Part III

Open Macroeconomic Systems of Debt Money

Chapter 10

Balance of Payments and Foreign Exchange

This chapter[1] explores a dynamic determination process of foreign exchange rate in an open macroeconomy in which goods and services are freely traded and financial capital flows efficiently for higher returns. For this purpose it becomes necessary to employ a new method contrary to a standard method of dealing with a foreign sector as adjunct to macroeconomy; that is, an introduction of another macroeconomy as a foreign sector. Within this new framework of open macroeconomy, transactions among domestic and foreign sectors are handled according to the principle of accounting system dynamics, and their balance of payments is attained. For the sake of simplicity of analyzing foreign exchange dynamics, macro variables such as GDP, its price level and interest rate are treated as outside parameters. Then, eight scenarios are produced and examined to see how exchange rate, trade balance and financial investment, etc. respond to such outside parameters. To our surprise, expectations of foreign exchange rate turn out to play a crucial role for destabilizing trade balance and financial investment. The impact of official intervention on foreign exchange and a path to default is also discussed.

10.1 Open Macroeconomy as a Mirror Image

As a natural step of the research, we are now in a position to open our macroeconomy to a foreign sector so that goods and services are freely traded and financial assets are efficiently invested for higher returns. The analytical method employed here is the same as the previous chapters; that is, the one based on the principle of accounting system dynamics.

[1]It is based on the paper: Balance of Payments and Foreign Exchange Dynamics – SD Macroeconomic Modeling (4) – in "Proceedings of the 24th International Conference of the System Dynamics Society", Boston, USA, July 29 - August 2, 2007. (ISBN 978-0-9745329-8-1)

The method requires to manipulate all transactions among macroeconomic sectors, and when applied to a foreign sector, it turns out to be necessary to introduce another macroeconomy as a reflective image of domestic macroeconomy. Contrary to a method employed in standard international economics textbooks such as [44] and [47], a foreign sector is no longer treated as an additional macroeconomic sector adjunct to a domestic macroeconomy [Companion Model: ForeignExchange.vpm].

To understand this, for instance, consider a transaction of importing goods. They add to the inventory of importers (a red disk numbered 1 in Figure 10.2 below), while the same amount is reduced from the inventory of foreign exporters (a red disk numbered 4 in Figure 10.3 below). To pay for the imported goods, importers withdraw their deposits from their bank and purchase foreign exchange, (red disks numbered 2 and 3 in Figures 10.2 and 10.5 below), which is then sent to the deposit account of foreign exporters' bank that will notify the receipts of export payments to exporters (red disks numbered 3 and 4 in Figures 10.6 and 10.3 below). In this way, a mirror image of domestic macroeconomy is needed for a foreign country as well to describe even domestic transaction processes of goods and services. Similar manipulations are also needed for the transactions of foreign direct and financial investment. Figure 10.1 expresses our image of modeling open macroeconomy by the principle of accounting system dynamics.

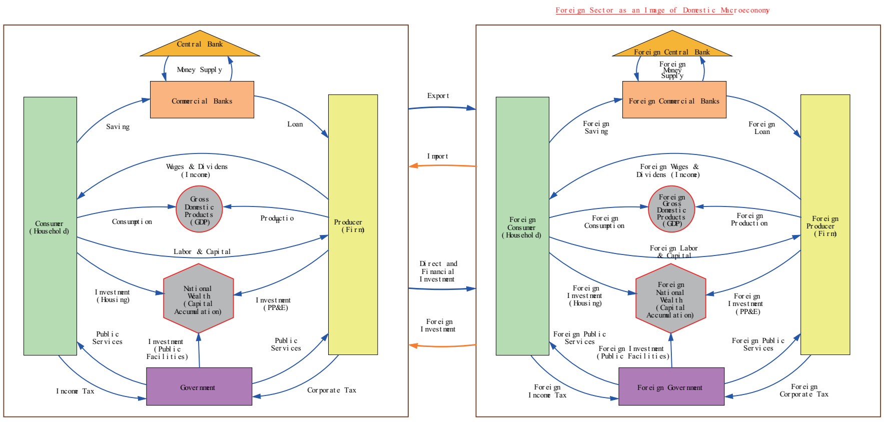

Figure 10.1: Foreign Sector as a Mirror Image of Domestic Macroeconomy

10.2 Open Macroeconomic Transactions

Modeling open macroeconomy was hitherto considered to be easily completed by merely adding a foreign sector. The introduction of a foreign country as a mirror image of domestic macroeconomy makes our analysis rather complicated. To overcome the complexity, we are forced, in this chapter, to focus only on a mechanism of the transactions of trade and foreign investment in terms of the balance of payments and dynamics of foreign exchange rate. For this purpose, transactions among five domestic sectors and their counterparts in a foreign country are simplified as follows.

Producers

Major transactions of producers are, as illustrated in Figure 10.2, summarized as follows.

- GDP (Gross Domestic Product) is assumed to be determined outside the economy, and grows at a growth rate of 2% annually.

- Producers are allowed to make direct investment abroad as well as financial investment out of their financial assets consisting of stocks, bonds and cash[2], and receive investment income from these investment abroad. Meanwhile, they are also required to pay foreign investment income (returns) to foreign investors according to their foreign financial liabilities and equity.

- Producers now add net investment income (investment income received less paid) to their GDP revenues (the added amount is called GNP (Gross National Product)), and deduct capital depreciation (the remaining amount is called NNP (Net National Product)).

- NNP thus obtained is completely paid out to consumers, consisting of workers and shareholders, as wages to workers and dividend to shareholders.

- Producers are thus constantly in a state of cash flow deficits. To make new investment, therefore, they have to borrow money from banks, but for simplicity no interest is assumed to be paid to the banks.

- Producers imports goods and services according to their economic activities, the amount of which is assumed to be 10% of GDP in this chapter.

- Similarly, their exports are determined by the economic activities of a foreign country, the amount of which is also assumed to be 10% of foreign GDP.

- Foreign producers are assumed to behave similarly as a mirror image of domestic producers as illustrated in Figure 10.3.

[2] In this chapter, financial assets are not broken down in detail and simply treated as financial assets. Hence, returns from financial investment are uniformly evaluated in terms of deposit returns.

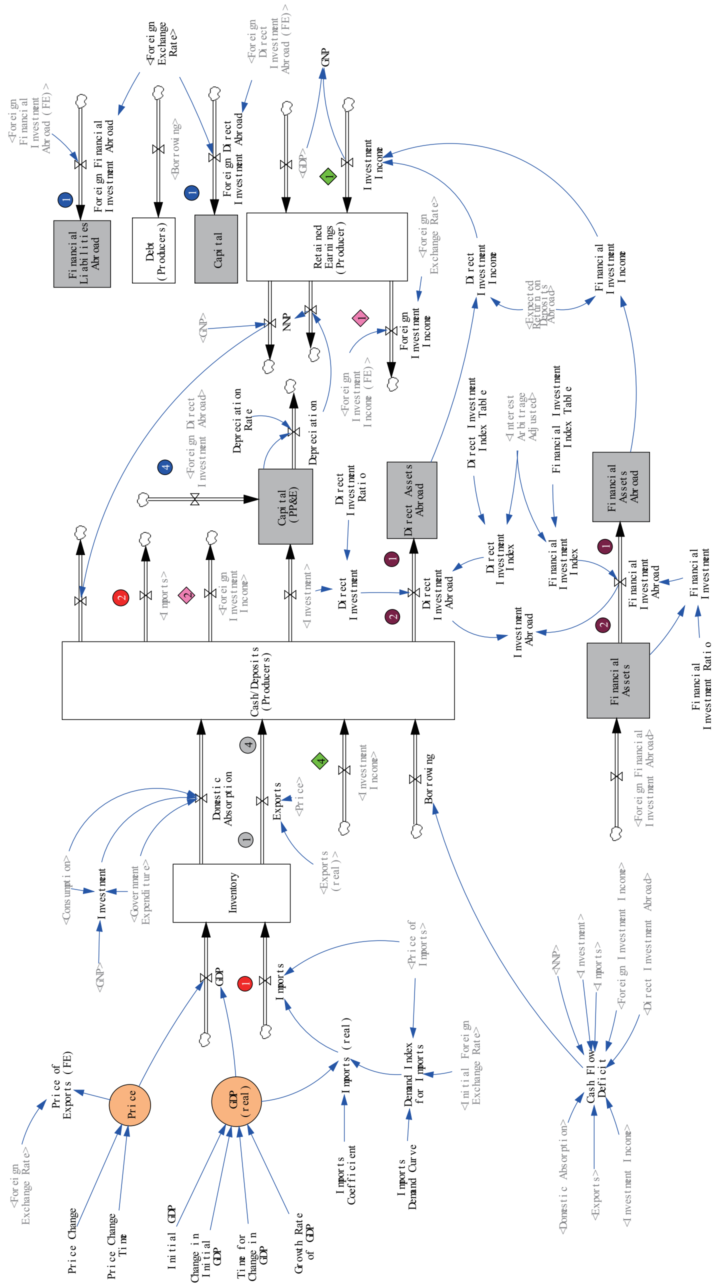

Figure 10.2: Transactions of Producers

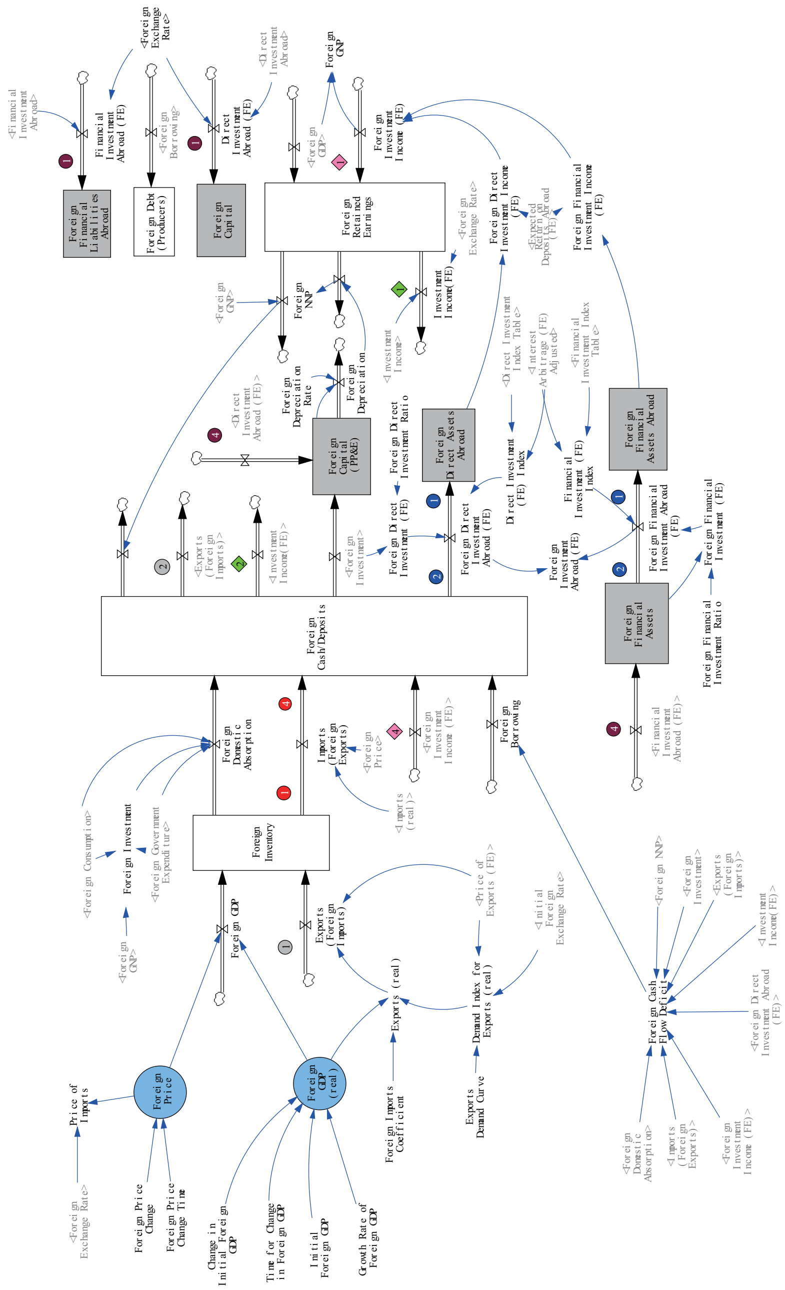

Figure 10.3: Transactions of Foreign Producers

Consumers and Government

Transactions of consumers and government are illustrated in Figure 10.4, some of which are summarized as follows.

- Consumers receive the amount of NNP as income, out of which 20% is levied by the government as income tax. The remaining amount becomes their disposable income.
- Consumers spend 60% of their disposable income and save the remaining as deposits with banks.
- Government only spends the amount it receives as income tax, and its budget is assumed to be in balance.

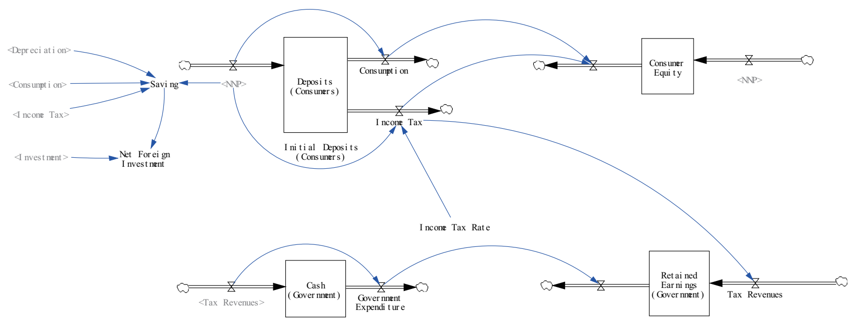

Figure 10.4: Transactions of Consumers and Government

Banks

Transactions of banks are illustrated in Figure 10.5, some of which are summarized as follows.

- Banks receive deposits from consumers and make loans to producers.
- Banks are obliged to deposit a portion of the deposits as required reserves with the central bank, but such activities are not considered in this chapter.
- Banks buy and sell foreign exchange at the request of producers and the central bank.
- Their foreign exchange are held as bank reserves and evaluated in terms of book value. In other words, foreign exchange reserves are not deposited with foreign banks. Thus net gains realized by the changes in foreign exchange rate become part of their retained earnings (or losses).

- Foreign currency is assumed to play a role of *key* currency or *vehicle* currency. Accordingly foreign banks need not set up foreign exchange account. This is a point where a mirror image of open macroeconomic symmetry breaks down, as illustrated in Figure 10.6.

Central Bank

In the integrated model of the previous chapter, the central bank played an important role of providing a means of transactions and store of value; that is, currency, and its sources of assets against which currency is issued were assumed to be gold, loan and government securities. Transactions of the central bank here are exceptionally simplified, as illustrated in Figure 10.7, so long as necessary for the analytical purpose in this chapter.

- The central bank can control the amount of money supply through monetary policies such as the manipulation of required reserve ratio and open market operations. However, such a role of money supply by the central bank is not considered here.
- The central bank is allowed to intervene foreign exchange market; that is, it can buy and sell foreign exchange to keep a foreign exchange ratio stable. These transactions are manipulated with commercial banks, which inescapably change the amount of currency outstanding and, hence, money supply. In this chapter, however, such an effect of money supply on interest rate is assumed to be out of consideration.
- Foreign exchange reserves held by the central bank is assumed to be deposited with foreign banks so that it receives interest payments.
- The central bank of foreign country is excluded simply because foreign currency is assumed to be a *vehicle* currency, and it needs not to hold foreign reserves (that is, its own currency) to stabilize its own exchange rate in this simplified open macroeconomy.

10.3 The Balance of Payments

All transactions with a foreign country such as foreign trade and foreign investment (that is, payments and receipts of foreign exchange) are booked according to a double entry bookkeeping rule, and such a bookkeeping record is called the balance of payments. According to [44] in page 295, all payments are recorded in the debit side with a minus sign, while all receipts are recorded in the credit side with plus sign. Hence, by definition, the balance of payments are kept in balance all the time. It consists of current account, capital and financial account, and net official reserve assets.

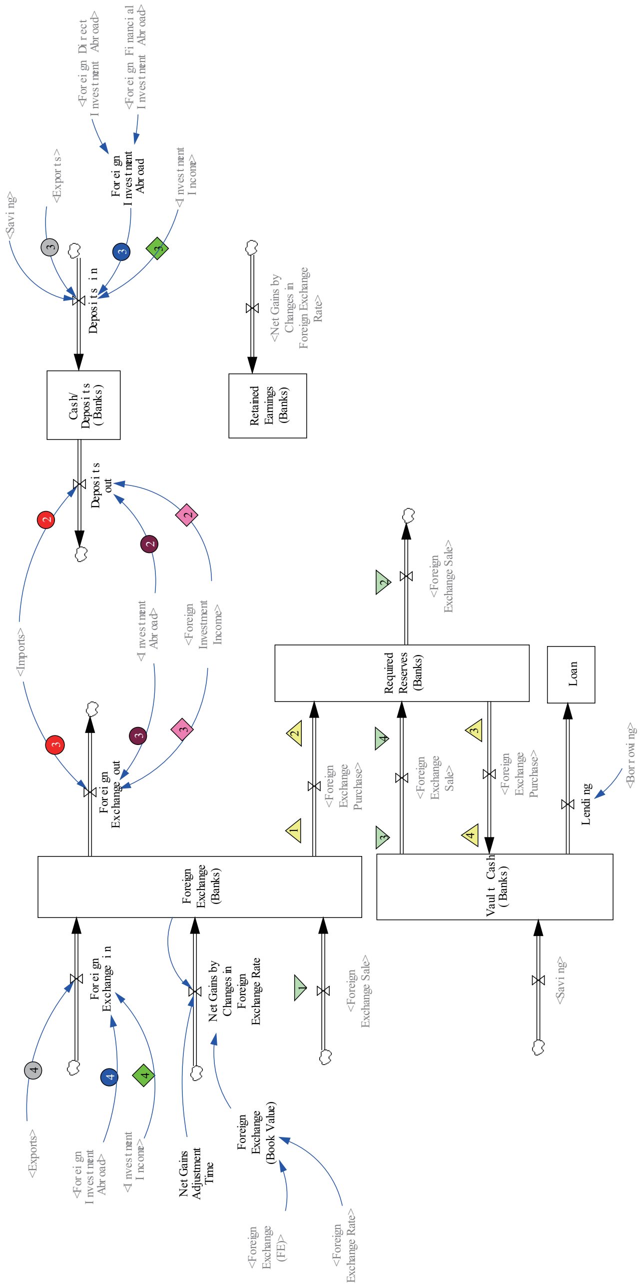

Figure 10.5: Transactions of Banks

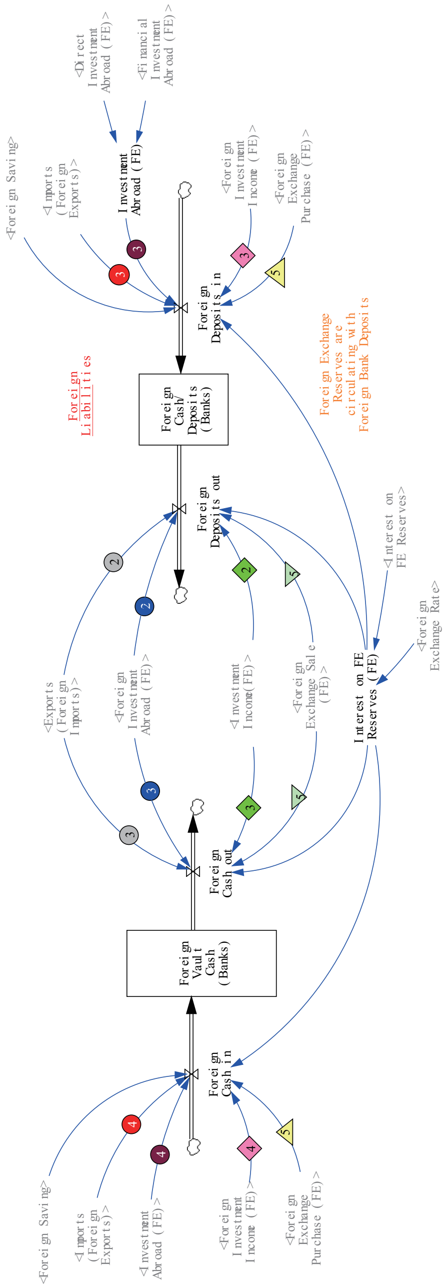

Figure 10.6: Transactions of Foreign Banks

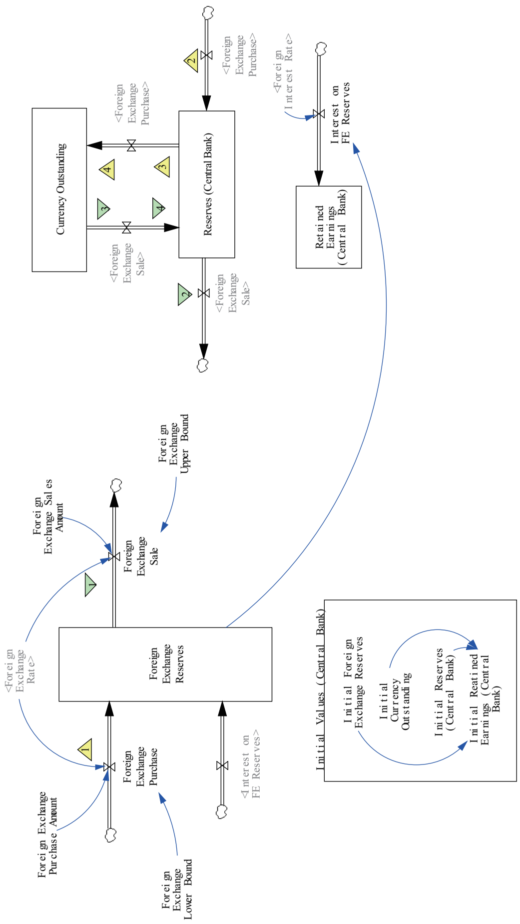

Figure 10.7: Transactions of the Central Bank

Current account consists of trade balance of goods and services and net investment income. Capital account is an one-way transfer of fund by the government that is excluded from our analysis here. Financial account consists of direct and financial foreign investment. Figure 10.8 illustrates all transactions which enter into the balance of payments account.

Figure 10.9, obtained from one of our simulation runs, displays relative positions of current account, capital and financial account, and net official reserve assets (or changes in reserve assets). A numerical value of the balance of payments is shown in the figure as being in balance all the time; that is a zero value.

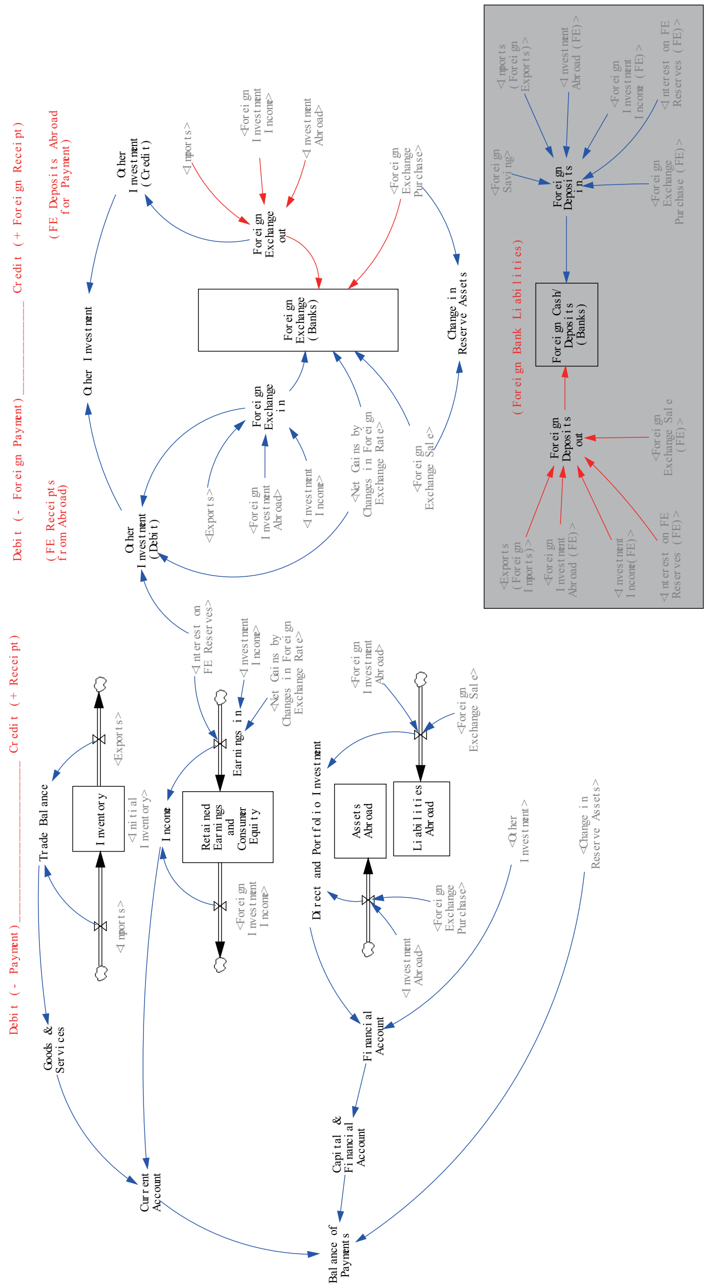

Figure 10.8: The Balance of Payments

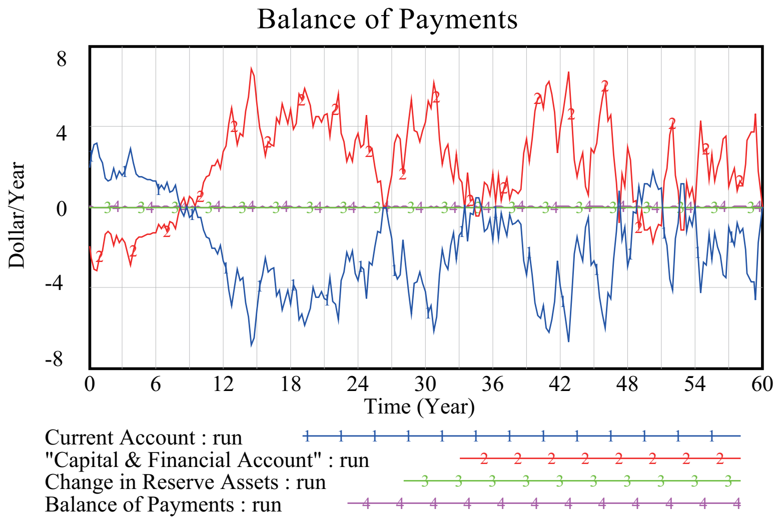

Figure 10.9: A Simulation of Balance of Payments

10.4 Determinants of Trade

Let M and X be real imports and exports, and Y and P be real GDP and its price level, respectively. Counterpart variables for a foreign country is denoted with a subscript f. A foreign exchange rate E is defined as a price of foreign currency (which has a unit of FE here) in terms of domestic dollar currency; for instance, 1.2 dollars per FE. Then, a price of imports is calculated as $P_M = P_f E$.

Imports are here simply assumed to be a function of real GDP and price of imports such that

$$M = M(Y, P_M), \text{ where } \frac{\partial M}{\partial Y} > 0 \text{ and } \frac{\partial M}{\partial P_M} < 0. \tag{10.1}$$

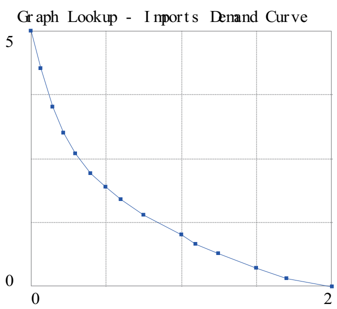

Figure 10.10: Normalized Demand Curve

This implies that imports increases as domestic economic activities, hence GDP expand, and decreases as price of imports rises as a standard downward-sloping demand curve conjectures. Figure 10.10 illustrates one of such demand curves employed in this chapter in which demand is normalized between a scale of zero and five on a vertical axis against a price level of between zero and two on a horizontal axis.

From these simple assumptions, we can

derive the following relations:

$$M = M(Y, P_M) = M(Y, P_f E), \quad (10.2)$$

$$\frac{\partial M}{\partial P_f} = \frac{\partial M}{\partial P_M}\frac{\partial P_M}{\partial P_f} = \frac{\partial M}{\partial P_M}E < 0 \quad (10.3)$$

$$\frac{\partial M}{\partial E} = \frac{\partial M}{\partial P_M}\frac{\partial P_M}{\partial E} = \frac{\partial M}{\partial P_M}P_f < 0 \quad (10.4)$$

These relations imply that imports decrease as foreign price of imports increases and/or foreign exchange rate appreciates.

In our model, imports function is further simplified as a product of imports determined by the size of GDP and a normalized demand curve such that

$$M = M(Y, P_M) = M(Y)D(P_M) = mYD(P_f E) \quad (10.5)$$

where m is a constant coefficient of imports on GDP.

Exports are nothing but imports of a foreign country, and similarly determined as a mirror image of domestic imports function such that

$$X = X(Y_f, P_{M,f}), \text{ where } \frac{\partial X}{\partial Y_f} > 0 \text{ and } \frac{\partial X}{\partial P_{M,f}} < 0. \quad (10.6)$$

This implies that exports increase as foreign economic activities, hence foreign GDP, expand, and decreases as price of imports in a foreign country rises as a standard downward-sloping demand curve conjectures.

Price of imports in a foreign country is calculated by a domestic price and foreign exchange rate such that $P_{M,f} = P/E$. Hence, we obtain the following relations:

$$X = X(Y_f, P_{M,f}) = X(Y_f, P/E), \quad (10.7)$$

$$\frac{\partial X}{\partial P} = \frac{\partial X}{\partial P_{M,f}}\frac{\partial P_{M,f}}{\partial P} = \frac{\partial X}{\partial P_{M,f}}\frac{1}{E} < 0 \quad (10.8)$$

$$\frac{\partial X}{\partial E} = \frac{\partial X}{\partial P_{M,f}}\frac{\partial P_{M,f}}{\partial E} = \frac{\partial X}{\partial P_{M,f}}(-\frac{P}{E^2}) > 0. \quad (10.9)$$

Thus, exports decrease as a domestic price rises. Meanwhile, whenever foreign exchange appreciates, our products become cheaper in a foreign country and exports increase.

Exports are similarly broken down as a product of foreign imports and normalized demand curve of foreign country, which is assumed to be exactly the same as domestic demand curve for imports.

$$X = X(Y_f, P_{M,f}) = X(Y_f)D(P_{M,f}) = m_f Y_f D(P/E) \quad (10.10)$$

where m_f is a constant import coefficient of a foreign country.

Let us define trade balance as

$$TB(E; Y, Y_f, P, P_f) = X(E; Y_f, P) - M(E; Y, P_f) \tag{10.11}$$

Then we have

$$\frac{\partial TB}{\partial Y} = -\frac{\partial M}{\partial Y} < 0, \ \frac{\partial TB}{\partial Y_f} = \frac{\partial X}{\partial Y_f} > 0, \tag{10.12}$$

$$\frac{\partial TB}{\partial P} = \frac{\partial X}{\partial P} < 0, \ \frac{\partial TB}{\partial P_f} = -\frac{\partial M}{\partial P_f} > 0. \tag{10.13}$$

$$\frac{\partial TB}{\partial E} = \frac{\partial X}{\partial E} - \frac{\partial M}{\partial E} > 0. \tag{10.14}$$

The last relation indicates that a trade balance is an increasing function of foreign exchange rate. The relation is also confirmed in our model as illustrated in the two diagrams of Figure 10.11 in which upward-sloping blue curves are obtained from our simulation runs. As an mirror image, foreign trade balance is shown to be a decreasing function of foreign exchange rate, as indicated by downward-sloping red curves.

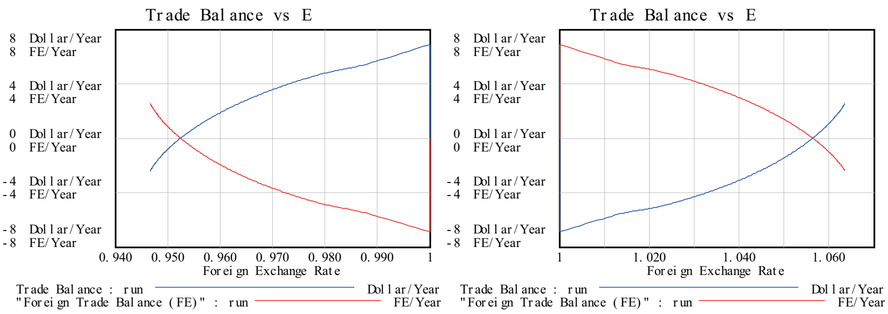

Figure 10.11: Trade Balance vs Foreign Exchange Rate

National Income Identity

Let us now briefly summarize our model in terms of national income account as follows:

$$Y = C(Y - T) + I + G + TB(E) \tag{10.15}$$

That is to say, GDP is the sum of consumption spending, investment, government expenditure and trade balance. In our model of foreign trade, investment is calculated to make this equation an identity all the time.

Private saving is defined as $S_p = Y - T - C$. Government saving is defined as $S_g = T - G$. Then national saving is obtained as a sum of these savings such that

$$S = S_p + S_g = Y - C - G, \tag{10.16}$$

which reduces to

$$S - I = TB(E). \tag{10.17}$$

Saving less investment is called net foreign investment, which is equal to trade balance. This becomes another way of describing the above national income identity in terms of net foreign investment and trade balance.

10.5 Determinants of Foreign Investment

Foreign investment consists of direct investment and financial investment such as stocks, bonds and cash, which constitute financial assets. In this chapter financial assets are not specified without losing generality as already mentioned in the footnote above. Foreign investments are here assumed to be determined on a principle of foreign exchange market efficiency under the uncovered interest rate parity (UIP) condition as explained in standard textbooks such as [44] and [57].

Let i and R be interest rate and a rate of return from financial investment, and E^e be an expected foreign exchange rate. A rate of return from a bank deposit is the same as the interest rate:

$$R = i \tag{10.18}$$

An expected return from a deposit with a foreign bank is calculated as

$$R_f = (1 + i_f)\frac{E^e}{E} - 1 \tag{10.19}$$

Thus we obtain

$$\frac{\partial R_f}{\partial E} = -\frac{(1 + i_f)E^e}{E^2} < 0 \tag{10.20}$$

$$\frac{\partial R_f}{\partial E^e} = \frac{(1 + i_f)}{E} > 0 \tag{10.21}$$

This implies that a rate of return from foreign financial investment decreases if foreign exchange rate appreciates, but it increases when foreign exchange rate is expected to appreciate.

Let us define an expected return arbitrage as

$$A(E, E^e; i, i_f) = R_f(E, E^e; i_f) - R(i) \tag{10.22}$$

and net capital flow(NCF) as

$$NCF = \text{Foreign Investment Abroad} - \text{Investment Abroad} \tag{10.23}$$

This is the amount of capital we receive from foreign country's investment less the amount we invest abroad. Under the assumption of an efficient financial market, if expected returns are greater in a foreign country and an expected return arbitrage becomes positive, then financial capital continues to outflow until the arbitrage ceases to exist. In a similar fashion, if expected returns are greater in a domestic market and an expected return arbitrage becomes negative, then financial capital continues to inflow until the arbitrage disappears. Hence, so long as a foreign exchange market is efficient, the relation between net capital flow and an expected return arbitrage become as follows:

$$\begin{cases} NCF < 0 & \text{if } A > 0 \\ NCF > 0 & \text{if } A < 0 \end{cases} \tag{10.24}$$

It is unrealistic, however, to assume an indefinite outflow of capital even if $A > 0$, or an indefinite inflow of capital even if $A < 0$. So it is assumed here that the maximum amount of direct and financial investment made available per year is a finite portion of domestic investment and financial assets. Yet, actual amount of financial investment is further assumed to be dependent on a level of an expected return arbitrage by its factor. Figure 10.12 illustrates table functions of investment levels that are assumed in our model in terms of expected return arbitrate.

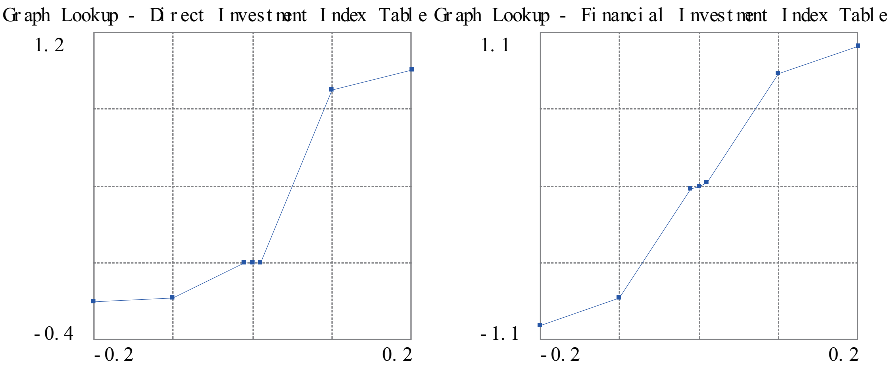

Figure 10.12: Direct and Financial Investment Indices

Specifically, left-hand diagram shows a table function of direct investment, which assumes that between the arbitrage range of -0.01 and 0.01 direct investment is not made. Right-hand diagram shows a table function of financial investment, which assumes that between the arbitrage range of -0.01 and 0.01 financial capital flows slowly between a portion of -0.02 and 0.02. These assumptions are made to reflects a realistic situation in which direct investment is not so sensitive to the arbitrage values compared with financial investment.

In this way net capital flow could be described as a function of an expected return arbitrage such that

$$NCF = NCF(A(E, E^e)), \text{ where } \frac{\partial NCF}{\partial A} < 0 \tag{10.25}$$

It is important to note, however, that this functional relation holds only in the neighborhood of equilibrium, so do the following relations as well.

$$\frac{\partial NCF}{\partial E} = \frac{\partial NCF}{\partial A}\frac{\partial A}{\partial E} = \frac{\partial NCF}{\partial A}\frac{\partial R_f}{\partial E} > 0 \tag{10.26}$$

$$\frac{\partial NCF}{\partial E^e} = \frac{\partial NCF}{\partial A}\frac{\partial A}{\partial E^e} = \frac{\partial NCF}{\partial A}\frac{\partial R_f}{\partial E^e} < 0 \tag{10.27}$$

Whenever a foreign exchange rate begins to appreciate, an expected return arbitrage declines, and capital begins to inflow, causing a positive net capital flow. When foreign exchange rate is expected to appreciate, an expected return arbitrage increases and capital begins to outflow, causing a negative net capital flow. In this way, changes in a foreign exchange rate and its expectations play a crucial role for financial investment.

It is examined in our model that these relations only hold in the neighborhood of equilibrium. In Figure 10.13, net capital flow is shown to be an

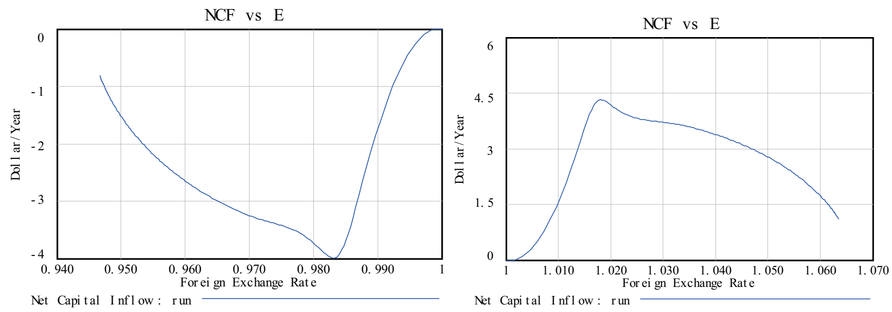

Figure 10.13: Net Capital Inflow vs Foreign Exchange Rate

increasing function only when a foreign exchange rate is around the equilibrium; that is, between 0.983 and 1.018. This may indicate a limitation of the above mathematical method of economic analysis which has been dominantly used in many textbooks. In other words, mutually interdependent economic behaviors cannot be fully captured unless they are simulated in a system dynamics model such as the one in this chapter.

10.6 Dynamics of Foreign Exchange Rates

How are the foreign exchange rate and its expectations determined, then? Foreign exchange rate is here simply assumed to be determined by the excess demand for foreign exchange; that is, a standard logic of price mechanism in economic theory. From the left-hand diagram of Figure 10.8, demand for foreign exchange is shown to stem from the need for payments due to imports, direct and financial investment abroad, and foreign investment income, as well as foreign exchange purchase by the central bank. Supply of foreign exchange results from the receipts from foreign country due to exports, foreign direct and financial investment abroad, and investment income from abroad, as well as foreign exchange sale by the central bank.

Hence, excess demand for foreign exchange is calculated as follows:

$$\begin{aligned}
& \text{Excess Demand for Foreign Exchange} \\
= \; & \text{Imports - Exports} \\
& + \text{Investment Abroad - Foreign Investment Abroad} \\
& + \text{Foreign Investment Income - Investment Income} \\
& + \text{Foreign Exchange Purchase - Foreign Exchange Sale} \\
= \; & - \text{Trade Balance } (TB) \\
& - \text{Net Capital Flow } (NCF) \\
& - \text{Net Investment Income } (NII) \\
& + \text{Net Exchange Reserves } (NER)
\end{aligned} \tag{10.28}$$

Net investment income is derived from the financial assets invested abroad and here assumed to be dependent only on domestic and foreign interest rates. Net exchange reserves depend on the official foreign exchange intervention. Therefore, NII and NER are not dependent on foreign exchange rate and its expectations.

With these relations taken into consideration, dynamics of foreign exchange rate is mathematically expressed as a function of excess demand for foreign exchange, which in turn becomes a function of E and E^e as follows:

$$\frac{dE}{dt} = \Psi(-TB(E) - NCF(E, E^e) - NII + NER) = \Psi(E, E^e) \tag{10.29}$$

On the other hand, a formation of expected foreign exchange rates is difficult to formalize. Here it is simply assumed that actual expectations of foreign exchange rate fluctuates randomly around the current exchange rate by the factor of random normal distribution of $N_{random}(m, sd)$ where (m, sd) denotes mean and standard deviation, and accordingly an expected foreign exchange rate is obtained as an adaptive expectation against the actual expectation of random normal distribution.

Mathematically, dynamics of the expected foreign exchange rate thus defined is described as

$$\frac{dE^e}{dt} = \Phi(N_{random}(m, sd)E - E^e) = \Phi(E, E^e) \tag{10.30}$$

Thus, expected foreign exchange rate can be easily adjusted to the actual trends and volatilities of various economic situations by refining values in mean and standard deviation. Figure 10.14 illustrates how foreign exchange rate and its expectation are modeled in our economy.

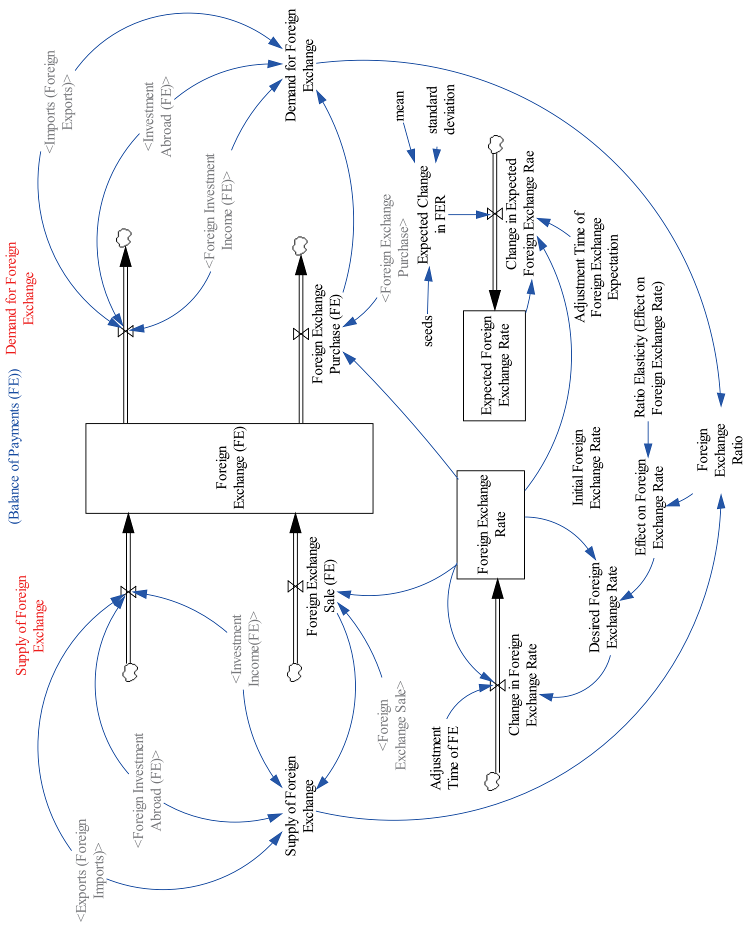

Figure 10.14: Determination of Foreign Exchange

Now dynamic modeling of foreign exchange rate in our open macroeconomy is complete. It consists of three equations: (10.15), (10.29), and (10.30), out of which three variables E, E^e and TB are determined, given parameters outside such as GDP, its price level and interest rate, as well as random normal distribution of expected foreign exchange rate. Schematically, it is written as

$$(Y, Y_f, P, P_f, i, i_f, N_{random}) \Longrightarrow (E, E^e, TB) \qquad (10.31)$$

Figure 10.15 draws a theoretical gist of our open macroeconomic framework as a simplified causal loop diagram of the dynamics of foreign exchange rate in our open macroeconomy.

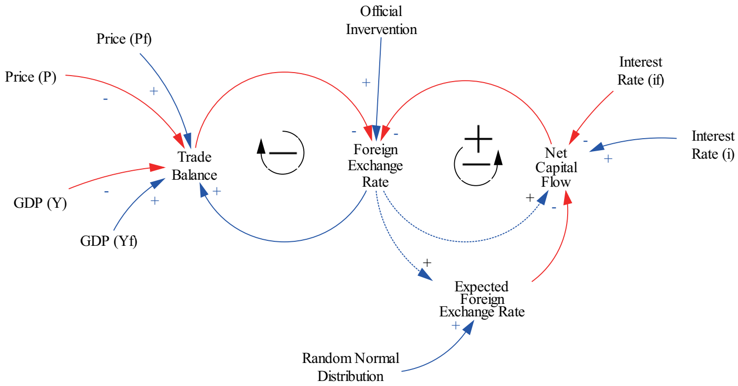

Figure 10.15: Causal Loop Diagram of the Foreign Exchange Dynamics

10.7 Behaviors of Current Account

An Equilibrium State (S)

We are now in a position to examine how our open macroeconomy behaves. Let us start with an equilibrium state of trade and foreign exchange. Domestic and foreign GDPs are assumed to grow at an annual rate of 2%. Random normal distribution for the expected foreign exchange rate is assumed to have a zero mean value and 0.1 value of standard deviation. Figure 10.16 illustrates the equilibrium state under such circumstances. Macroeconomic figures such as consumption spending, investment, government expenditures, exports and imports are shown to be growing, while trade balance is in equilibrium at a zero value in the left-hand diagram. On the other hand, a constant foreign exchange rate at one dollar per FE and its fluctuating expected rates are shown in the right-hand diagram.

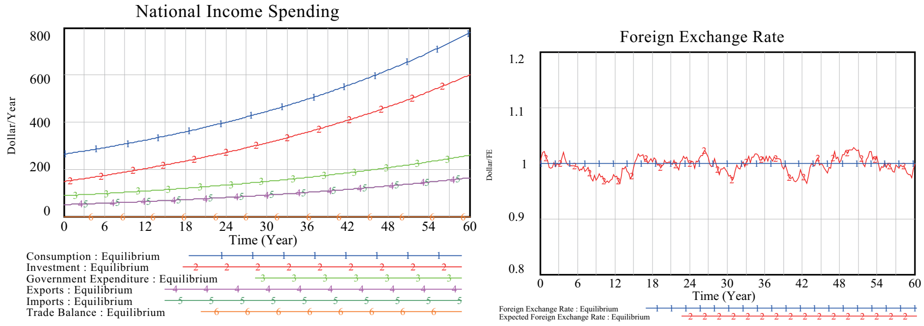

Figure 10.16: Equilibrium State of Trade and Foreign Exchange Rate (S)

In this state of equilibrium, financial investment is not yet considered. Hence, in spite of non-zero expected return arbitrate, caused by the fluctuations of estimated foreign exchange rates, capital flows are not provoked, and accordingly trade balance stays undisturbed.

Change in real GDP (S1)

Several scenarios can be considered that lead economic behaviors out of the above equilibrium state. Let us start with two simple cases in which no capital flows are allowed; that is, our dynamic system of foreign exchange rate is now simply described as

$$\frac{dE}{dt} = \Psi(-TB(E)) \tag{10.32}$$

As a first scenario, suppose a foreign real GDP decreases by 60 (billion) dollars at the year 7 due to a recession in a foreign country. The effect of this recession appears first of all as a sudden drop in our exports which are wholy dependent on foreign economic activities. This sudden plunge in exports causes a trade deficit. This will begin to increase demand for foreign exchange, because imports become relatively larger than exports, which in turn will cause foreign exchange rate to appreciate. The appreciation of foreign exchange rate makes imported goods more expensive, and eventually curbs the imports and trade balance will be gradually restored. In due course a new equilibrium state of foreign exchange rate will be attained at 1.056 dollars per FE (an appreciation rate of 5.6%)

In this way a flexible foreign exchange rate plays a decisive role of restoring trade imbalance as illustrated in Figure 10.17. Trade balance in a foreign country moves exactly into the opposite direction, so that a perfect mirror image of trade balance is created as reflected in the right-hand diagram.

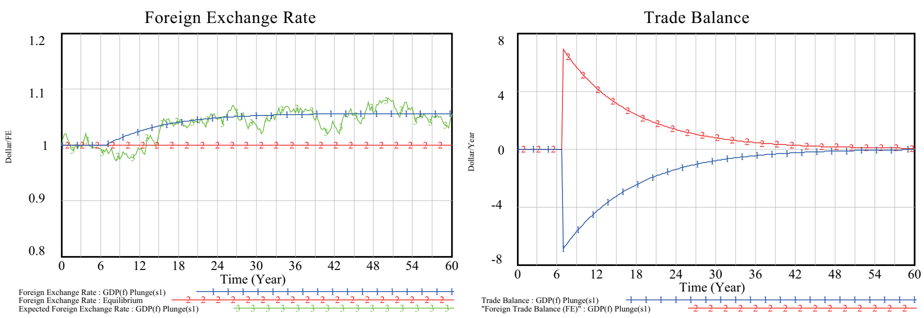

Figure 10.17: Foreign GDP Plunge and Restoring Trade Balance (S1)

Change in Price (S2)

As a second scenario, let us consider an opposite situation in which a foreign price rises by 10% due to an economic boom in a foreign country. The inflation makes imported goods more expensive and imports are suddenly suppressed, causing a surplus trade balance. Trade surplus will bring in more foreign exchange, causing a foreign exchange rate to depreciate. The depreciated foreign exchange rate now makes imported goods relatively cheaper and stimulates imports again. In this way trade balance will be restored and a new level of exchange rate is attained in due course at 0.97 dollars per FE (a depreciation rate of 3 %) as illustrated in Figure 10.18.

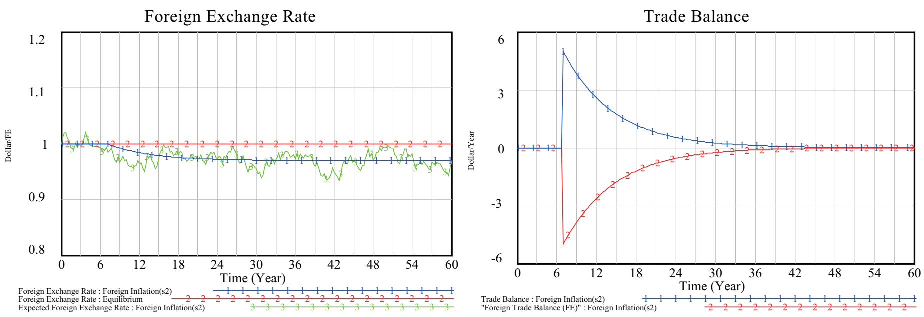

Figure 10.18: Foreign Inflation and Restoring Trade Balance (S2)

10.8 Behaviors of Financial Account

Expectations and Foreign Investment (S3)

In the above equilibrium state, standard deviation of random normal distribution is assumed to be 0.1, and expected foreign exchange rates are allowed to move randomly. Accordingly, non-zero return arbitrage caused by such fluctuations of foreign exchange rate could have triggered capital inflows and outflows under the assumption of efficient financial market. Yet, in order to see the effect of economic activities and price levels on trade balance and exchange rate, financial investment is excluded from the analysis. In this sense, the equilibrium state discussed above is not a real equilibrium state under free capital flows.

From now on let us consider three cases in which free capital flows are allowed for higher returns. In other words, behaviors of three variables E, E^e and TB are fully analyzed under the three equations: (10.15), (10.29), and (10.30).

As a scenario 3, let us consider the original equilibrium state again and see what will happen if free capital flows are additionally allowed for higher returns. As a source of financial investment, 20 % of domestic investment is assigned to direct investment abroad, and 30 % of financial assets are allowed for financial investment for both economies. The actual financial investment, however, depends on the scale of investment indices illustrated in Figure 10.12 above.

Figure 10.19 illustrates a revised equilibrium state under free flows of capital. Top-right figure shows the existence of the expected return arbitrage under the fluctuations of expected foreign exchange rates. The emergence of the arbitrage undoubtedly trigger capital flows of financial investment for higher returns, breaking down the original equilibrium state of trade balance, as shown in the bottom two diagrams. In this way, the original equilibrium state of trade is easily thrown out of balance by merely introducing random expectations of foreign exchange rate under an efficient capital market. In other words, random expectations among financial investors are shown to be a cause of trade turbulence, and hence economic fluctuations of boom and bust in international trade. A flexible foreign exchange rate can no longer restore a trade balance. This is an unexpected and surprising simulation result in this chapter.

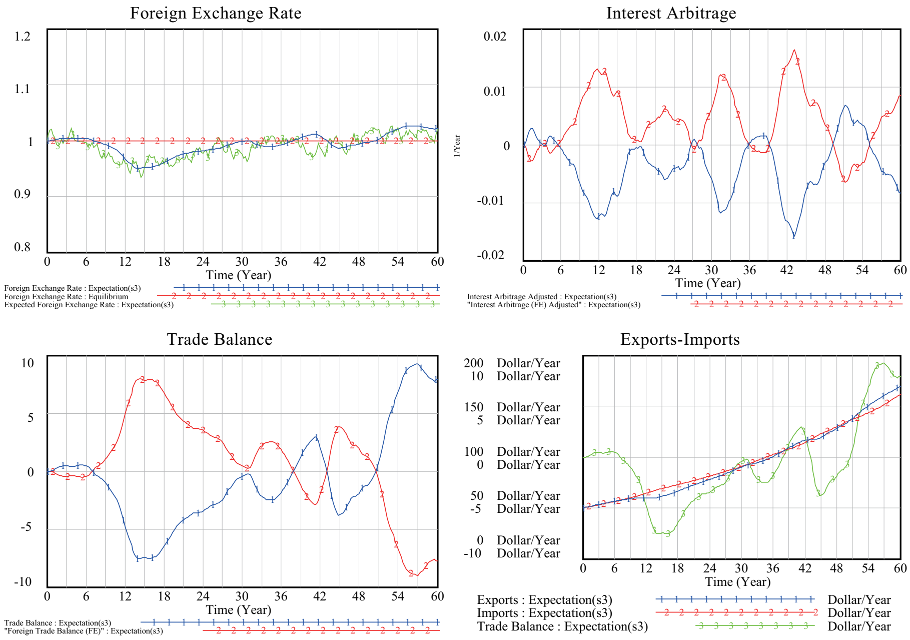

Figure 10.19: Random Expectations and Foreign Investment (S3)

Change in Interest Rate (S4)

Under the situation of the above scenario 3, let us additionally suppose, as scenario 4, that a domestic interest rate suddenly plummets by 2% and becomes 1%

from the original 3% at the year 7. This drop may be caused by an increase in money supply. The lowered interest rate surely drives capital outflows abroad. This in turn will increase the demand for foreign exchange, and a foreign exchange rate will begin to appreciate. The appreciation of foreign exchange rate makes exports price relatively cheaper, and trade balance turns out to become surplus. Figure 10.20 illustrates how a plummet of interest rate appreciates foreign exchange rate and improve a trade balance.

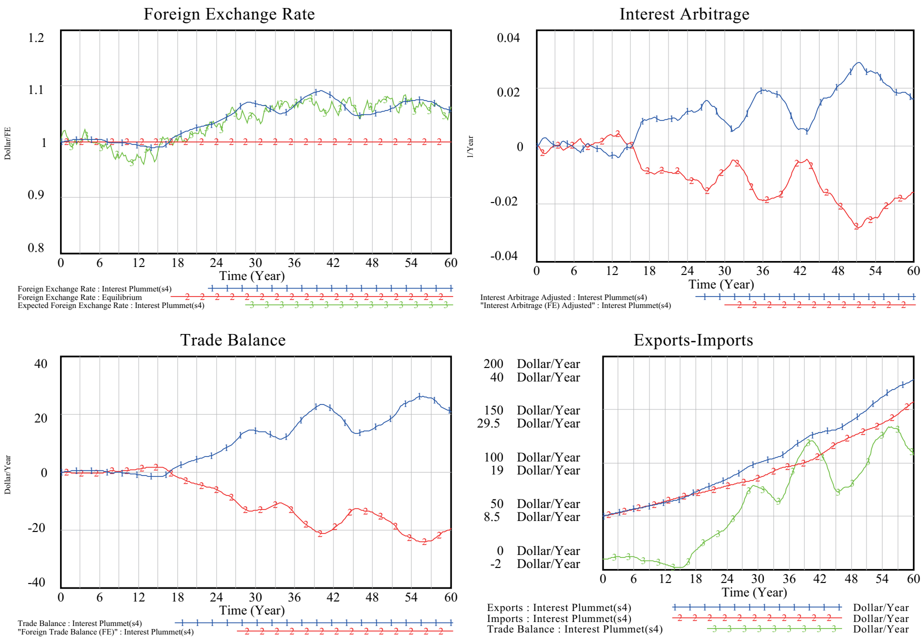

Figure 10.20: Interest Plummet under Random Expectations (S4)

Left-hand diagram of Figure 10.21 illustrates the balance of payments under the original equilibrium state (scenario 3). Current account is shown to be in deficit all the time, and in order to finance it financial account has to be in surplus. Under the same situation, a domestic interest rate is additionally lowered (scenario 4). Right-hand diagram indicates how lowered interest rate stimulates the economy and improves a deficit state of the balance of payments.

Change in GDP and Free Capital Flow (S5)

Let us revisit the scenario 3. Then as a scenario 5, let us additionally assume a decrease in foreign GDP by 60 (billion) dollars at the year 7 due to a recession in a foreign country as in the scenario 1. Furthermore, the central bank is now assumed to hold foreign exchange reserves of 100 (billion) dollars that are deposited with foreign banks.

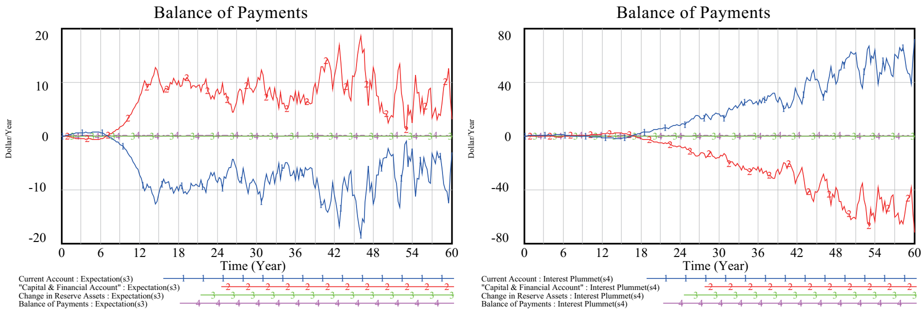

Figure 10.21: Comparison of the Balance of Payments between S3 and S4

As already discussed in the scenario 1, foreign exchange rate continues to appreciate, yet trade balance is no longer attained and trade deficits continues for a foreseeable future due to the disturbance caused by free capital flows as explored in the scenario 3. Top diagrams of Figure 10.22 illustrate these situations. Bottom-left diagram indicates current account deficits in the balance of payments, which has to be offset by the net inflow of capital.

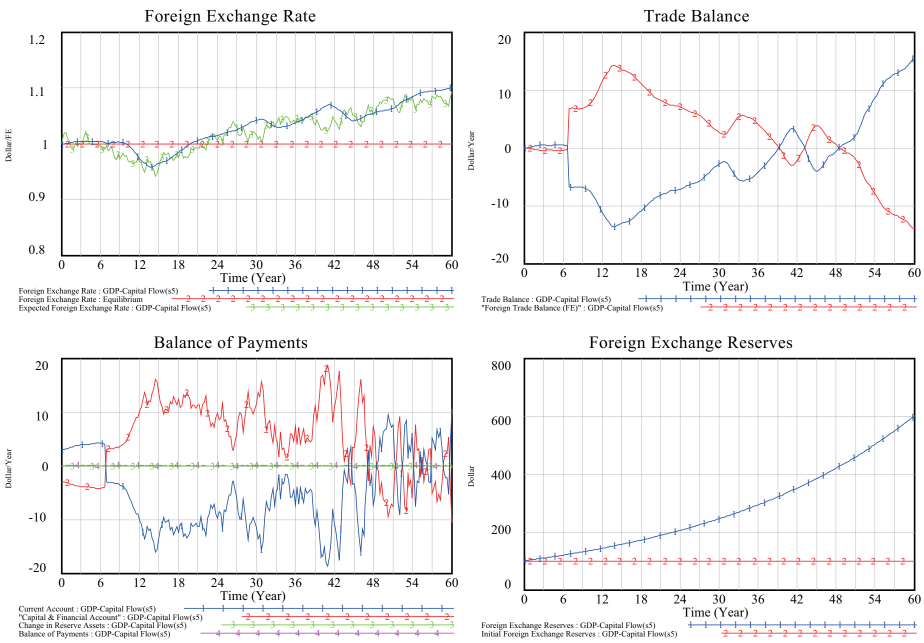

Figure 10.22: Foreign GDP Plunge and Foreign Investment (S5)

Bottom-right diagram shows that foreign exchange reserves by the central bank continues to grow at a rate of the foreign interest rate of 3 %. From a well-known principle of a doubling time of exponential growth, the reserves keep doubling approximately every 23 years.

10.9 Foreign Exchange Intervention

Official Intervention and Default (S6)

In the scenario 5 above, our macroeconomy continues to suffer from a continual depreciation of domestic currency (or an appreciation of foreign exchange rate), and deficits in trade and accordingly in current account. Surely, such a critical macroeconomic situation in a competitive international economic environment cannot be left uncontrolled. To prevent such an economic crisis let us introduce, as scenario 6, an official intervention to the foreign exchange market; specifically, the central bank (and government) begins to sell foreign exchange in order to reduce foreign exchange rate, say, to 1.02 dollars per FE; that is, by 2 % of the original equilibrium exchange rate.

As Figure 10.23 illustrates, even under such circumstances trade and current account deficits continue to persist. Gradually, the foreign exchange reserves begins to decline due to the official intervention, and becomes lower than the original reserve level of 100 (billion) dollars around the year 40 and completely gets depleted around the year 50, as indicated in the bottom right-hand diagram. This implies the government is forced to declare financial *default*, that is, an economic destruction, unless successfully eliciting an emergent loan from the international institutions such as the IMF.

Zero Interest Rate and Default (S7)

To avoid such financial default, now suppose, as scenario 7, money supply is increased to stimulate the economy and a domestic interest rate is lowered by 3%; that is, a zero interest rate is introduced from the original 3% at the year 3. This policy of zero interest rate surely improves trade balance and the balance of payments as Figure 10.24 indicates. Yet, under the official intervention of keeping a foreign exchange rate below 1.02 dollars per FE, the central bank (and the government) is forced to keep selling foreign exchange reserves[3]. The original 100 (billion) dollars of foreign exchange reserves will be completely depleted around the year 11 as the bottom right-hand diagram indicates. Therefore, this zero interest policy does not work unless the government can successfully borrow foreign exchange from the international institutions such as the IMF.

[3]To be precise, for maintaining the rate below this level, the central bank (and the government) has to keep selling 60 (billion) dollars of foreign exchange annually instead of 20 (billion) dollars in the previous scenario

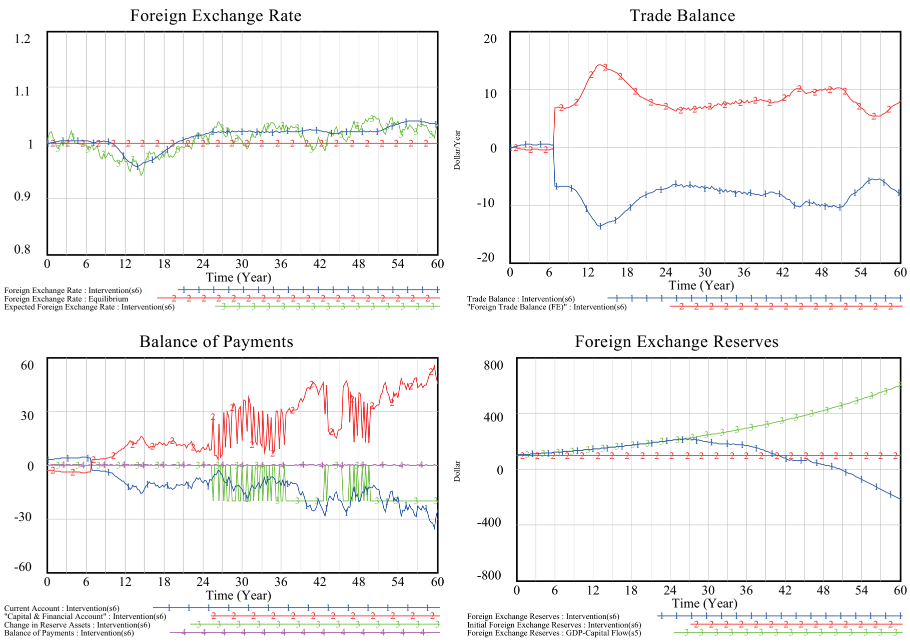

Figure 10.23: Official Intervention and Default (S6)

No Official Intervention (S8)

Let us further suppose that the central bank (and the government) gives up official intervention and stops selling foreign exchange to avoid a depletion of its foreign reserves. This scenario 8 surely brings about a further appreciation of foreign exchange rate. But to our surprise, after attaining a highest value of 1.225 dollars at the year 41, it begins to depreciate as the top left-hand diagram of Figure 10.25 illustrates. Moreover, trade balance and the balance of payments are getting improved, and foreign exchange reserves keeps growing according to the same figure. This is another counter-intuitive result in a sense that official intervention to foreign exchange market won't work to save the economic crisis.

In this way, so long as the working of our domestic macroeconomy is concerned, combined policies of zero interest rate and no official intervention seem to work. Yet, from a foreign country's point of view, the same policies worsen its economy as a mirror image of our economy. Hence, a so-called trade war becomes unavoidable in the international macroeconomic framework. Our simple open macroeconomic model has successfully exposed one of the fundamental causes of economic conflicts among nations.

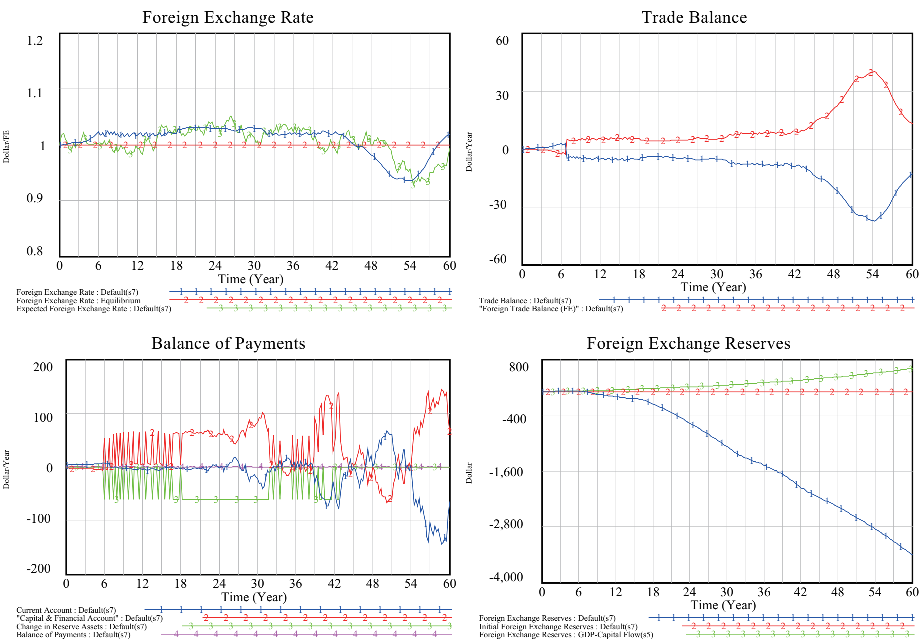

Figure 10.24: Zero Interest Rate and Default (S7)

10.10 Missing Feedback Loops

We have now presented eight different scenarios of international trade and financial investment, which indicates capability of our open macroeconomic modeling. Yet, our generic model is far from a complete open macroeconomy, because significant economic variables such as GDP, its price level and interest rate are treated as outside parameters, and no feedback loops exist in the sense that they are affected by the endogenous variables such as a foreign exchange rate and its expectations. Schematically, one-way direction of decision-making in the equation (10.31) has to be made two-way such that

$$(Y, Y_f, P, P_f, i, i_f, N_{random}) \Longleftrightarrow (E, E^e, TB) \tag{10.33}$$

Mundell-Fleming Model

Compared with our model, one of the repeatedly used open macroeconomic model in standard international economics textbooks is the Mundell-Fleming

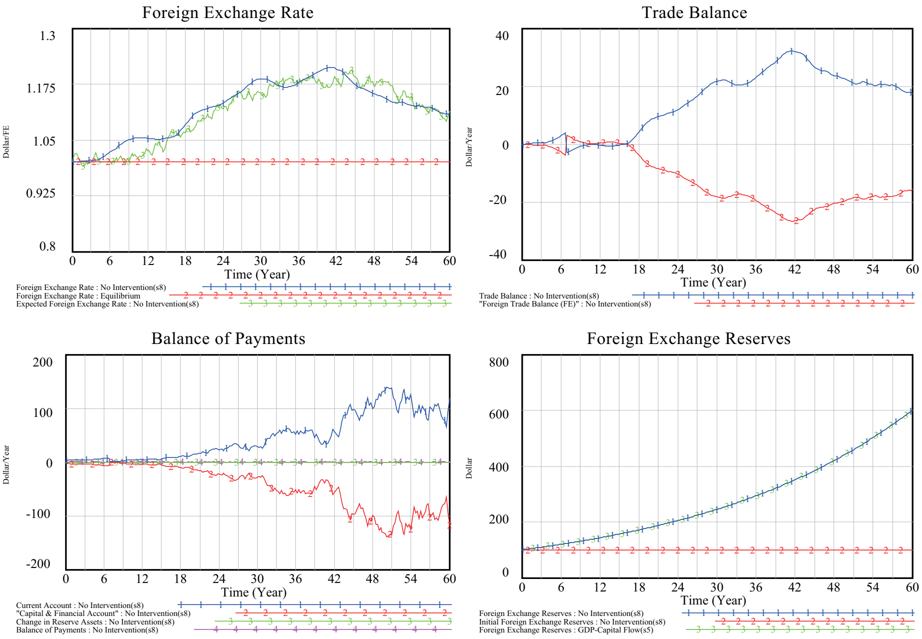

Figure 10.25: No Official Intervention (S8)

model that is described, according to [47], as

$$Y = C(Y-T) + I(i)) + G + TB(E) \tag{10.34}$$

$$\frac{M^s}{P} = L(i, Y) \tag{10.35}$$

$$i = i_f \tag{10.36}$$

This macroeconomic model indeed determines Y, E and i. In other words, significant economic variables such as GDP and interest rate are simultaneously determined in the model, though interest rate is restricted by a competitive world interest rate. In comparison, our model consisting of the three equations: (10.15), (10.29), and (10.30), determines only three variables E, E^e and TB, and fails to determine Y and i.

Hence, Mundel-Fleming model could be said to be a better presentation of open macroeconomy. Yet, it lacks a mechanism of determining money supply M^s and a price level P. In this sense, it is still far from a complete open macroeconomic model.

Missing Loops

It is now clear from the above arguments that for a complete open macroeconomic model some missing feedback loops have to be supplemented. They could constitute the following in our model:

- Imports and exports are assumed to be determined by the economic activities of GDPs, which are in turn affected by the size of trade balance. Yet, they are missing.
- Foreign exchange intervention by the central bank (and the government) such as the purchase or sale of foreign exchange surely changes the amount of currency outstanding and money supply, which in turn must affect an interest rate and a price level. Yet, they are being fixed.
- A change in interest rates affects investment, which in turn determines the level of GDP. Yet, investment is not playing such a role.
- A change in price level must also affect consumption spending and hence real GDP. Yet, these loops are missing.
- Official intervention must influence speculations and estimations on foreign exchange and investment returns among international financial investors. Yet, these fluctuations are only given by outside random normal distribution.

If we could add these missing feedback loops to the causal loop diagram of the foreign exchange dynamics in Figure 10.15, then we can obtain a complete feedback loop diagram as illustrated in Figure 10.26.

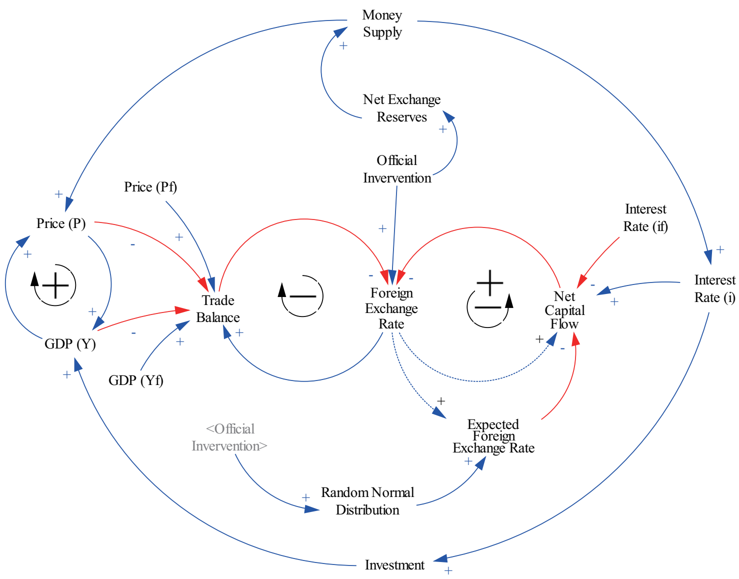

Figure 10.26: Missing Feedback Loops Added to the Foreign Exchange Dynamics

Obviously, our open macroeconomic model is not complete until these missing loops are incorporated in the model. Specifically, the previous chapter has presented a model of macroeconomic system which determines GDP, money supply, a price level, investment and interest rate, to name but a few. Therefore, our next challenge is to integrate the model with our present foreign exchange model by creating a whole image of domestic macroeconomy as its foreign sector macroeconomy.

10.11 Conclusion

Our open macroeconomic modeling turned out to need another model of the balance of payments and dynamics of foreign exchange rate. Consequently, the approach in this chapter led by the logic of accounting system dynamics became an entirely new one in the field of international economics.

Under the framework, a double-booking accounting of the balance of payments is modeled. Then determinants of trade and foreign direct and financial investment are analytically examined together with an introduction of differential equations of foreign exchange rate and its expected rate.

Upon a completion of the model, eight scenarios are produced and examined by running various simulations to obtain some behaviors observed in actual international trade and financial investment. It is a surprise to see how an equilibrium state of trade balance is easily disturbed by merely introducing random expectations among financial investors under the assumption of efficient financial market. To indicate the capability of our model furthermore, the impact of official intervention on foreign exchange and a path to default is discussed.

Finally, several missing feedback loops in our model are pointed out for making it a complete open macroeconomic model. This task of completion will inevitably lead to our next research in this system dynamics macroeconomic modeling series in the next chapter.