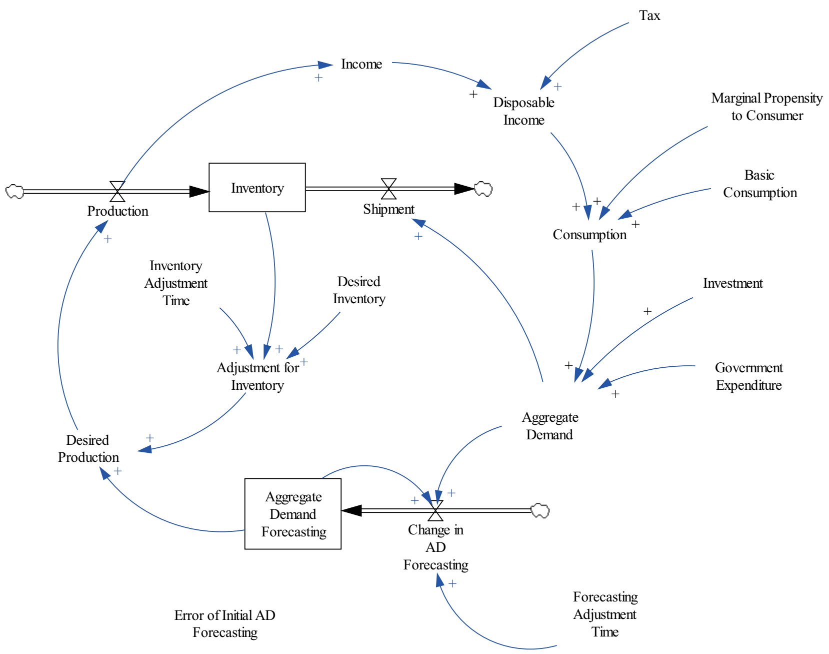

Figure 8.6: Revised Keynesian SD Model of GDP

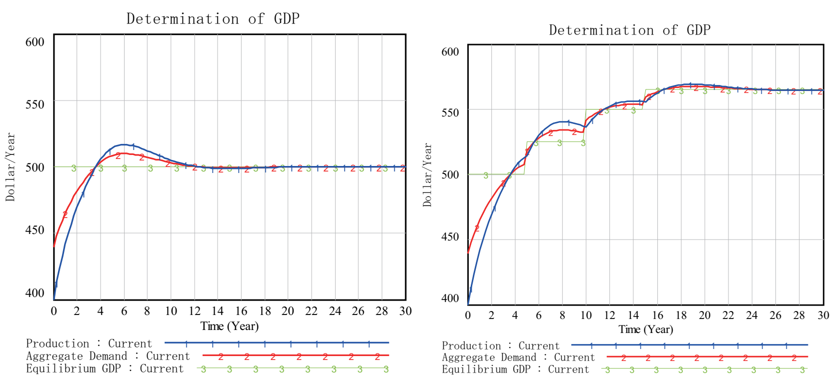

Figure 8.7: SD Determination of GDP

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):

$$T = T_0 + tY - T_r \tag{8.20}$$

where t is an income tax rate.

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

$$I(i) = \frac{I_0}{i} - \alpha i \tag{8.21}$$

where α 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 supply used in a year is equal to the demand for money:

$$\frac{M^s}{P} V = aY - bi \tag{8.22}$$

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:

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

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

$$Y = \frac{1}{a} \frac{M^s}{P} V + \frac{b}{a} i \tag{8.24}$$

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

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

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.

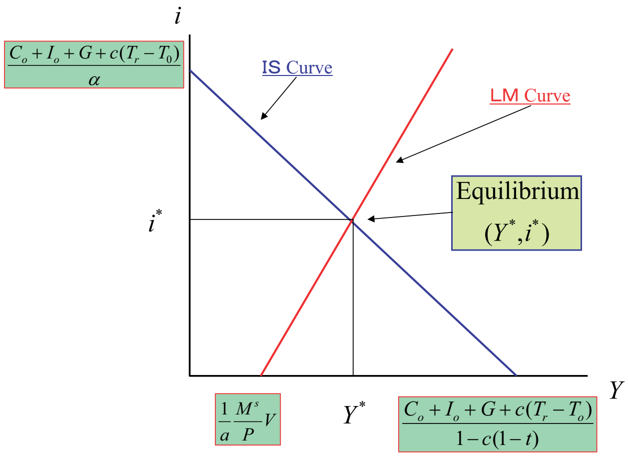

Figure 8.8: IS-LM Determination of GDP and Interest Rate

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

$$\frac{d\,G}{dt} = g(t)G. \tag{8.26}$$

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:

$$G = \beta T \tag{8.27}$$

where β is a ratio between government expenditures and tax revenues, called primary balance ratio here. When $\beta = 1$, we have a so-called balanced budget, while if $\beta > 1$, we have budget deficit.

With the introduction of the government expenditures in either one of these two ways, all exogenously determined variables such as T, I, and G are now endogenously determined within the macroeconomic system.

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

$$Y = \frac{C_0 + I_0 + (\beta - c)(T_0 - T_r)}{1 - c - (\beta - c)t} - \frac{\alpha}{1 - c - (\beta - c)t} i \tag{8.28}$$

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

$$Y^* = \frac{C_0 + I_0 + (\beta - c)(T_0 - T_r)}{1 - c - (\beta - c)t + \alpha(a/b)} + \frac{\alpha/b}{1 - c - (\beta - c)t + \alpha(a/b)} \frac{M^s}{P} V \tag{8.29}$$

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)

$$\frac{dY}{dT_0} = \frac{1 - c}{(1 - c)(1 - t) + \alpha(a/b)} > 0 \tag{8.30}$$

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

$$\frac{dY}{dT_0} = \frac{-c}{1 - c(1 - t) + \alpha(a/b)} < 0 \tag{8.31}$$

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).vpm]. 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:

$$\frac{d\,i}{dt} = \Phi\left((aY - bi) - \frac{M^s}{P} V\right) \tag{8.32}$$

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

$$\frac{d\,i}{dt} = \frac{i^* - i}{\text{DelayTime}} \tag{8.33}$$

where the desired interest rate i^* is obtained as

$$i^* = \frac{i}{\left(\frac{M^s}{P}V/(aY - bi)\right)^e}, \tag{8.34}$$

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

Figure 8.9 illustrates the adjustment process of interest rate.

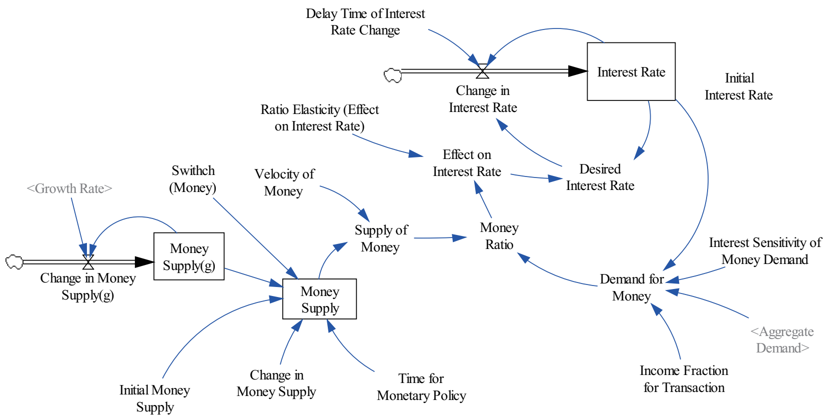

Figure 8.9: Interest Rate Adjustment Process

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

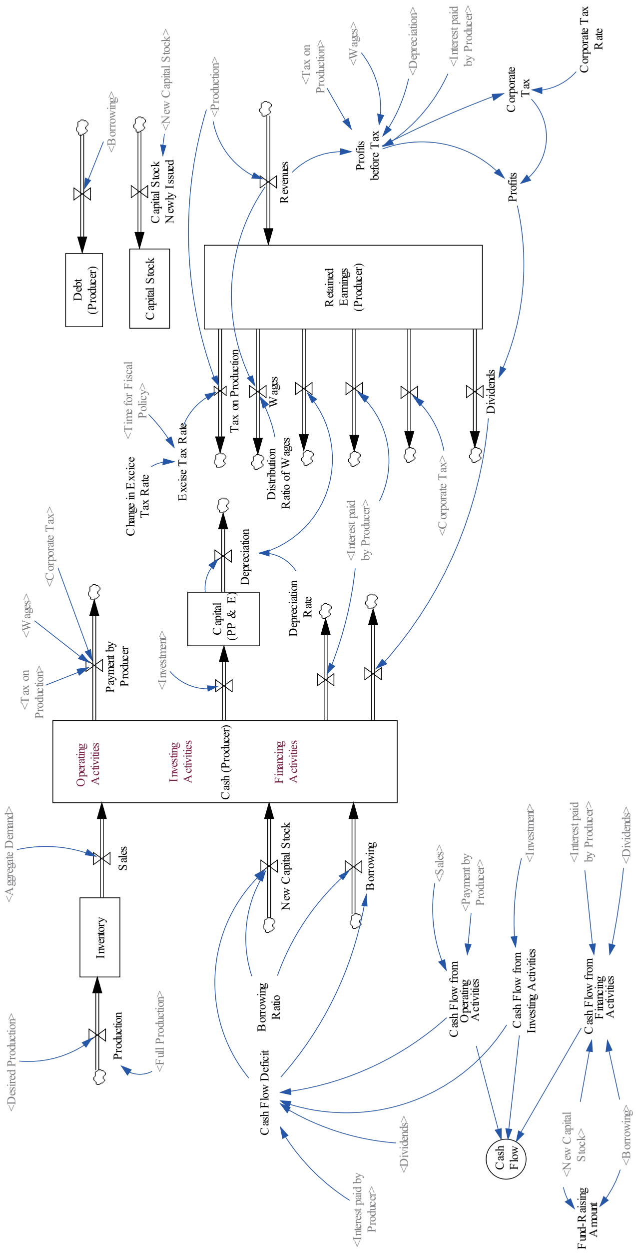

Figure 8.10: Transactions of Producers

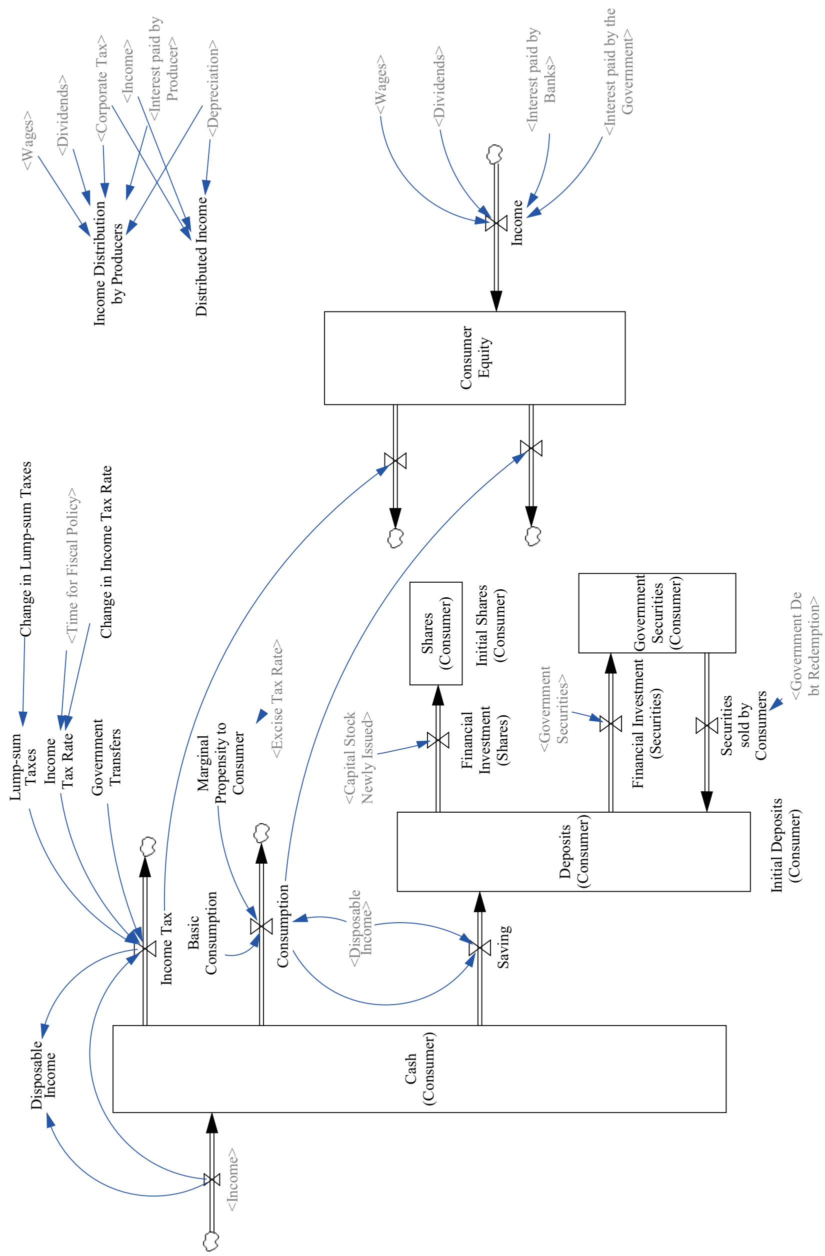

Figure 8.11: Transactions of Consumer

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.

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.

$$Y = \mathrm{Min}(Y_{full},\ Y^D) \tag{8.35}$$

Moreover, the full capacity output level in equation (8.14) is specified as follows:

$$Y_{full} = e^{\kappa t}\frac{1}{\theta}K \tag{8.36}$$

where κ is an annual increase rate of technological progress, and θ 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.

Top diagram in Figure 8.15 shows mostly equilibrium growth path of production around full capacity level. Bottom diagram 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.

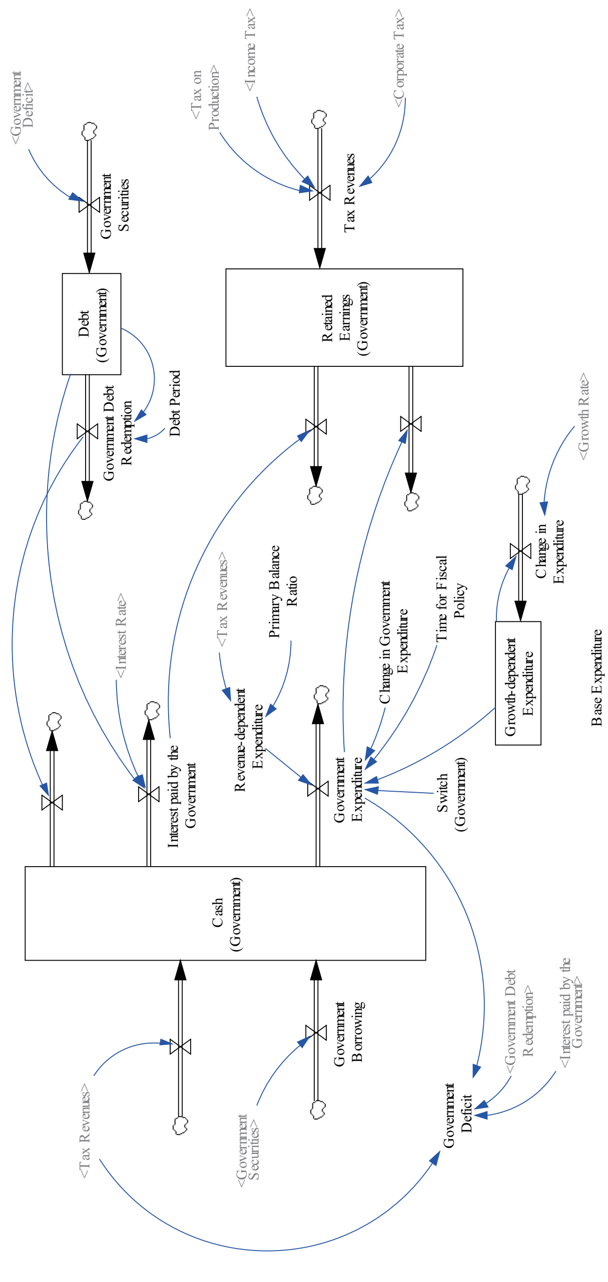

Figure 8.12: Transactions of Government

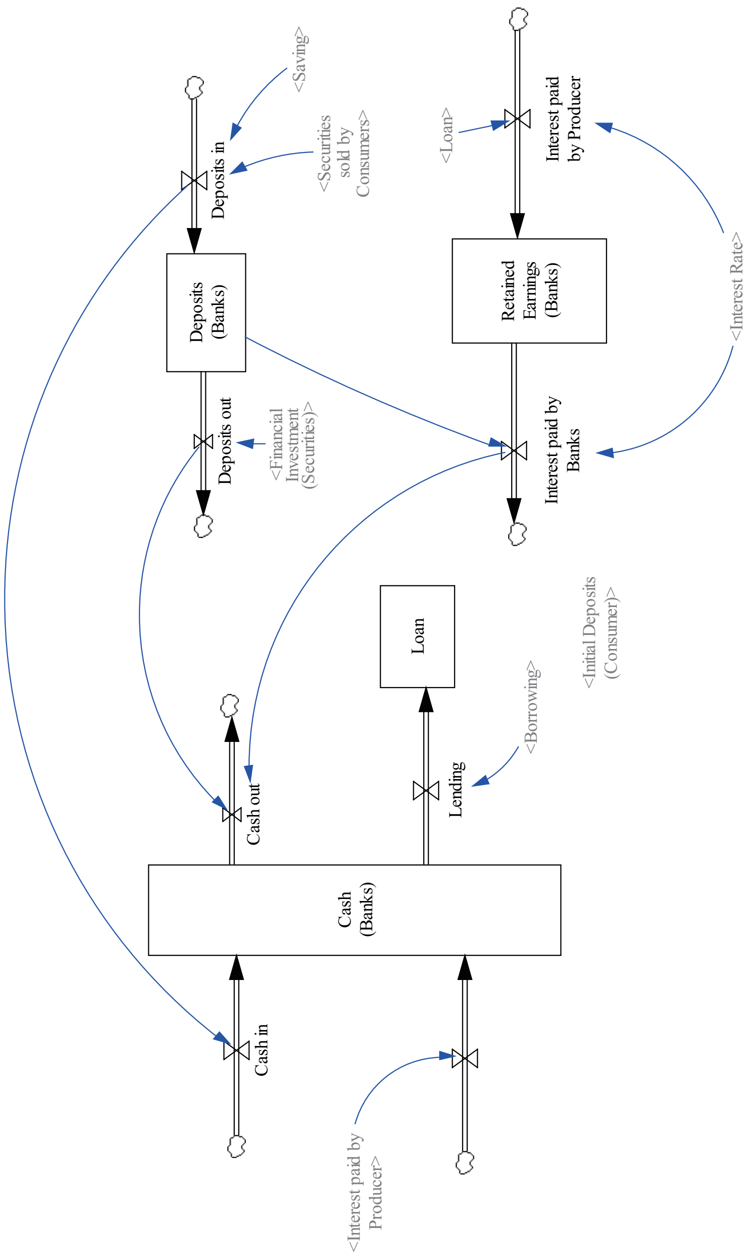

Figure 8.13: Transactions of Banks

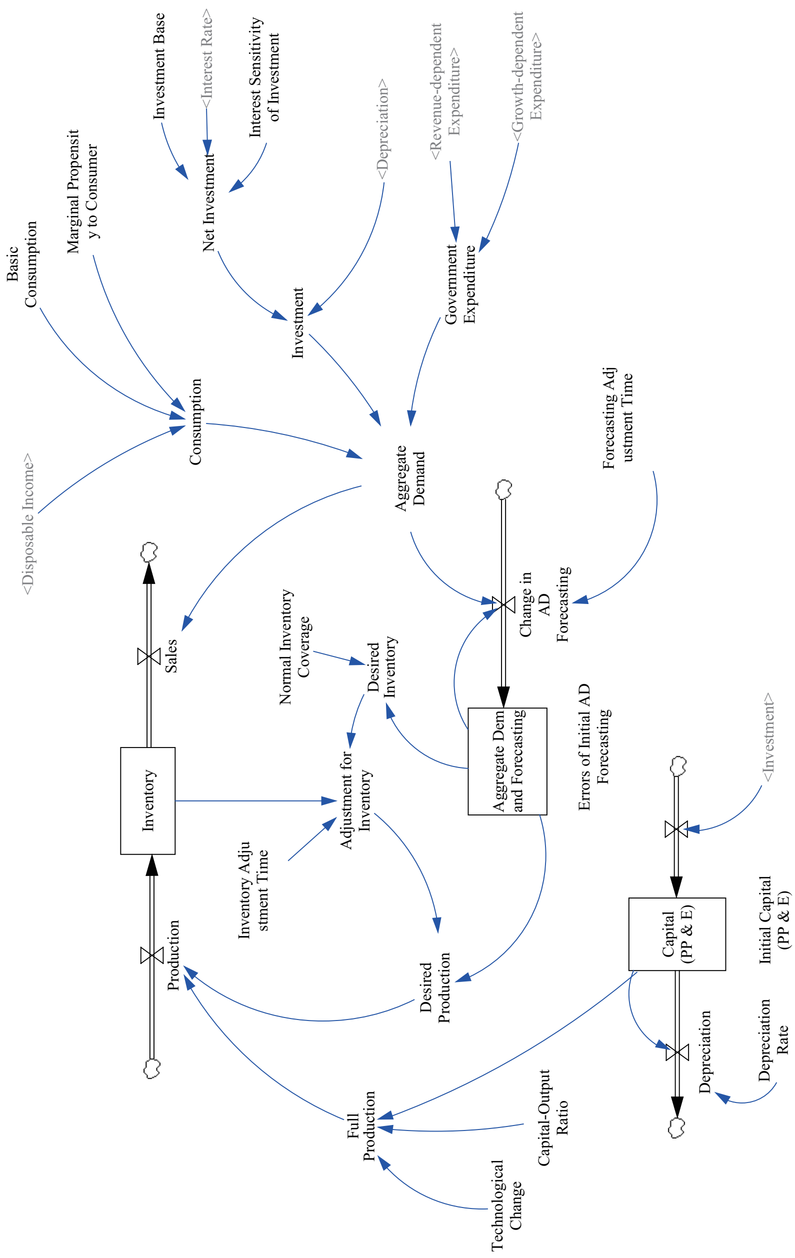

Figure 8.14: Full Capacity Production

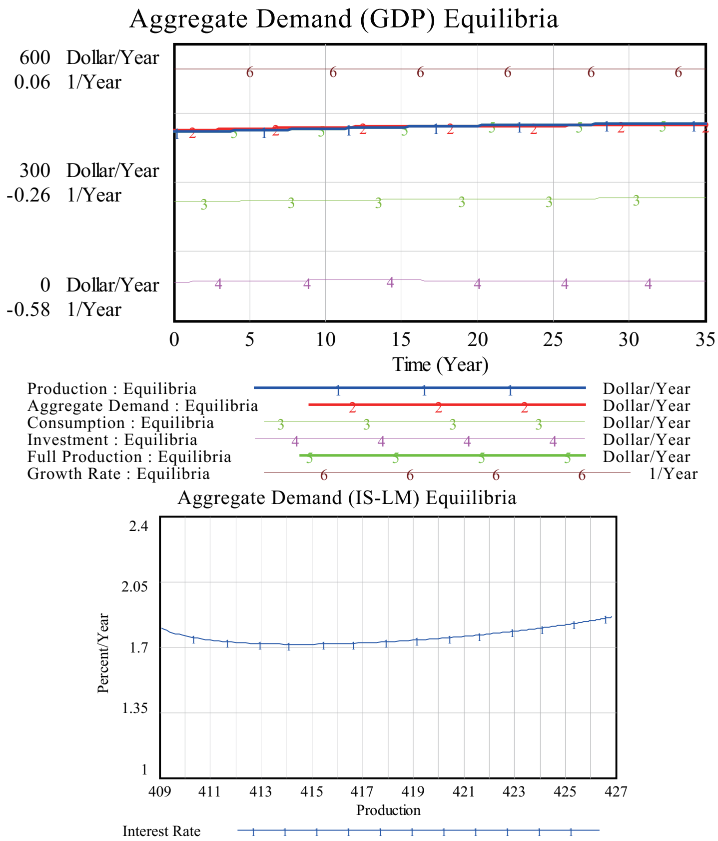

Figure 8.15: Aggregate Demand Mostly Equilibria

Causes of Disequilibria

According to the IS-LM analysis, disequilibria or recessions are caused by the shift of IS and lM curves in Figure 7.8 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 changing the amount of basic consumption from 101 to 90. Top diagram in Figure 8.16 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.

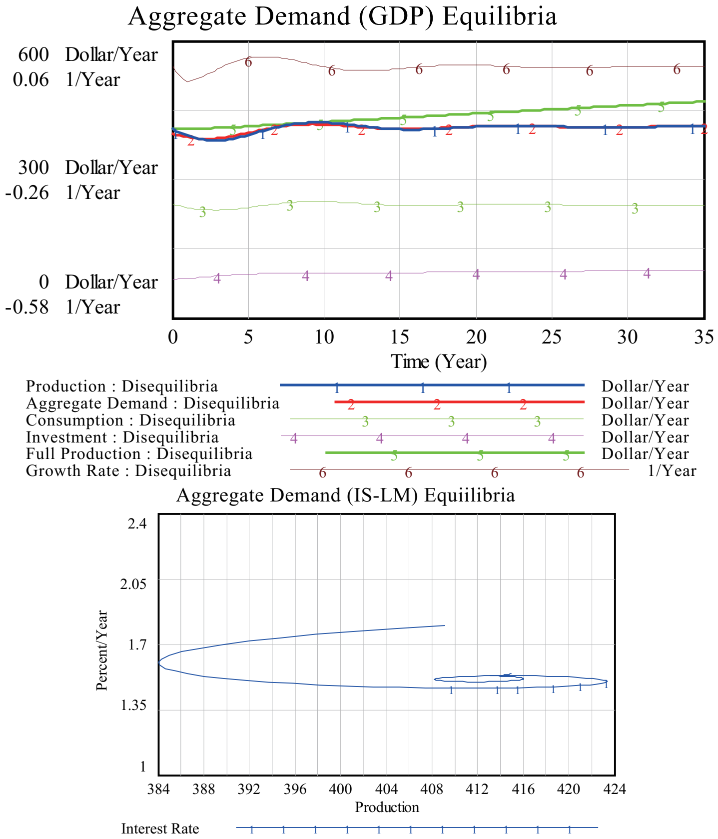

Figure 8.16: Aggregate Demand Disequilibria

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 16 at period 14. 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 8.17, it also pushes up i^*, and eventually discourages investment, which is a well known crowding-out effect of government expenditures.

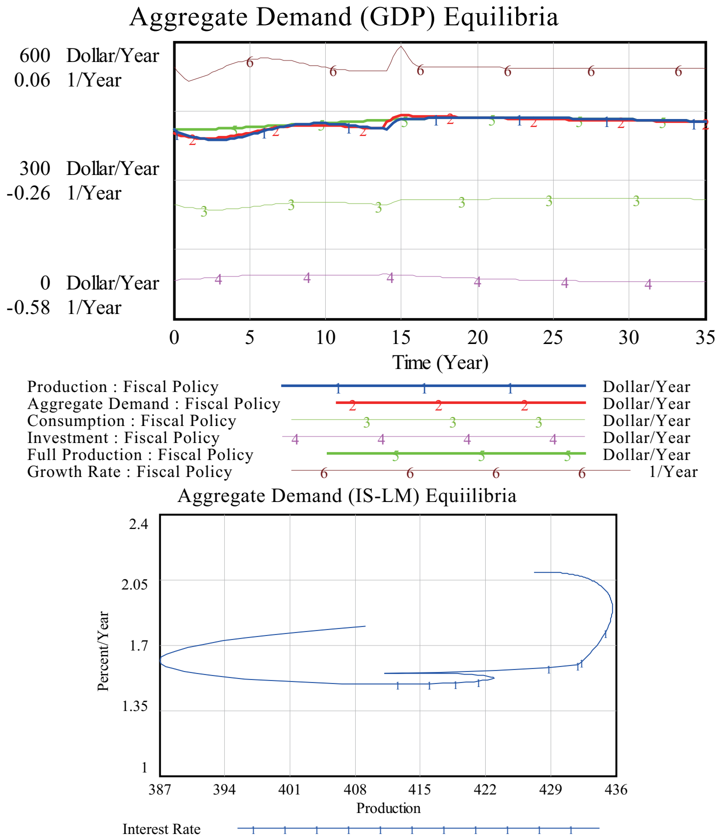

Figure 8.17: Effect of Fiscal Policy

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 8.18 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 puses up interest rate, discouraging the investment.

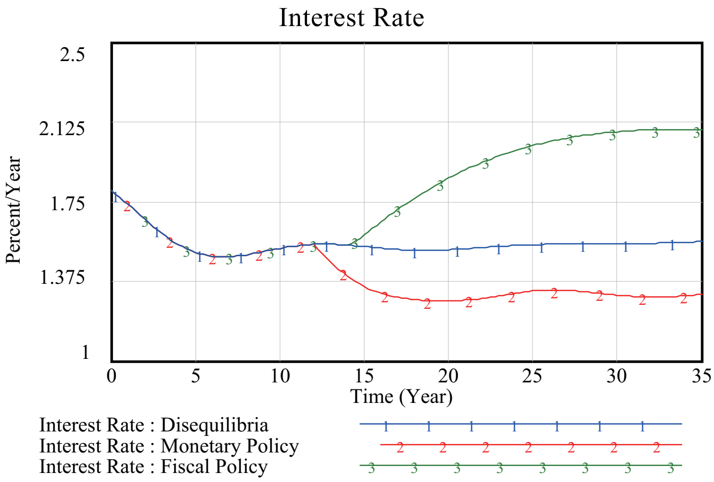

Figure 8.18: Behaviors of Interest Rate Compared

Government Debt

Figure 8.19 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.*

Fiscal Policy 2: Tax Cut

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

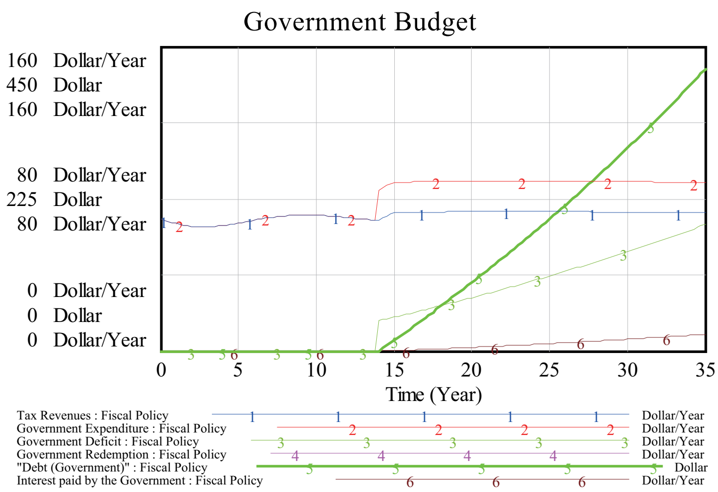

Figure 8.19: Skyrocketing Government Debt

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 supply by 8 at period 12. According to textbook explanation, this increase in money supply shifts the LM curve to the right, and accordingly i^* is lowered while Y^* increases. In the top diagram of Figure 8.20 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 supply. However, it eventually begins to increase as aggregate demand fails to sustain a full capacity equilibrium.

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

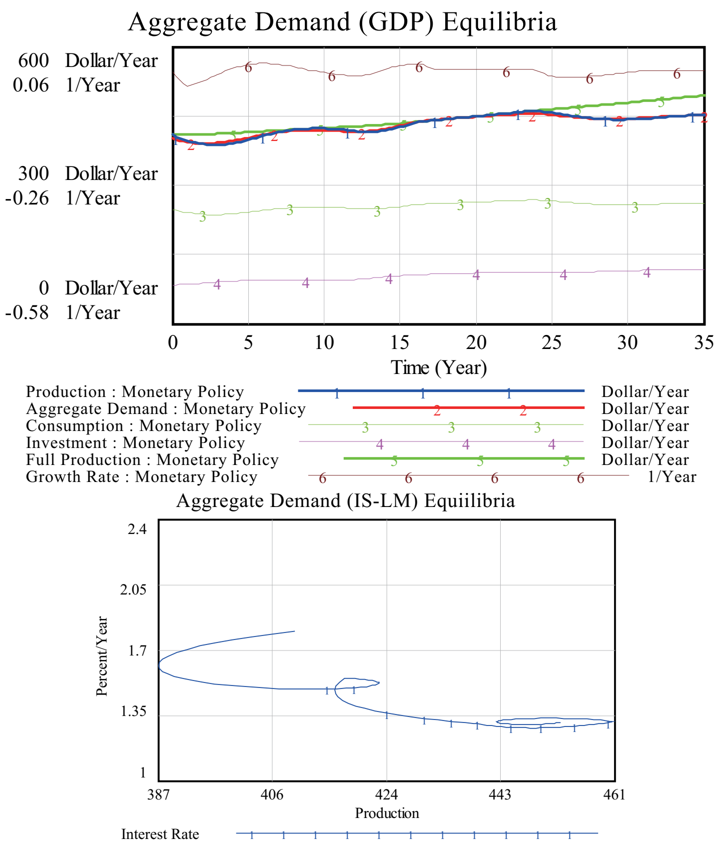

Figure 8.20: Effect of Monetary Policy

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 shifts 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).

Irvins 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:

$$Y^*(P) = A + B\frac{M^s}{P}V, \tag{8.37}$$

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

$$Y_{full} = Y^*(P) \tag{8.38}$$

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

$$\frac{dP}{dt} = \Psi(Y^D - Y_{full}, I^*_{nv} - I_{nv}). \tag{8.39}$$

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

$$\frac{dP}{dt} = \frac{P^* - P}{Delay\ Time} \tag{8.40}$$

where the desired price P^* is obtained as

$$P^* = \frac{P}{\left((1-\omega)\frac{Y_{full}}{Y^D} + \omega\frac{I_{nv}}{I^*_{nv}}\right)^e} \tag{8.41}$$

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

This completes our SD macroeconomic modeling of Keynesian IS-LM model. Figure 8.21 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 8.22 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

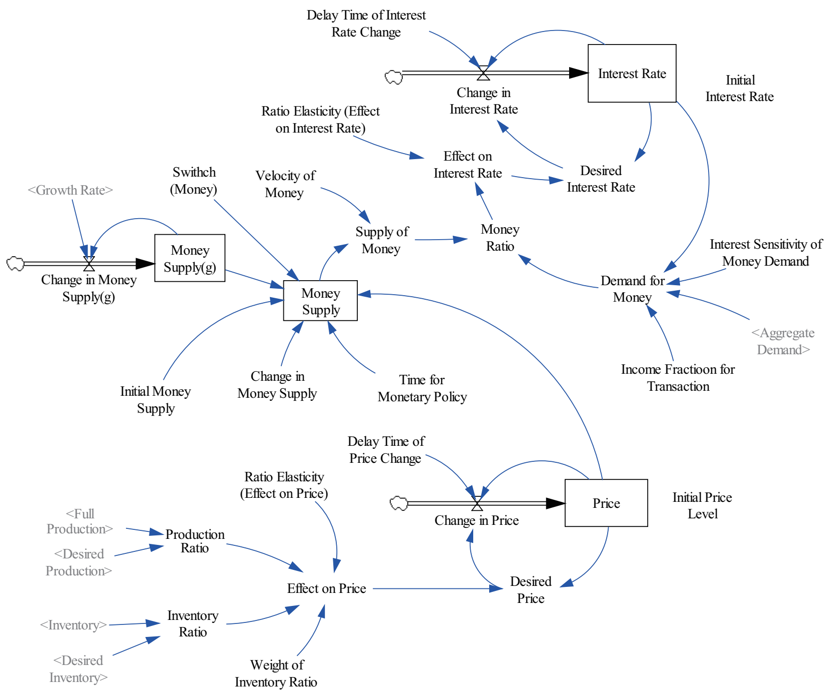

Figure 8.21: Price and Interest Rate Adjustment Processes

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 8.23, 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 supply, demand and interest rate, which have similar fluctuation periods as business cycle of growth rate.

Figure 8.24 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.

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

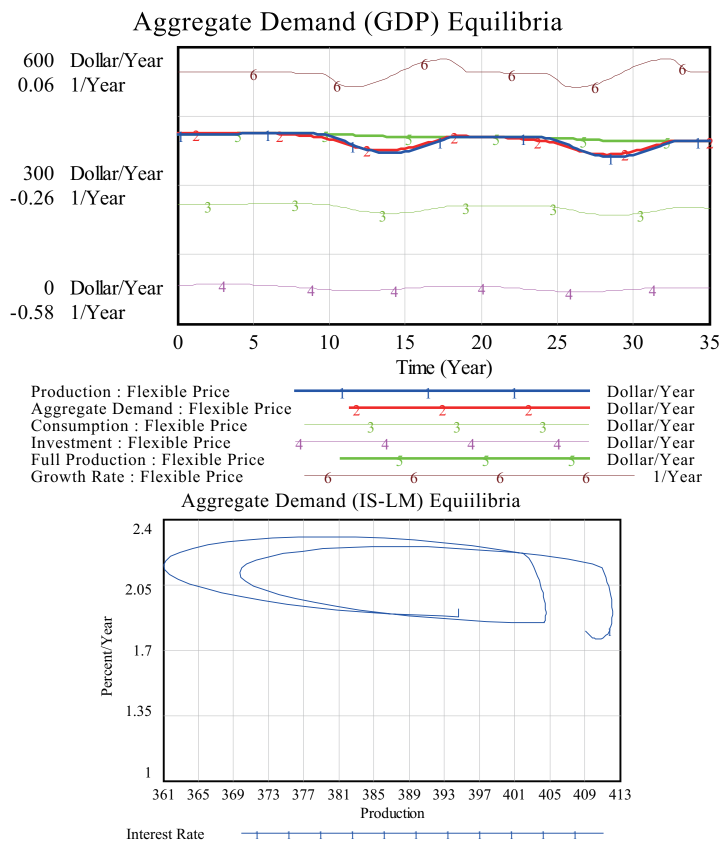

Figure 8.22: Flexible Price Equilibria

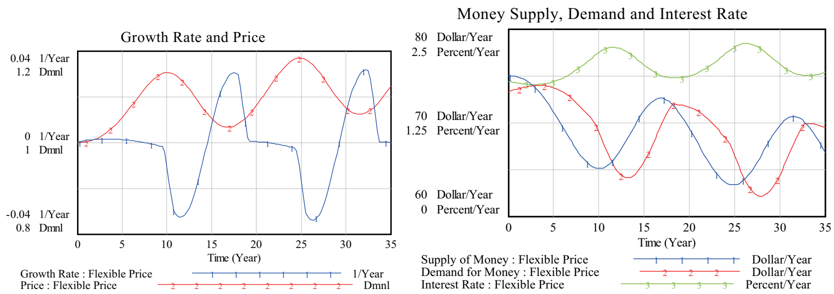

Figure 8.23: Growth, Price, Money Supply, Demand and Interest Rate

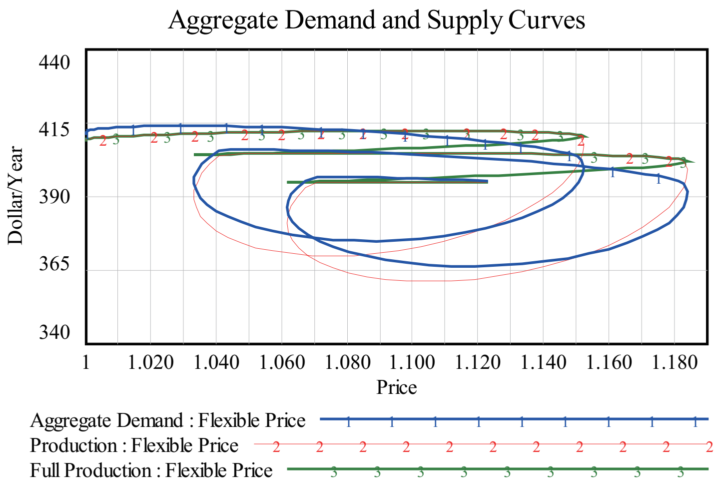

Figure 8.24: Aggregate Demand and Supply Curves

disequilibrium situation is successfully produced as the Figure 8.25 illustrates.

In other words, similar business cycles are observed, this time, at a larger scale. This can be confirmed with Figure 8.26

Growth-dependent Money Supply

It will be interesting to see how a change in money supply affects the behaviors of the above disequilibria 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 supply model developed in the previous chapters. Otherwise, it will be misleading to merely change money supply without examining its feedback relations within the system.

Even so, just for our curiosity, let us change money supply 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 supply in the same fashion as we introduced growth-dependent government expenditures in equation (8.26):

$$\frac{dM^s}{dt} = g(t)M^s. \tag{8.42}$$

In Figure 8.27, line 1 indicates a reference curve with constant money supply. Line 2 represents the behaviors with a growth-dependent money supply. Line 3 shows the behaviors with a growth-dependent money supply under disequilibria.

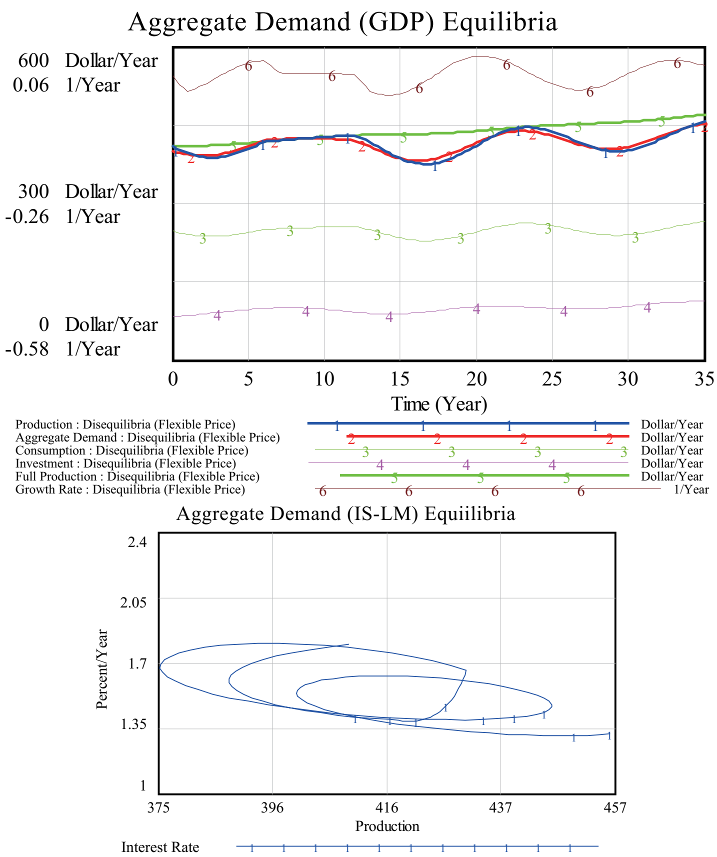

Figure 8.25: Flexible Price Disequilibria

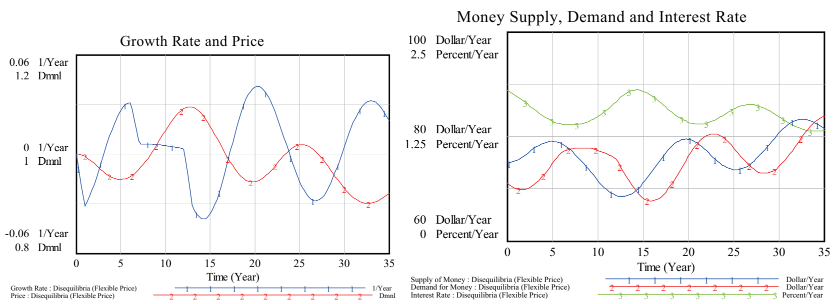

Figure 8.26: Growth, Price, Money Supply, Demand and Interest Rate

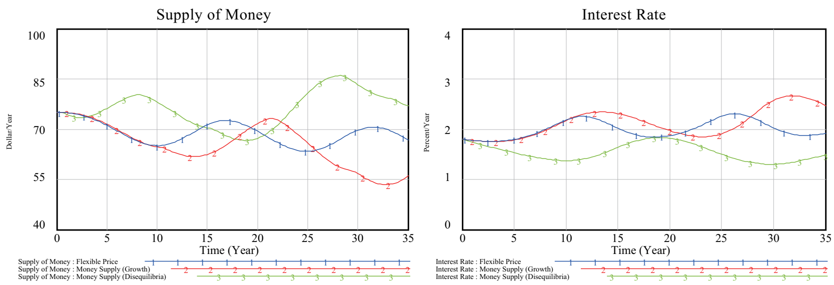

Figure 8.27: Growth-dependent Money Supply and its Effect on Interest Rate

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 8.28 illustrates that production continues to grow. Right-hand diagram shows constant growth of money supply 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.

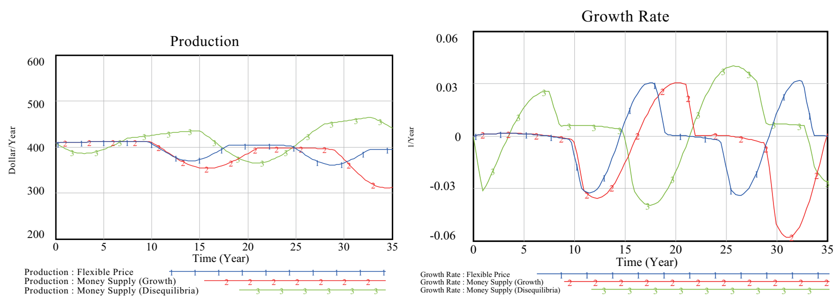

Figure 8.28: Growth-dependent Money Supply on GDP and Growth Rate

Figure 8.29 demonstrates that IS-LM curves extends to the right as the increasing money supply 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.

8.8 A Comprehensive IS-LM Model

Keynesian IS-LM model has a serious limitation; that is, money supply is exogenously given. On the contrary our SD approach of IS-LM model can treat

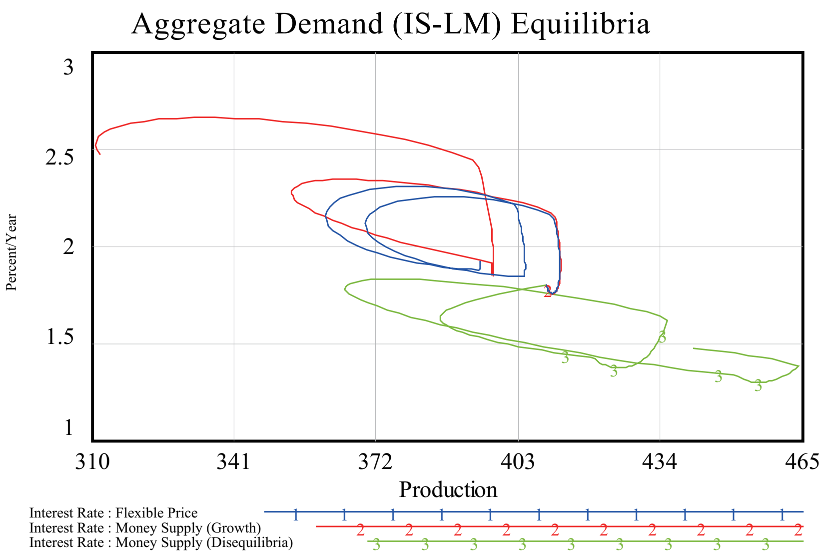

Figure 8.29: Growth-dependent Money Supply on IS-LM

money supply endogenously, which is now presented in this section [Companion model: 4 GDP(IS-Money).vpm]. Money supply is defined in the previous chapters as follows:

$$\text{Money Supply} = \text{Currency in Circulation} + \text{Deposits} \tag{8.43}$$

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 supply.

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

$$i^* = \frac{i}{\left(\frac{\text{Supply of Money}}{\text{Demand for Money}}\right)^e} \tag{8.44}$$

Figure 8.30 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 supply 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 supply within the system.

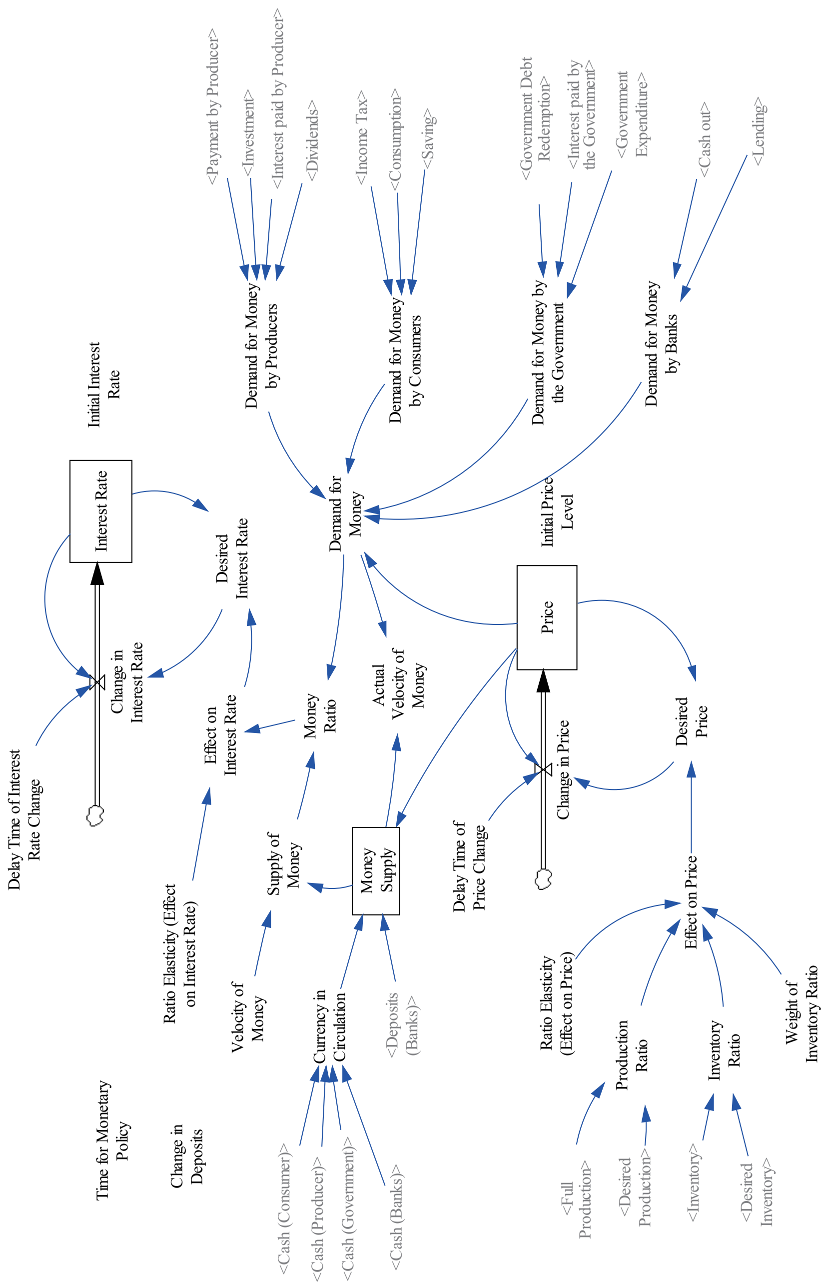

Figure 8.30: Interest Rate and Price Adjustment Process Revisited

Price Flexibility

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

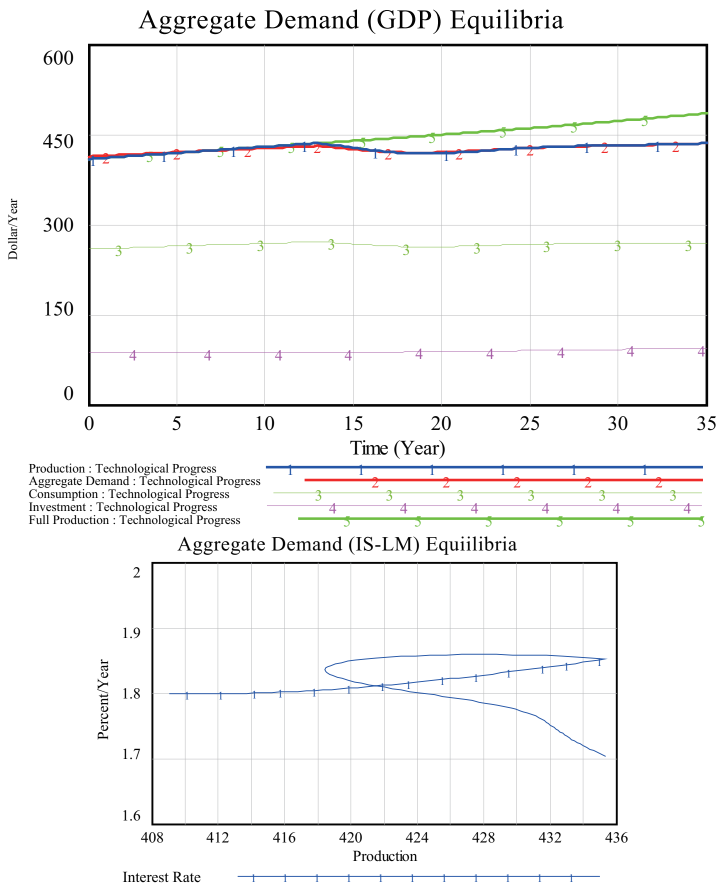

Figure 8.31: Disequilibria triggered by A Technological Progress

As Figure 8.31 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 8.32 illustrates how a production gap can be filled with business cycles.

Figure 8.33 illustrates aggregate demand and supply curves.

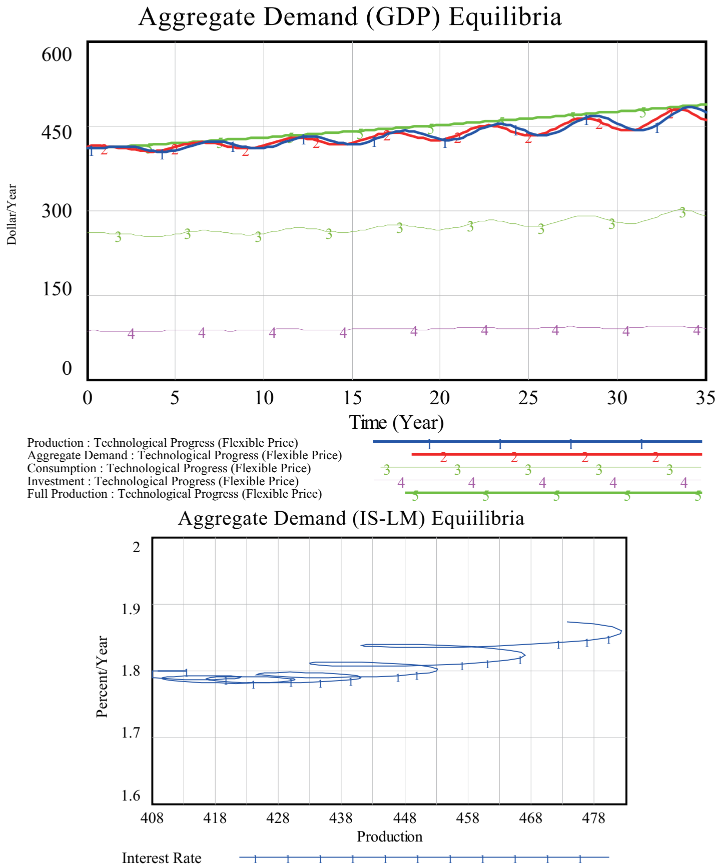

Figure 8.32: Business Cycles under Price Flexibility

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

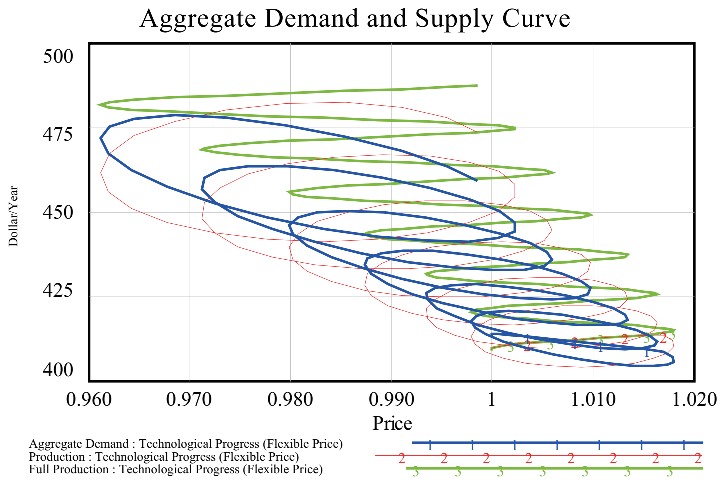

Figure 8.33: Aggregate Demand and Supply Curves

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 supply is fixed under a flexible price, price and interest rate continue to fluctuate.
- When money supply is changed proportionately to an economic growth rate, price and interest rate, as well as real money supply, begin to fluctuate larger than in the fixed money supply. Moreover, price and interest rate fluctuates oppositely to money supply.
- Keynesian IS-LM model thus presented above has a serious limitation; that is, money supply 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 supply in the previous two chapters, because an endogenous change in money supply may trigger an overall feedback reactions among all macroeconomic sectors, and the mechanistic change in money supply 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.

Questions for Deeper Understanding

1. In the companion model: 2 Keynesian(SD).vpm, 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 ($\equiv \frac{dY^*}{Y^*}/\frac{dc}{c}$). Then, re-build the Keynesian model: 2 Keynesian(SD).vpm by adding this MPC elasticity to the model, and show how the MPC elasticity is affected by the changes in aggregate demand; specifically, by tax cut. This may suggest the existence of a missing feedback loop from Change in Tax to Change in MPC in our Keynesian SD model such that

$$\text{Change in Tax} \Longrightarrow \text{Change in MPC} \longrightarrow \text{Consumption} \longrightarrow \text{GDP}.$$

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

4. Balance sheet of producers in the model: 3 GDP(IS-LM).vpm 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).vpm. 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

Full Production = Production = Aggregate Demand.

Fiscal policies can be more specifically implemented by the changes in

(1) Government Expenditure

(2) Lump-sum Taxes

(3) Excise Tax Rate, and

(4) Income Tax Rate.

Monetary policy can be implemented by the change in

(5) Money Supply.

Neoclassical theory proposes that the equilibrium can be restored by introducing

(6) Flexible Price.

The ASD Keynesian model can handle these 6 macroeconomic policies in a uniform fashion. Show how these 6 policies can attain the equilibrium, one by one, by illustrating simulation results in the graph titled: "Full Production, Production & Aggregate Demand" which is included in the three simulation pages of the model. Then, summarize these 6 policies by integrating all of them as graphs of Interest Rate and Debt (Government), and briefly compare them.

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 supply by 25% from 1929 to 1933. This is a well-acknowledged "money hypothesis". Yet, Mankiw pointed out as follows:

> "Using the IS-LM model, we might interpret the money hypothesis as explaining the Depression by a contractionary shift in the LM curve. ⋯
> The second problem for the money hypothesis is the behavior of interest rates. If a contractionary shift in the LM curve triggered the Depression, we should have observed higher interest rates.Yet nominal interest rates fell continuously from

1929 to 1933."
– Macroeconomics, 9th edition, 2016, by Gregory Mankiw, page 354 –

(b) After her bubble burst in mid 1990’s, Japanese economy has been suffering from the prolonged recessions of almost three decades. To get out of the recessions, Japanese government as well as the Bank of Japan have heavily applied the Keynesian monetary policy of increasing money supply 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 supply 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.

$$
\begin{aligned}
Y_{full} &= \frac{1}{\theta}K \ \ \text{(Full Capacity Output)} && (8.45)\\
Y &= Min(Y_{full},\ Y^D) \ \ \text{(Production Decision)} && (8.46)\\
Y^D &= (I^*_{nv} - I_{nv}) + AD \ \ \text{(Desired Production)} && (8.47)\\
\frac{dI_{nv}}{dt} &= Y - AD \ \ \text{(Inventory Adjustment)} && (8.48)\\
AD &= C + I + G \ \ \text{(Aggregate Demand)} && (8.49)\\
C &= C_0 + cY_d \ \ \text{(Consumption Decisions)} && (8.50)\\
Y_d &= Y - T - \delta K \ \ \text{(Disposable Income)} && (8.51)\\
T &= T_0 + tY - T_r \ \ \text{(Tax Revenues)} && (8.52)\\
I &= \frac{I_0}{i} - \alpha i \ \ \text{(Investment Decisions)} && (8.53)\\
\frac{dK}{dt} &= I - \delta K \ \ \text{(Net Capital Accumulation)} && (8.54)\\
\frac{dG}{dt} &= gG \ (\text{or } G = \beta T) \ \ \text{(Government Expenditures)} && (8.55)\\
\frac{dP}{dt} &= \Psi(Y^D - Y_{full}, I^*_{nv} - I_{nv}) \ \ \text{(Price Adjustment)} && (8.56)\\
m^s &= \frac{M^s}{P}V \ \ \text{(Real Money Supply)} && (8.57)\\
m^d &= aY - bi \ \ \text{(Demand for Money)} && (8.58)\\
\frac{d\,i}{dt} &= \Phi(m^d - m^s) \ \ \text{(Interest Adjustment)} && (8.59)
\end{aligned}
$$

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