

## Chapter 9

# A Macroeconomic System

In the previous chapter, monetary and real parts of macroeconomies are integrated to present a macroeconomic dynamic model. In this chapter<sup>1</sup>, 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.

### 9.1 Macroeconomic System Overview

This chapter tries to bring population and labor market to the stage to make the integrated model complete [Companion model: MacroSystem.vpm]. 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 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 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.

### 9.2 Production Function

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

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<sup>1</sup>This chapter is based on the paper: Integration of Real and Monetary Sectors with Labor Market – SD Macroeconomic Modeling (3) – in “Proceedings of the 24th International Conference of the System Dynamics Society”, Nijmegen, The Netherlands, July 23 - 27, 2006. (ISBN 978-0-9745329-5-0)

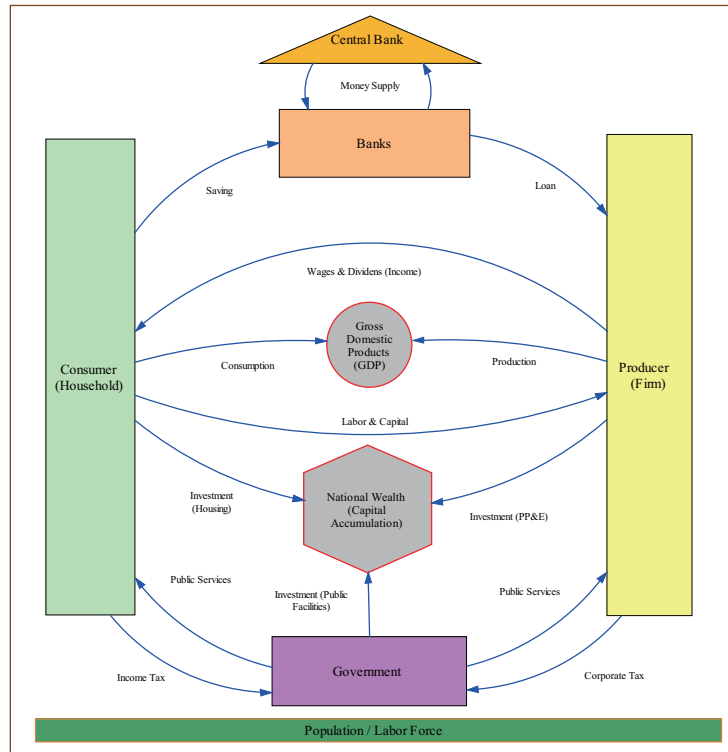


Figure 9.1: Macroeconomic System Overview

$$Y_{full} = e^{\kappa t} \frac{1}{\theta} K \quad (9.1)$$

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:

$$Y_{full} = F(K, L, A) = AK^\alpha L^\beta \quad (9.2)$$

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

$$Y_{potential} = F(K, LF, A) = AK^\alpha LF^\beta \quad (9.3)$$

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 (14.8) needs be slightly revised to reflect the gap between potential GDP and desired output  $Y^D$  as

$$P^* = \frac{P}{\left( (1 - \omega) \frac{Y_{potential}}{Y^D} + \omega \frac{I_{inv}}{I_{inv}^*} \right)^e} \quad (9.4)$$

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

Let us assume that productivity due to technological progress grows exponentially such that

$$A = \bar{A}e^{\kappa t} \quad (9.5)$$

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 [28], let us normalize this production function with the initial potential GDP at  $t = 0$ :

$$\bar{Y}_{potential} = F(\bar{K}, \bar{L}\bar{F}, \bar{A}) = \bar{A}\bar{K}^\alpha \bar{L}\bar{F}^\beta \quad (\text{Initial Potential Output}) \quad (9.6)$$

Then, we have

$$Y_{full} = e^{\kappa t} \bar{Y}_{potential} \left( \frac{K}{\bar{K}} \right)^\alpha \left( \frac{L}{\bar{L}\bar{F}} \right)^\beta \quad (9.7)$$

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 9.5), while income tax, consisting of lump-sum tax and a proportional part of income tax, is paid by consumers (Figure 9.6). With these into consideration, profits after tax  $\Pi$  are now defined as

$$\Pi = ((1 - t)PY_{full} - (i + \delta)P_K K - wL)(1 - t_c) \quad (9.8)$$

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 accounting system enables to handle this distinction. Specifically, capital cost (= interest paid by producers) are calculated in the model as

$$iP_K K \approx \text{Prime Rate} \times \text{Loan (or Debt by producers)} \quad (9.9)$$

First order condition for profit maximization with respect to capital stock is calculated by partially differentiating profits with respect to capital as

$$\begin{aligned}
\left(\frac{1}{1-t_c}\right) \frac{\partial \Pi}{\partial K} &= \alpha(1-t)Pe^{\kappa t} \left(\frac{\bar{Y}_{full}}{\bar{K}}\right) \left(\frac{K}{\bar{K}}\right)^{\alpha-1} \left(\frac{L}{\bar{L}}\right)^\beta - (i+\delta)P_K \\
&= \frac{\alpha(1-t)Pe^{\kappa t} \left(\frac{\bar{Y}_{full}}{\bar{K}}\right) \left(\frac{K}{\bar{K}}\right)^\alpha \left(\frac{L}{\bar{L}}\right)^\beta}{\frac{K}{\bar{K}}} - (i+\delta)P_K \\
&= \frac{\alpha(1-t)PY_{full}}{K} - (i+\delta)P_K \\
&= 0
\end{aligned} \tag{9.10}$$

The demand function for capital is thus obtained as

$$K = \frac{\alpha(1-t)PY_{full}}{(i+\delta)P_K} \tag{9.11}$$

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

$$K^*(i) = \frac{\alpha(1-t)Y^*}{i+\delta} \tag{9.12}$$

In our model desired output  $Y^*$  is represented by the variable: Aggregate Demand Forecasting (Long-run) as illustrated in Figure 9.2 (see also [28]).

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

$$I(i) = \frac{K^*(i) - K}{\text{Time to Adjust Capital}} + \delta K \tag{9.13}$$

Furthermore, let us define desired capital-output ratio as follows:

$$\theta^*(i) = \frac{K^*}{Y^*} = \frac{\alpha(1-t)}{i+\delta} \tag{9.14}$$

Then, the above investment function can be rewritten as<sup>2</sup>

$$I(i) = \frac{(\theta^*(i) - \theta)Y^*}{\text{Time to Adjust Capital}} + \delta K \tag{9.15}$$

The new investment function obtained above replaces our previous investment function in equation (7.21) that is determined by the interest rate:

$$I(i) = \frac{I_0}{i} - ai \tag{9.16}$$

where  $a$  is an interest sensitivity of investment.

<sup>2</sup>To be precise, this reformulation cannot be used as an alternative investment function without minor behavioral changes. Hence equation (9.13) is used in this model.

First order condition for profit maximization with respect to labor is calculated as follows:

$$\begin{aligned}
 \left(\frac{1}{1-t_c}\right) \frac{\partial \Pi}{\partial L} &= \beta(1-t)Pe^{\kappa t} \left(\frac{\bar{Y}_{full}}{\bar{L}}\right) \left(\frac{K}{\bar{K}}\right)^\alpha \left(\frac{L}{\bar{L}}\right)^{\beta-1} - w \\
 &= \frac{\beta(1-t)Pe^{\kappa t} \left(\frac{\bar{Y}_{full}}{\bar{L}}\right) \left(\frac{K}{\bar{K}}\right)^\alpha \left(\frac{L}{\bar{L}}\right)^\beta}{\frac{L}{\bar{L}}} - w \\
 &= \frac{\beta(1-t)PY_{full}}{L} - w \\
 &= 0
 \end{aligned} \tag{9.17}$$

Demand for labor is thus obtained as

$$L^d = \frac{\beta(1-t)PY_{full}}{w}. \tag{9.18}$$

Specifically, it is a decreasing function of real wage rate such that  $R = w/P$ .

From this demand function for labor, desired level of labor  $L^*$  could be approximately obtained by desired output  $Y^*$  and expected wage rate  $w^e$  as

$$L^*(Y^*, w^e) = \frac{\beta(1-t)PY^*}{w^e} \tag{9.19}$$

The expected wage rate is assumed to be determined as

$$w^e = w(1 + \text{inflation rate}) \tag{9.20}$$

The determination of the wage rate will be discussed in the following section.

Net employment decision is now made according to the difference between desired and actual amount of labor such that

$$E(Y^*, w^e) = \frac{L^*(Y^*, w^e) - L}{\text{Time to Adjust Labor}} \tag{9.21}$$

Net employment thus defined has a downward-sloping shape such that

$$\frac{\partial E}{\partial w^e} = -\frac{\beta(1-t)Y^*}{\text{Time to Adjust Labor}} \frac{1}{(w^e)^2} < 0. \tag{9.22}$$

The amount of wages to be paid by producers is determined by

$$W = wL \tag{9.23}$$

as illustrated in Figure 9.5.

With the above first-order conditions, profits after tax are now rewritten as

$$\begin{aligned}
 \Pi &= ((1-t)PY_{full} - (i+\delta)P_K K - wL)(1-t_c) \\
 &= ((1-t)PY_{full} - \alpha(1-t)PY_{full} - \beta(1-t)PY_{full})(1-t_c) \\
 &= (1-t)(1-t_c)(1-\alpha-\beta)PY_{full}
 \end{aligned} \tag{9.24}$$

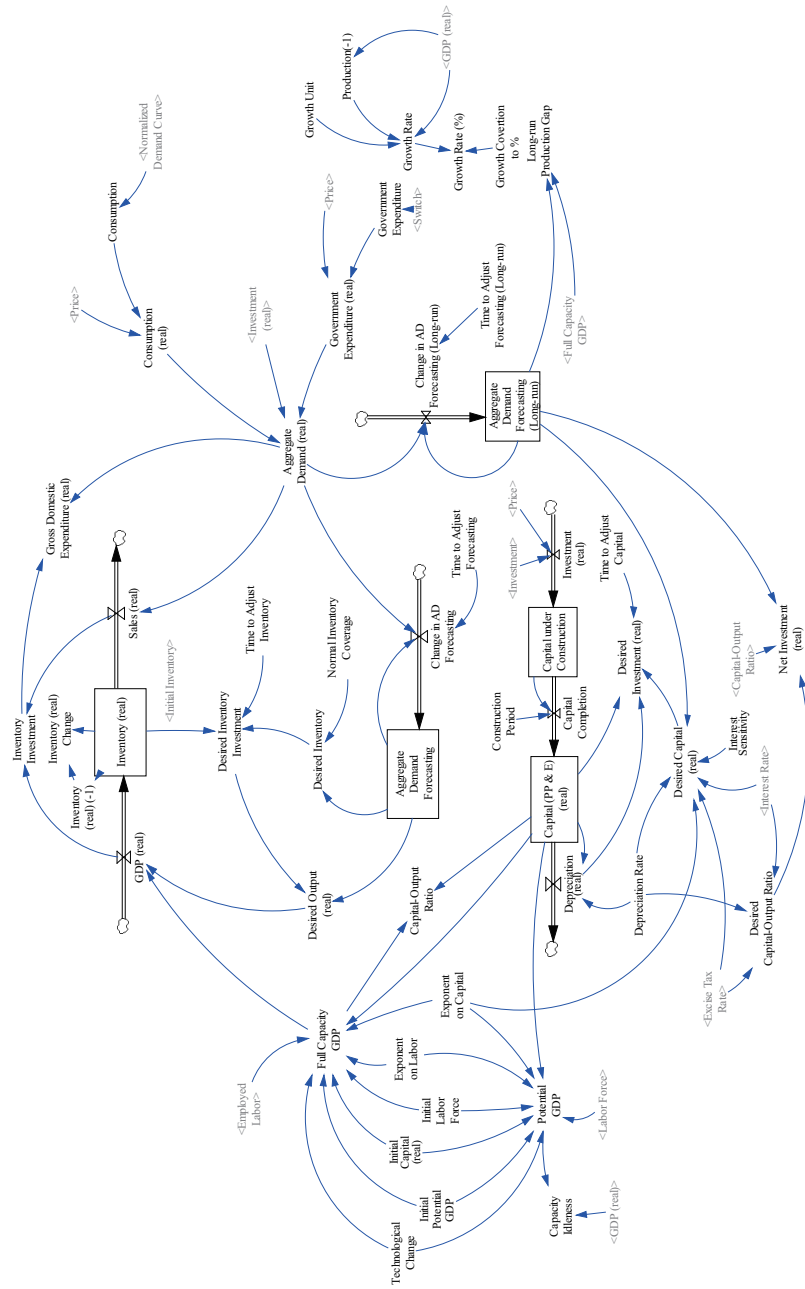


Figure 9.2: Real Production of GDP

Hence, if constant returns to scale is assumed as production technology, as often done; that is,  $\alpha + \beta = 1$ , then no profits after tax are made available, out of which dividends have to be paid to shareholders. Accordingly, a diminishing returns to scale is assumed in our model; that is,  $\alpha = 0.4$  and  $\beta = 0.5$  so that  $\alpha + \beta < 1$ .

## 9.3 Population and Labor Market

### Labor Market and Wage Rate Adjustment

So far labor demand is assumed to be fully met as the equation (9.21) 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<sup>3</sup>. 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 9.3. 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:

$$\frac{dw}{dt} = \phi(L^* - L^s) \quad (9.25)$$

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 (9.18).

Let us further specify the wage rate equation, as in the interest rate and price equations, as follows:

$$\frac{dw}{dt} = \frac{w^* - w}{\text{DelayTime}} \quad (9.26)$$

where the desired wage rate  $w^*$  is obtained as

$$w^* = \frac{w}{\left(\frac{L^s}{L^*}\right)^e} \quad (9.27)$$

where  $e$  is a labor ratio elasticity.

These features are reflected in Figure 9.4.

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<sup>3</sup>Vensim version of the World3 model is provided in the vendor's sample models by Ventana Systems, Inc.

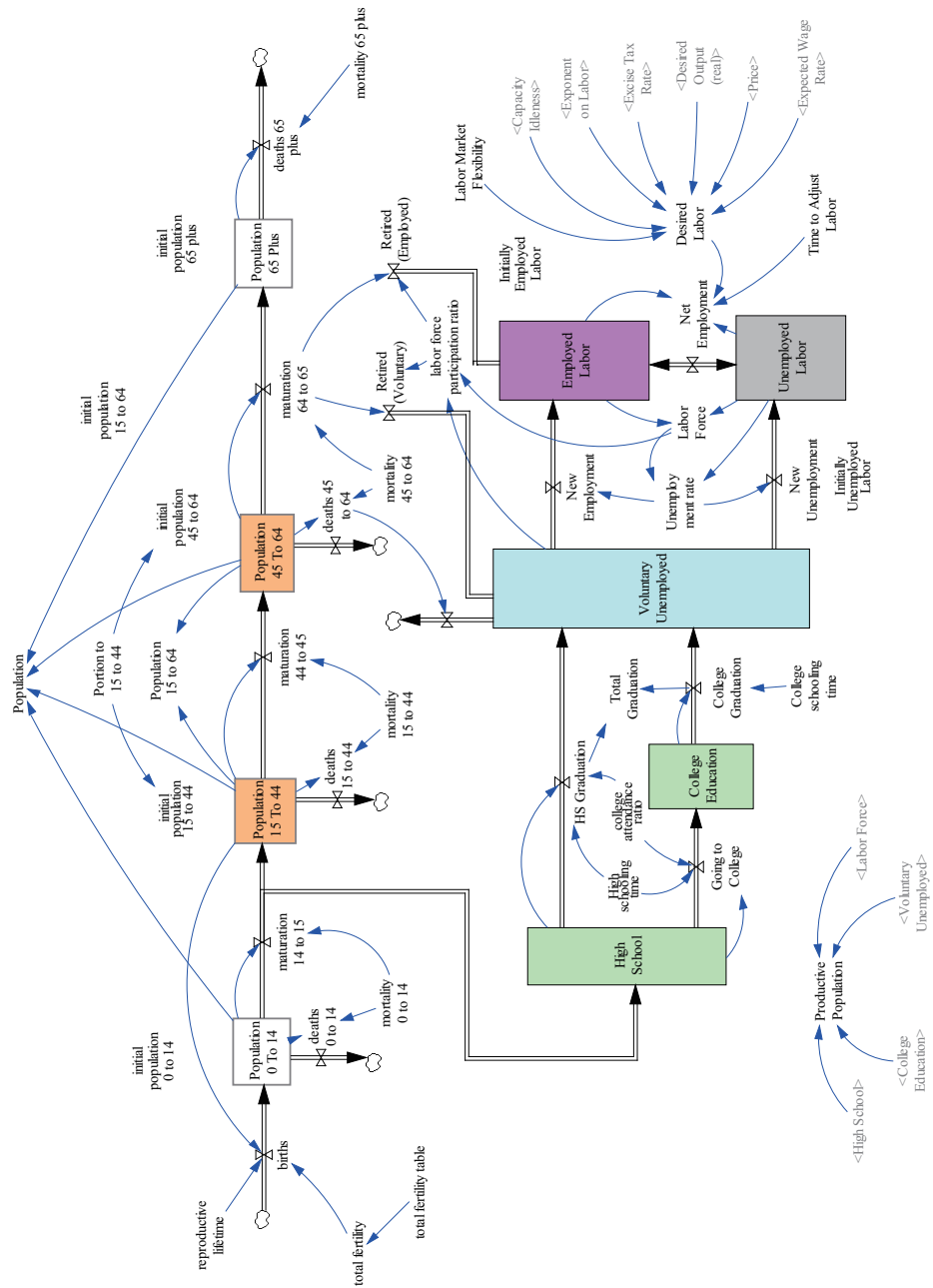


Figure 9.3: Population and Labor Market



### Price Adjustment by Cost-push Force

In the model, price is assumed to be adjusted by the demand-pull forces generated by discrepancies between desired aggregate demand and potential GDP, and between inventory gap such that

$$\frac{dP}{dt} = \Psi(Y^D - Y_{potential}, I_{inv}^* - I_{inv}). \quad (9.28)$$

With the introduction of wage determination in equation (9.26), 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

$$w_g = \frac{d \log(w)}{dt} \quad (9.29)$$

The price adjustment process is now influenced by demand-pull and cost-push forces as well such that

$$\frac{dP}{dt} = \Psi_1(Y^D - Y_{potential}, I_{inv}^* - I_{inv}) + \Psi_2(w_g) \quad (9.30)$$

Figure 9.4 illustrates our revised model for adjustment processes of price and wage rate as well as interest rate.

## 9.4 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 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.
- 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.



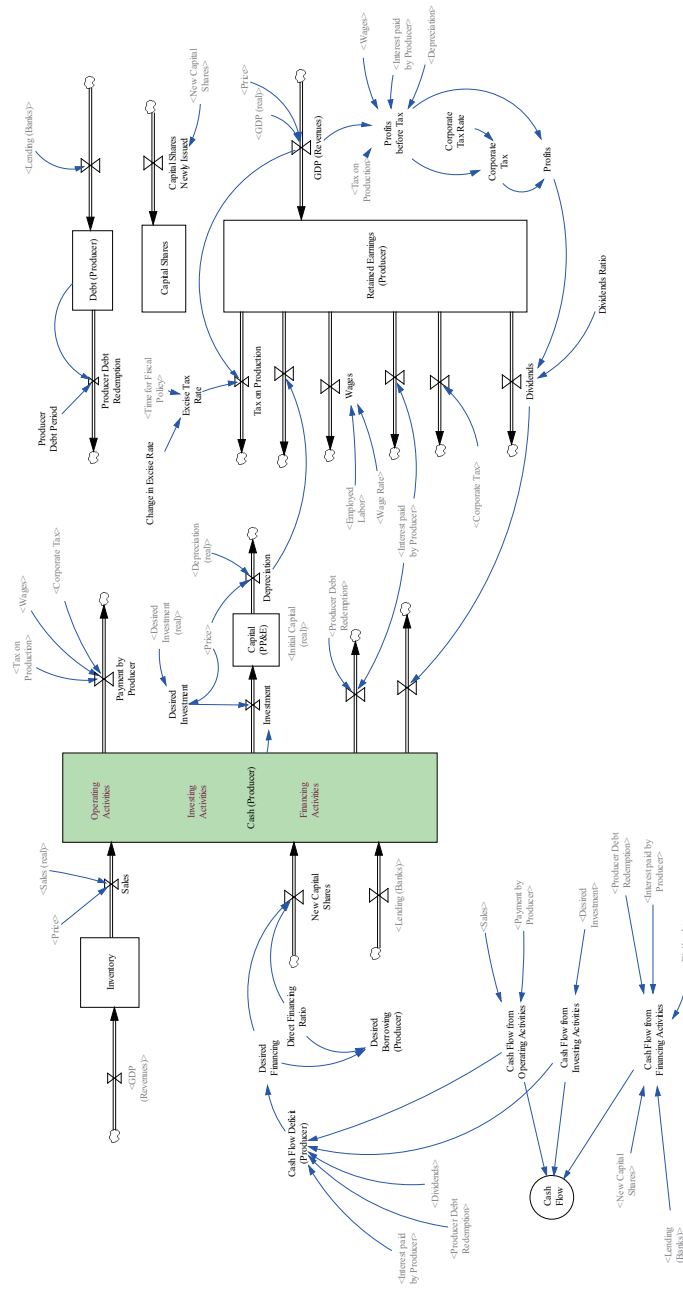


Figure 9.5: Transactions of Producers



## Consumers

Transactions of consumers are illustrated in Figure 9.6, 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 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.

## 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.

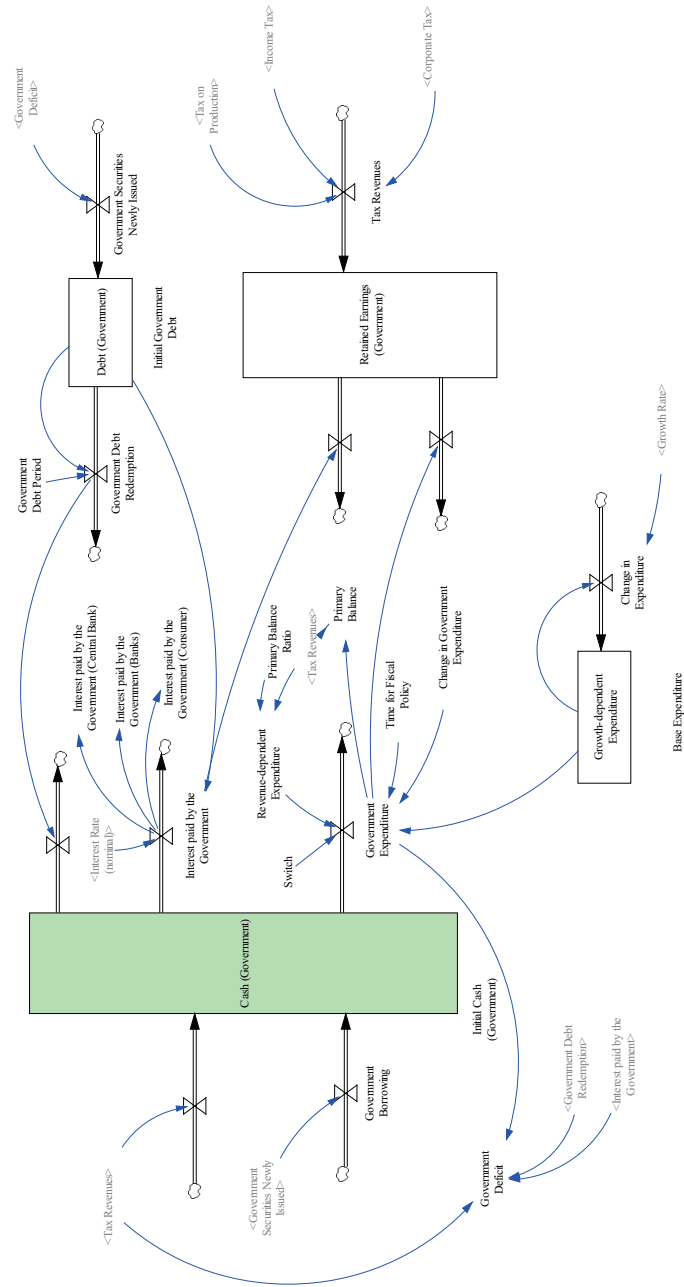


Figure 9.7: Transactions of Government

- They are obliged to deposit a portion of the deposits as the required reserves with the central bank (which is called *a fractional banking system*).
- Out of the remaining deposits they purchase government securities, against which interests are paid from the government.
- Then, loans are made to producers and they receive interests for which a prime rate is applied.
- Their retained earnings thus become interest receipts from producers and government less interest payment to consumers. Positive earning will be distributed among bank workers as consumers.

### Central Bank

In this complete macroeconomic model, the central bank plays a very important role of providing a means of transactions and store of value; that is, money or currency. To make a story simple, its sources of assets against which currency is issued are confined to gold, loan and government securities. In short, money is mostly issued as debt by the government and commercial banks. The central bank can control the amount of money supply 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, 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 supply through monetary policies such as open market operations, reserve ratio and discount rate.

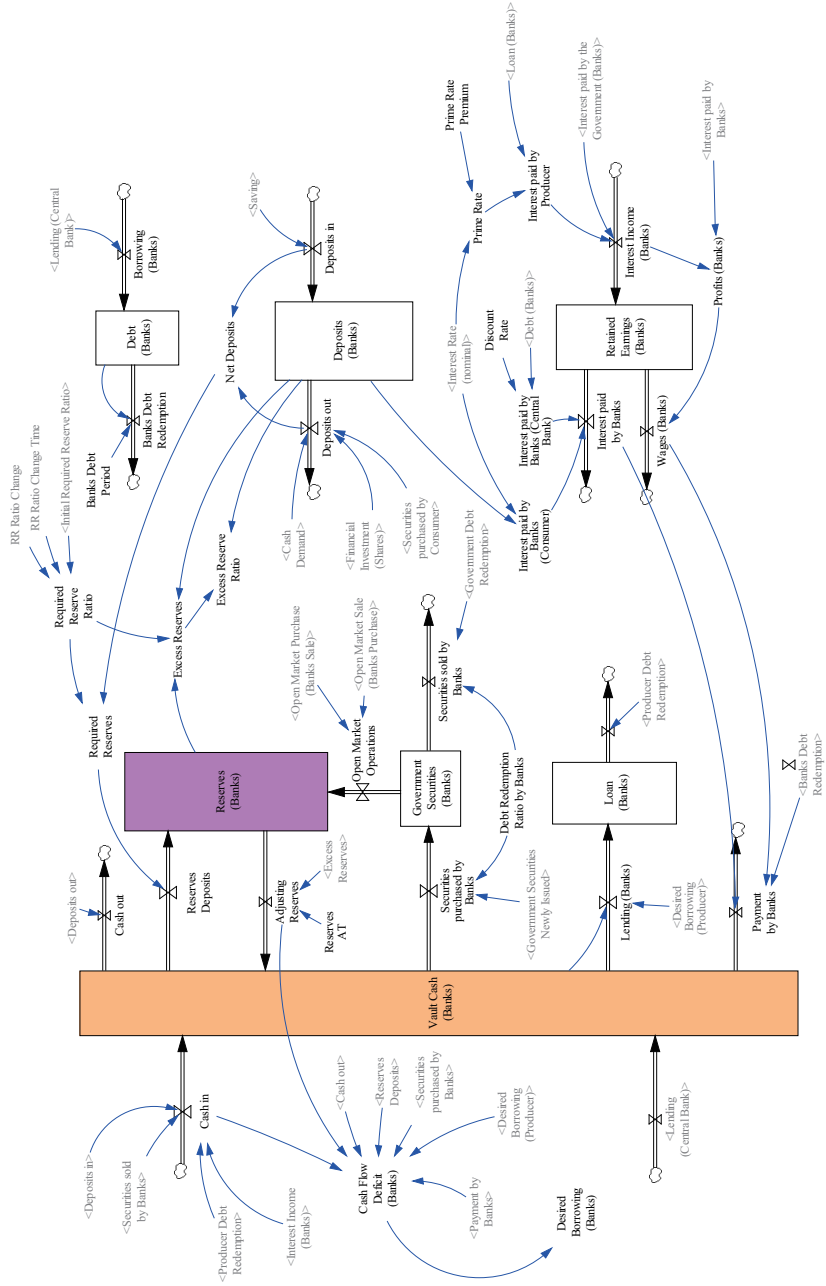


Figure 9.8: Transactions of Banks



- 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.)

## 9.5 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 aggregate demand equilibrium* if the following three output and demand levels are met:

$$\text{Full Capacity GDP} = \text{Desired Output} = \text{Aggregate Demand} \quad (9.31)$$

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

$$\text{GDP} = \text{MIN} (\text{Full Capacity GDP}, \text{Desired Output} ) \quad (9.32)$$

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

$$\text{Potential GDP} = \text{Full Capacity GDP} \quad (9.33)$$

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

$$\text{GDP Gap Ratio} = \frac{Y_{\text{potential}} - \text{GDP}}{Y_{\text{potential}}} \quad (9.34)$$

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 9.10.

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 9.11 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.



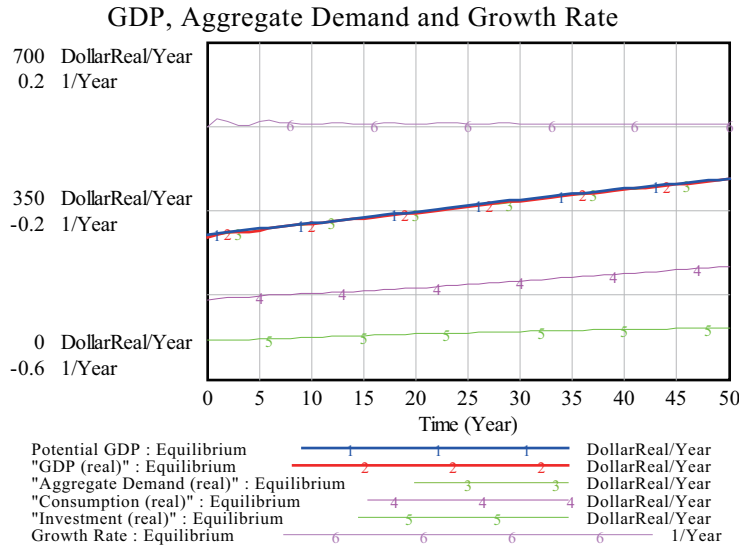


Figure 9.10: Mostly Equilibrium States

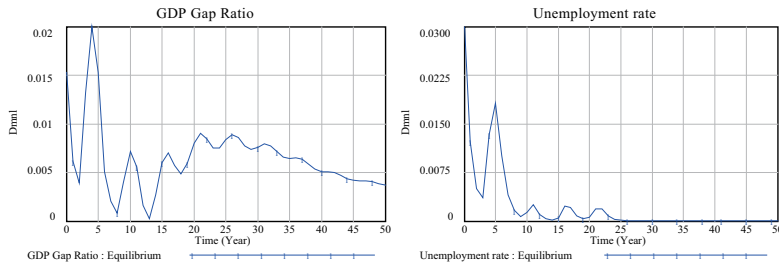


Figure 9.11: GDP Gap Ratio and Unemployment Rate of the Equilibrium States

### 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 9.12 illustrates how fixprice causes to expand GDP gap to 17% at the year 50. Right-hand diagram shows the unemployment rate fluctuates with its peak of 3.8% at the year 7. In this way under fixprice the economy seems to stagger.

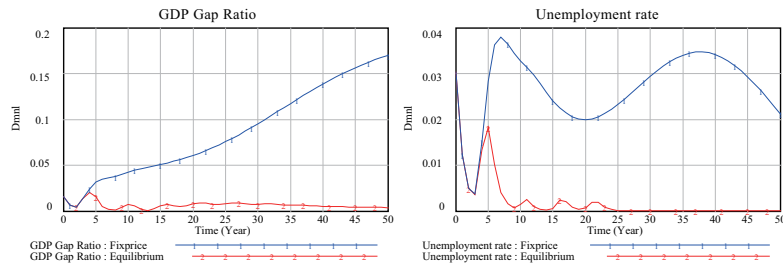


Figure 9.12: Fixprice and Mostly Equilibrium States

### Business Cycles by Inventory Coverage

From now on, let us start our analyses with the mostly equilibrium path. One of the interesting questions is to find out a macroeconomic structure that may produce economic fluctuations or business cycles. How can the mostly equilibrium growth path be broken and business cycles will be triggered?

Our complete macroeconomic model can successfully produce at least two different ways of causing macroeconomic fluctuations as in the previous chapter; that is, changes in inventory coverage and price fluctuation. Firstly, they can be caused by increasing normal inventory coverage period. Specifically, suppose the normal inventory coverage now increases to 0.5 or 6 months instead of the initial value of 0.1 or 1.2 month. The economy, then, begins to be troubled with short period's business cycles of 6 or 7 years as Figure 9.13 portrays.

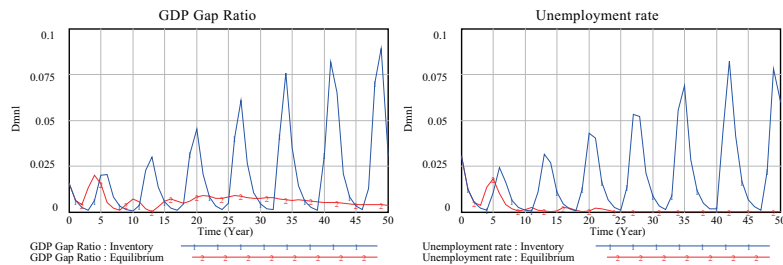


Figure 9.13: Business Cycles caused by Inventory Coverage

### Business Cycles by Elastic Price Fluctuation

Secondly, the equilibrium growth path can also be broken and business cycle is triggered, in a totally different fashion, by price fluctuation. Price can be fluctuated by changes in its elasticity and cost-push factor such as changes in wage rate. Let us consider the former first by assuming that a price response to the excess demand for products becomes more sensitive so that output ratio

elasticity now becomes elastic with a value of 1.6 from 1, and a weight of inventory ratio to the effect on price becomes 0.6 from 0.1. Again, the economy is thrown into business cycle as depicted in Figure 9.14.

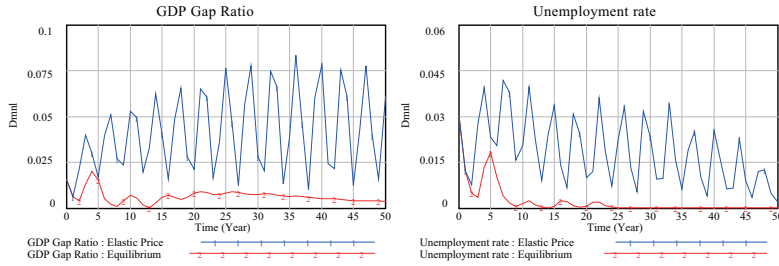


Figure 9.14: Business Cycles caused by Elastic Price Fluctuation

### Business Cycles by Cost-push Price

Since price adjustment process is revised in equation (9.30), 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 9.15.

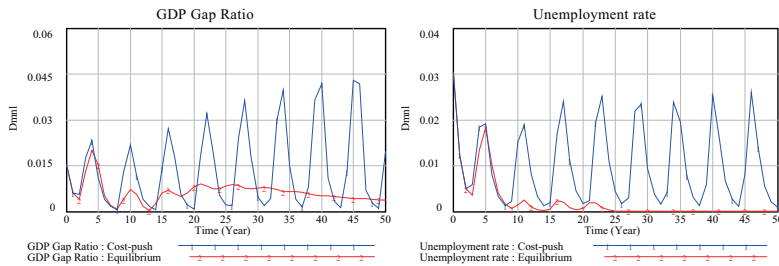


Figure 9.15: Business Cycles caused by Cost-push Price

It would be worth examining this case of business cycle furthermore. Figure 9.16 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



Figure 9.16: 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 9.17).

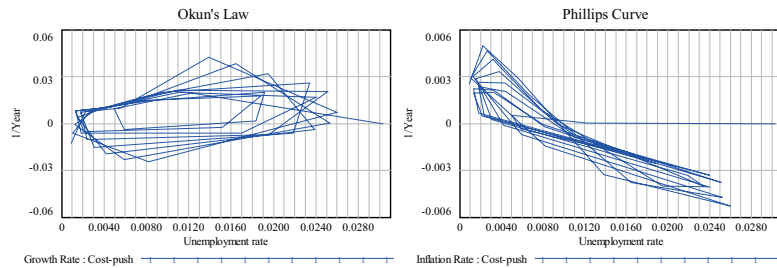


Figure 9.17: Okun's Law and Phillips Curve

In this way, two similar business cycles are triggered, out of the same almost equilibrium growth path, by two different causes; one by an increase in inventory coverage period, and the other by the price and wage changes. The ability to produce these different behaviors of business cycles and economic fluctuations indicates a richness of our macroeconomic generic model.

### Recessions by Credit Crunch (Window Guidance)

With the introduction of discount credit loans to banks, the central bank seems to have acquired an almighty power to control credit. The power has been overlooked in standard textbooks. This hidden exerting power has been known in Japan as “window guidance”.

To demonstrate how influential the power is, let us suppose that the central bank reduces the amount of discount credit loans by 30%; that is, window guidance value is reduced to 0.7 from 1. In other words, banks can borrow only 70% of the desired amount of borrowing from the central bank.

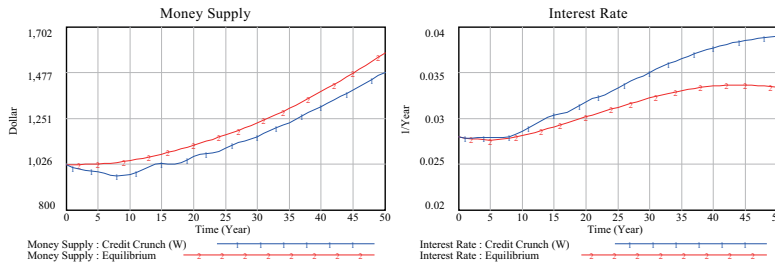


Figure 9.18: Money Supply and Interest Rate by Credit Crunch

Figure 9.18 illustrates how money supply shrinks and, accordingly, interest rate increases by the credit crunch caused by the central bank. Figure 9.19

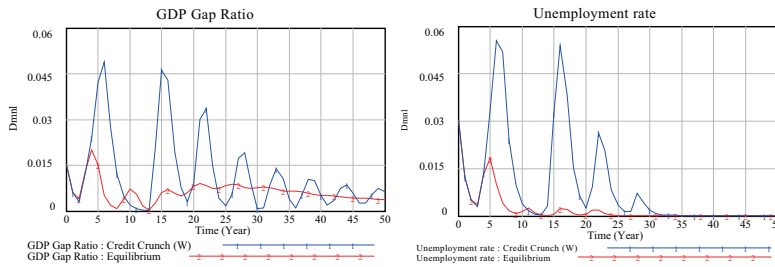


Figure 9.19: Economic Recessions caused by Credit Crunch

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  $-1.94\%$  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 9.20 illustrates how currency in circulation jumps (line 3) and deposits plummets (line 3), compared with equilibrium states (lines 2) and credit crunch (lines 1).

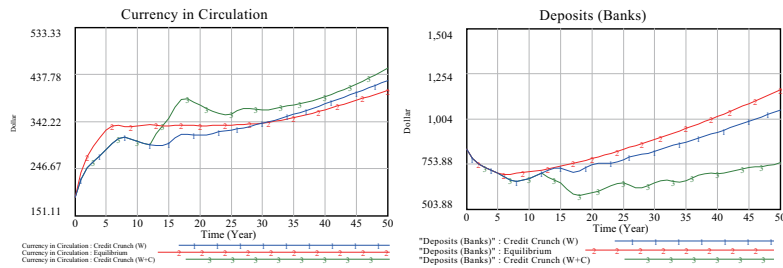


Figure 9.20: Currency in Circulation and Deposits by Bank Run

These changes affect overall behavior of money supply, specifically it is decreased as indicated by the left diagram of Figure 9.21 (line 3), which in turn worsens the GDP growth and causes depressions as shown by the right diagram of Figure 9.21 (line 3).

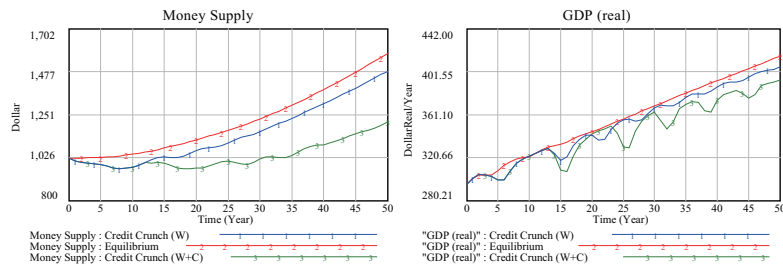


Figure 9.21: Money Supply and Depression by Bank Run

GDP gap ratio jumps to  $8.5\%$  at the year 16 from  $4.6\%$  caused by the previous recession at the year 15 as illustrated in the left diagram of Figure 9.22 (line 3). Meanwhile, unemployment rate reaches to  $9.9\%$  at the year 16 from the previous recession of  $5.4\%$  at the same year as shown in the right



diagram of Figure 9.22 (line 3). Indeed, these recessions are appropriately called *Depression*.

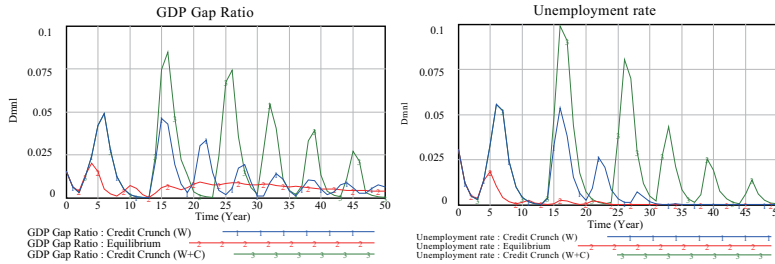


Figure 9.22: Depression by Bank Run

As already discussed in the previous chapter, during the Great Depression in 1930s, currency in circulation continued to increase from 4.52 \$ billion in 1930 to 5.72 \$ billion in 1933, while demand deposits continued to decline from 22.0 \$ billion to 14.8 \$ billion during the same period. As a result, money supply 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 9.23). Then, money supply continues to grow gradually, and interest rate eventually starts to decrease (see top right diagram.). These changes in the monetary sector will eventually restore full capacity GDP at the year 22 through the year 39 for 18 years, and almost full employment equilibria from the year 20 through the year 39 for 20 years. (see the bottom two diagrams).

Second scenario of restoring the equilibrium is to apply fiscal policy. In our model quite a few tools are available for fiscal policy such as changes in income tax rate, lump-sum taxes, excise rate, corporate tax rates and government expenditures. We employ here income tax rate. The reader can try other policy tools by running the model.

Facing the fixprice disequilibria, the government now decides to introduce an increase in income tax rate by 5%; that is, from the original 10% to 15 %,

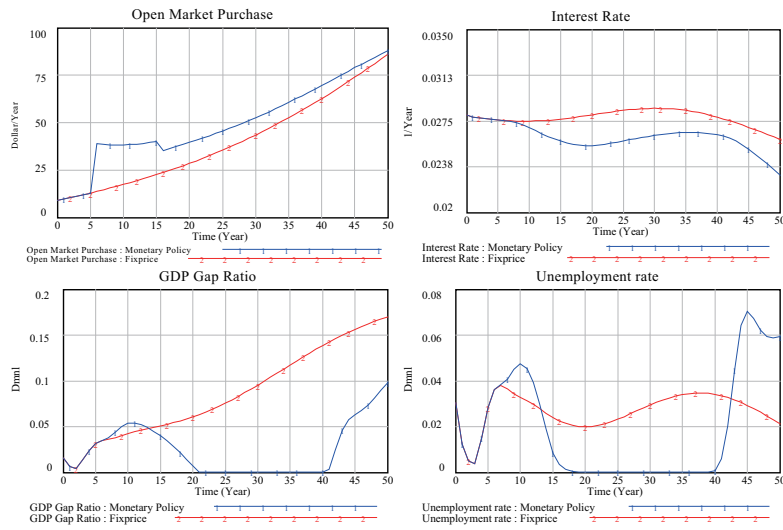


Figure 9.23: Monetary Policy of Open Market Purchase and GDP

at the year 15. Under the assumption of balanced budget, or a unitary primary balanced ratio, an increase in income tax also becomes the same amount of increase in government expenditure (see top left hand diagram in Figure 9.24).

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 9.24, government debt continues to accumulate as the left diagram of Figure 9.25 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

$$\text{Deficit} = \text{Tax Revenues} - \text{Expenditure} - \text{Debt Redemption} - \text{Interest} \quad (9.35)$$

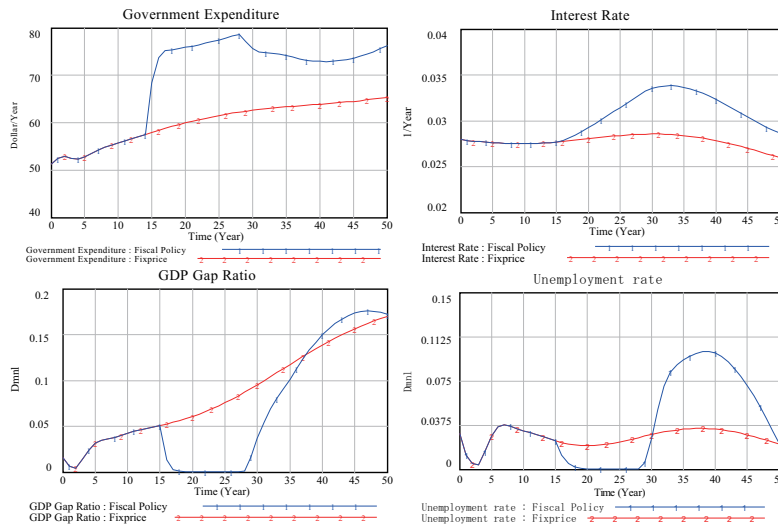


Figure 9.24: Fiscal Policy of a Change in Income Tax Rate and GDP

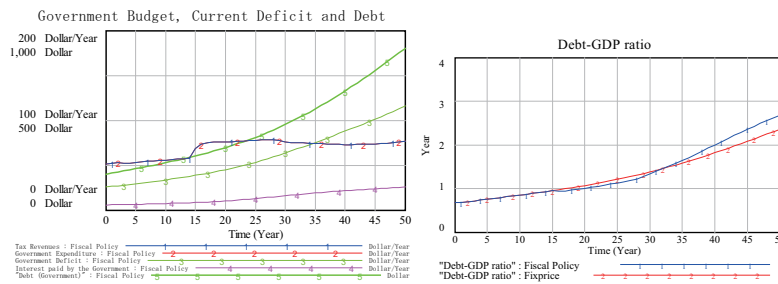


Figure 9.25: Accumulation of Government Debt

Therefore, even if balanced budget is maintained, the government still has to keep paying its debt redemption and interest. This is why it has to keep borrowing and accumulating its debt, a negative side of exponential growth in the current financial system. Initial GDP in the model is obtained to be 295, while government debt is initially set to be 200. Hence, the initial debt-GDP ratio is around 0.68 year (a little bit higher than the current ratios among EU countries). The ratio continues to increase to 2.7 years at the year 50 in the model as illustrated in the right diagram of Figure 9.25. 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<sup>4</sup>.

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 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 9.26, debt-GDP ratio will be reduced to around one (right diagram) and the accumulation of debt will be eventually curved (left diagram).

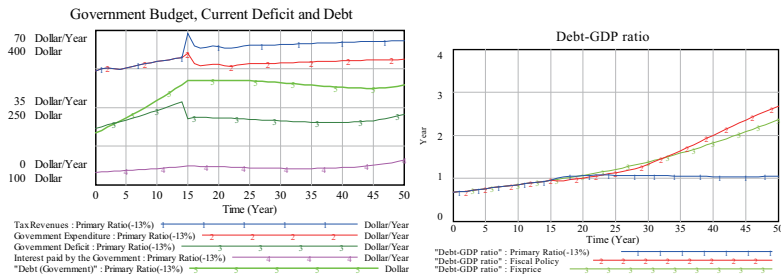


Figure 9.26: Government Debt Deduction

Even so, this radical financial reform becomes very costly to the government and its people as well. At the year of the implementation of 13 % reduction of a primary balance ratio, growth rate is forced to drop to minus 4.86%, and

<sup>4</sup>This feedback loop from the accumulating debt to the higher interest rate is not yet fully incorporated in the model.

the economy fails to sustain a full capacity and full employment equilibrium as illustrated by line 1 in Figure 9.27. In fact, GDP gap ratio continues to rise to 30% and unemployment rate peaks to 15.5% at the year 22. In other words, the reduction of the primary balance ratio by 13% totally nullifies the attained full capacity and full employment equilibrium by fiscal policy. The same diagrams compare three states of GDP; line 3 is when price is fixed, line 2 is when fiscal policy is applied, and line 1 is when primary balance ratio is reduced by 13%.

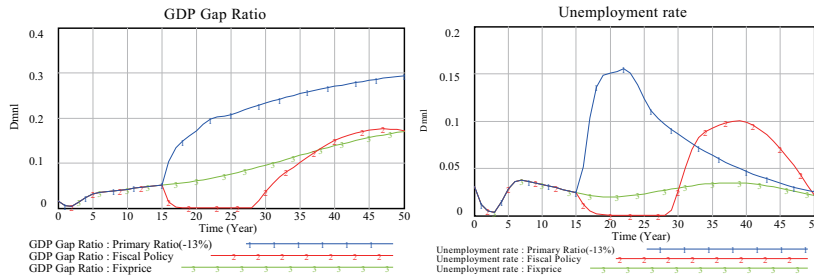


Figure 9.27: Effect of Government Debt Deduction

### 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 9.28 shows that GDP gap ratio is again reduced to be below 0.1, while right diagram (line 1) shows that unemployment rate gradually gets reduced to zero.

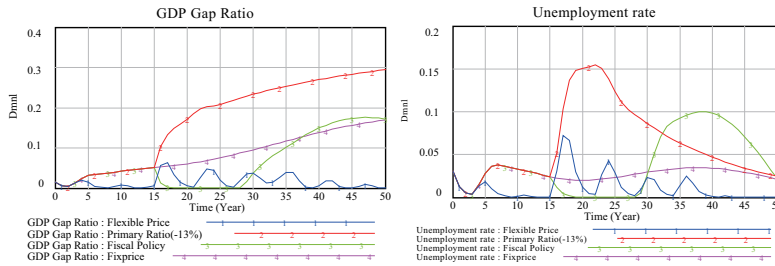


Figure 9.28: GDP Gap and Unemployment Rate under Price Flexibility

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 9.29 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.

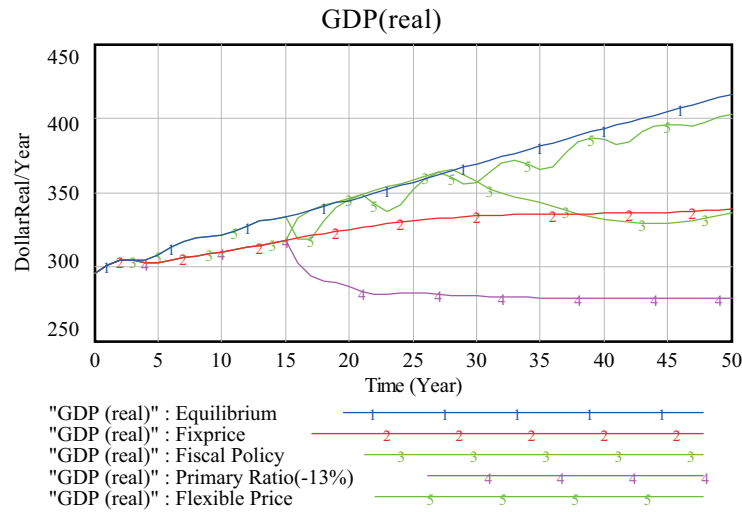


Figure 9.29: Comparison of GDP paths

## 9.6 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.