The Difference in Development Stages and the Costs of Monetary Union

—A New Open Economy Macroeconomics model

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Abstract

This paper deals with the problem of how the difference in development stages affects the costs of monetary union by analyzing the responses of the countries to symmetric shocks in a New Open Economy Macroeconomics model. Focusing on differences in sectors such as differences in the degree of price rigidity, technology level, the coefficient regarding labor input of firms between the developed and developing countries, the model emphasizes the extremely important role of the movement of labor across sectors in the transmission mechanism of shocks. Some of the main findings are as follows. In the short run, a symmetric increase in money supply can cause GDP to rise sharply the developed country and to fall in the developing country, while a symmetric technology shock to the agricultural sector has opposite effects. In addition, a symmetric positive technology shock to the industrial sector could raise GDP more in the developing country than in the developed country. The results suggest that the difference in development stages is important because it affects the costs of monetary union.

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1. Introduction

This paper deals with the problem of how the difference in development stages affects the costs of monetary union by analyzing the responses of the countries to symmetric shocks in a New Open Economy Macroeconomics model.

Recently, there has been a wide discussion of forming a common currency area[1] (CCA) in East Asia, which is motivated by factors such as the recognition of the weakness of the unilateral dollar-peg regime after the Asian crisis 1997-98, the rapid economic integration prevailing inside the region, the successful launch of the euro in Europe and so on. In this discussion, it is often argued that forming a CCA for East Asia is difficult because countries in the region are at very different in development stages[2]. In fact, if we look at per capita GDP in the region, we will find a large range where at one extreme are low-income developing countries like Myanmar, Vietnam etc., and at the other extreme are highly developed countries like Japan. It is not clear, however, why the difference in development stages makes it difficult to form a CCA. Moreover, how to define development stage is also an important issue that should be dealt with before talking about development stage and monetary integration. These are the main motivations of this paper.

According to the theory of optimum currency area[3], one of the main costs for countries when forming a CCA is the cost that arises when these countries have to relinquish their monetary policy autonomy and follow a common monetary policy.

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[1] The two expressions "monetary union" and "common currency area" are used interchangeably in this paper.

[2] An example I saw recently is in an interview on East Asian monetary integration by Nikkei Newspaper with Dr. Masahiro Kawai, Special Advisor to the President of the Asian Development Bank. One question asked was "Is it not difficult for Asia (to form a CCA) because the difference in development stages of countries in the region is too large in comparison with the EU ?".

[3] See also De Grauwe (2005) for a detailed discussion regarding the costs of monetary union.

This cost will be relatively small if shocks occurring in these countries are symmetric (i.e. highly correlated) because in that case they can use a common monetary policy to tackle the shocks. Based on this, many empirical studies such as Bayoumi and Eichengreen (1992, 1994, 2000), Zhang et al. (2003), among others, specify the shocks and analyze for the case of Europe as well as East Asia[4]. However, it should be noted that for the above argument to hold we need to add one more condition that the responses of economic variables of the economies in question to the symmetric shock need to be the same. Put differently, the structure of the economies needs to be similar. The above argument implicitly takes this condition for granted. We then ask what would happen when this condition does not hold?. In Vu (2005), based on the same empirical framework as the studies noted above I examine[5] the responses of price levels and outputs in various ASEAN countries (which can be thought of having different structures) to the same supply and demand shocks, and find that in many cases the responses are different. This suggests that the difference in structures might be relevant to the responses to shocks. The problem is how to explain the mechanisms that cause asymmetric responses in different countries. To do this we need a theoretical framework.

The paper first gives an explicit definition of the difference in development stages by looking at the differences in sectors between countries. And by incorporating these differences into a model, it is successful in analyzing how they generate asymmetric responses of the economies to various kinds of symmetric shocks, and thus affect the costs of a CCA[6].

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[4] The method used in these studies is structural vector auto-regression (SVAR) developed by Blanchard and Quah (1989).

[5] I use the bootstrapping method.

[6] One of the few studies that mention the relationship between the gap between the countries and the

The model built here extends the framework of the so-called New Open Economy Macroeconomics (NOEM), which is rooted in the seminal work of Obstfeld and Rogoff (1995, 1996) and has a very rapid development recently. The NOEM framework, characterized by dynamic structures, micro-foundations, monopolistic competitive firms, nominal rigidities in the short run etc., is flexible to incorporate many aspects of international economic reality, and especially suitable to analyze the effects of shocks internationally[7]. Using a theoretical model enables us to overcome some limitations of the empirical noted above. First, it allows us to understand firmly the transmission mechanisms of the shock. Second, we are able to study the effects of shocks in various settings, some of which, e.g. the case of economies under a common currency regime, could not be analyzed within the framework of an empirical study that uses the data in the past when such a regime does not exist.

Although the model in this paper inherits many features of the NOEM literature, it differs from other NOEM models developed so far in one important point. That is, it emphasizes the role of labor movement (resource allocation) across sectors which is crucial to propagate the shock to the whole economy.

Although I keep in mind the facts of East Asia when building the model, I believe that the model here can be applied for other groups of countries in the world, if they consist of countries of different development stages and are to consider forming a CCA.

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costs of monetary union is Feldstein (1992), where the author argues that it would be costly for countries of different income levels to form a CCA because in the catch-up process of lower income countries there are usually large adjustments in real exchange rates, but if the nominal exchange rate is eternally fixed those adjustments must be carried out through changes in wages and price levels which must be more painful. Costs of this kind, however, would occur in a quite long time span, say decades, while the costs considered in this paper are of a shorter period, say some quarters or years.

[7] See Shioji (2006) for a more detailed discussion of the features and application of the NOEM.

The remainder of the paper is organized as follows. Section 2 examines briefly the differences between sectors and between countries of different development stages through data. Section 3 describes the model. Section 4 discusses the calibration results and the transmission mechanisms of various kinds of shocks. Section 5 concludes the paper.

2. The differences between sectors and between countries of different development stages

In section 3 we will model a world with two countries that are at different stages of development, say a developed country and a developing country. Before that, in this section we will discuss the difference between them from the sectoral point of view with the help of some stylized facts from data.

Figure 1 shows the GDP per capita of 10 East Asia countries in period 1960-2003. One can see from the graph the continuous growth pattern of these countries. They get into a higher development stage as their GDP per capita grows.

Figure 2 shows snap pictures of GDP per capita[8] "taken" at three moments 1990, 2000 and 2003. In the horizontal axis countries are put in order such that their GDP per capita gets higher from right to left. We keep this order in the horizontal axis in figures 3~5 and replace in the vertical axis with data of various indicators concerning agricultural sector. It is easy to see that these figures show quite clear trends. That is, a country with higher per capita income will generally have a lower share of the agricultural employment in total employment, a lower share of agriculture in GDP, and higher productivity in agriculture. Also, we can see from figure 5 that in all countries productivity in industrial sector is much higher than that in agricultural sector.

As will be seen later, the difference in relative size of domestic sectors, i.e. the ratio size of industrial sector/agricultural sector in terms of both labor input and output, will play a crucial role in generating asymmetric responses to symmetric

[8] In figures 2~5, Hong Kong and Singapore are dropped because of the non-agrarian characteristic of their economies, which we want to focus on here.

shocks between countries. This difference, in turn, is introduced mainly through the differences in three factors, namely technology levels, the degree to which the marginal costs of firms increase when raising output, and the degree of competition within sectors. For the first one, it is clear as noted above. Regarding the second one, it could be argued from the experience of development in East Asia (for instance, Japan in the past and China and Vietnam today) that when the economy is at a lower stage of development, the agricultural sector will have an “excess of labor” so the marginal cost of firms in this sector does not increase much when raising output. When the economy gets to a higher stage, this excess of labor will disappear and in both sectors firms which attempt to raise output must face increasing marginal costs due to the increase in working hours and wage bid up. On the third factor, agricultural goods (say, rice and corn) are better substitutes of one other than industrial goods (say, cars and shoes), so the degree of competition is higher in the agricultural sector than in the industrial sector.

Another factor that is important when considering the difference between sectors is price rigidity in the short run. From our experience, we observe that prices of the agricultural goods change more often than that of industrial goods. Consistent with this, some empirical studies such as Saita et al. (2006) and Dhyne et al. (2005) show evidence that prices of industrial goods are more rigid than that of agricultural goods[9].

[9] Saita et al. show that the results of price revising frequency (per month) for Japan in the period 1999-2003 is 71.8%, 30.8% and 22.7% for unprocessed food, processed food and non-energy industrial product, respectively. While in the study about the US and nine EU countries in various periods within 1989-2004 of Dhyne et al., these numbers are 37.8%, 17.0%, 11.2% on average.

3. The Model

The world, whose population is normalized to be unity, consists of two countries, the developing country denoted by TH with population n, and the developed country denoted by JP with population $1-n$. In each country, there are two sectors, the agricultural (or traditional) sector T and the industrial (or modern) sector M. In each country, for simplicity we assume that the number of firms is the same as the number of individuals. Firms are arranged in the following intervals $[0, \gamma_{T,TH} * n]$, $[\gamma_{T,TH} * n, n]$, $[n, n+\gamma_{T,JP} *(1-n)]$, $[n+\gamma_{T,JP} *(1-n), 1]$ for firms in sector T of TH, sector M of TH, sector T of JP and sector M of JP, respectively. Firms are monopolistically competitive, i.e. each firm produces one differentiated good and owns the brand of that good, but the firm also has to compete with other firms because goods are, to some extent (although not perfect), substitutes of one another. Also note that, the elasticity of substitution between goods within the same type (e.g. between T goods) is greater than that between goods of different types (e.g. between T goods and M goods). Firms use only labor for their production.

There are consumers, firms (in sectors T and M) and the government in each economy. All goods are traded and are consumed in the same fashion by consumers and the government in each country. Below we will consider the behavior and the optimization problems of these agents one by one in detail.

3.1 The Household

In Obstfeld and Rogoff (1995), one household owns one firm and at the same time supplies labor only to that firm. If we maintain this assumption in this paper, there would be *heterogeneity* between domestic households because firms in each country are now heterogeneous. The model then would become complicated. To avoid this, we need to "separate" the household from being the owner, the laborer of a particular firm. So here assume that in each country, households supply labor to domestic firms in both sectors T and M, and hold stocks of all domestic firms in a way that they receive the same labor income and the same dividend from firms.

3.1.1 The household's utility

The representative household x^j (in country j ($j = TH, JP$) derives its utility from consumption and holding money and disutility from working. Its life-time utility at time 0 (the present) and utility at each period of time (t) are as follows,

$$U_0(x^j) = \sum_{t=0}^{\infty} \beta^t u_t(x^j) \qquad (1)$$

$$u(x^j) = \ln C(x^j) - \frac{\kappa}{2}\left[h(x^j)\right]^2 + \chi \ln\left[\frac{M(x^j)}{P^j}\right] \qquad (2)$$ [10]

Where C, h and $\frac{M}{P}$ are the aggregate consumption basket, working hours and real money holdings of the household, respectively. And β, κ and χ denotes the time discount factor, the parameter regarding disutility from working, the parameter regarding utility from holding money.

3.1.2 The household's consumption

The aggregate consumption basket of household x^j is comprised of consumption

[10] From now on, for the sake of convenience we will not write explicitly the time subscript t if not necessary (e.g. when all variables expressed in the equation are in the same period).

of agricultural goods and industrial goods,

$$C(x^j) = \left[(C(x_T^j))^{(1-\rho)/\rho} + (C(x_M^j))^{(1-\rho)/\rho} \right]^{\rho/(1-\rho)} \qquad (3)$$

Consumption of agricultural goods and consumption of industrial goods are themselves, respectively, baskets of agricultural and industrial goods from both TH and JP,

$$C(x_T^j) = \left[\left(\int_{z_j^{T,TH}} c(x^j, z_j^{T,TH}) dz_j^{T,TH} \right)^{(\theta_T - 1)/\theta_T} + \left(\int_{z_j^{T,JP}} c(x^j, z_j^{T,JP}) dz_j^{T,JP} \right)^{(\theta_T - 1)/\theta_T} \right]^{\theta_T/(\theta_T - 1)} \qquad (4)$$

$$C(x_M^j) = \left[\left(\int_{z_j^{M,TH}} c(x^j, z_j^{M,TH}) dz_j^{M,TH} \right)^{(\theta_M - 1)/\theta_M} + \left(\int_{z_j^{M,JP}} c(x^j, z_j^{M,JP}) dz_j^{M,JP} \right)^{(\theta_M - 1)/\theta_M} \right]^{\theta_M/(\theta_M - 1)} \qquad (5)$$

Where $z_j^{k,s}$ stands for the good produced by firm z in sector k ($k = T, M$) of country s ($s = TH, JP$) and sold in country j. The parameters ρ, θ_T and θ_M denote the elasticities of substitution between agricultural goods and industrial goods, within agricultural goods and within industrial goods, respectively.

From (3)~(5) we have the optimal consumption of household x^j for each good,

$$c(x^j, z_j^{k,s}) = \left[\frac{p(z_j^{k,s})}{P^{k,j}} \right]^{-\theta_k} \left[\frac{P^{k,j}}{P^j} \right]^{-\rho} C(x^j) \qquad (6)$$

Where $p(z_j^{k,s})$, $P^{k,j}$ and P^j are the price of good z (explained above[11]), the price level in sector k of country j, and the price level of country j, respectively.

3.1.3 The household's budget constraint

With the above setup we can write the budget constraint of household x^j as follows,

[11] Note that, by definition, the price $p(z_j^{k,s})$ is denominated in the currency of country j

$$M_t(x^j)+P_t^jB_t(x^j)=(1+r_{t-1}^j)P_t^jB_{t-1}(x^j)+M_{t-1}(x^j)-P_t^jC_t(x^j)-P_t^jT_t(x^j)$$

$$+W_t^jh_t(x^j)+\gamma_{T,j}\prod_t(z^{T,j})+(1-\gamma_{T,j})\prod_t(z^{M,j}) \qquad (7)$$

Where B, T, W are real bond holdings, tax paid for (or transfer from) the government, and wage, respectively. The term $\prod(z^{k,j})$ is the total dividend received from firms in sector k, which equals exactly the profit of the representative firm in sector k times the fraction of firms in sector k. Note that we assume labor movement across sectors in each country so that domestic wages in different sectors are equalized (we will discuss this in more detail below).

3.1.4 The household's optimization problem

The household will choose B, C, h and M in order to maximize its life-time utility given in (1) and (2), under the budget constraint given in (7). Solving this optimization problem, we get the Euler equation for consumption, the money demand function and labor supply function as optimality conditions for the household[12].

3.2 The Government

We assume that in each country, the government issues no debt. The government in country j consumes goods in the same fashion as the household, and finance that by issuing money (seigniorage) $\frac{M_t^j-M_{t-1}^j}{P_t^j}$ and lump-sum tax T_t. If T_t is negative, then it is lump-sum transfer from the government to domestic households.

[12] Though not shown here, the results of this will be provided upon request.

The budget constraint, and the demand for good $z_j^{k,s}$ of the government respectively are,

$$G_t^j = \frac{M_t^j - M_{t-1}^j}{P_t^j} + T_t(x^j) \qquad (8)$$

$$g^j(z_j^{k,s}) = \left[\frac{p(z_j^{k,s})}{P^{k,j}}\right]^{-\theta_k} \left[\frac{P^{k,j}}{P^j}\right]^{-\rho} G^j \qquad (9)$$

Note that G, M and T here are per capita values.

3.3 Price Indexes and Demand

With the CES aggregator of consumption and government spending used above we can define the price indexes for each sector and for the whole economy as follows,

$$P^{T,j} = \left[\left(\int_{z_j^{T,TH}} p(z_j^{T,TH})dz_j^{T,TH}\right)^{1-\theta_T} + \left(\int_{z_j^{T,JP}} p(z_j^{T,JP})dz_j^{T,JP}\right)^{1-\theta_T}\right]^{1/(1-\theta_T)} \qquad (10)$$

$$P^{M,j} = \left[\left(\int_{z_j^{M,TH}} p(z_j^{M,TH})dz_j^{M,TH}\right)^{1-\theta_M} + \left(\int_{z_j^{M,JP}} p(z_j^{M,JP})dz_j^{M,JP}\right)^{1-\theta_M}\right]^{1/(1-\theta_M)} \qquad (11)$$

$$P^j = \left[\left(P^{T,j}\right)^{1-\rho} + \left(P^{M,j}\right)^{1-\rho}\right]^{1/(1-\rho)} \qquad (12)$$

In addition, the demand worldwide for the good produced by firm z in sector k ($k = T, M$) of country s is the sum of consumption by households and governments all over the world,

$$y^d(z^{k,s}) = n\left[c(x^{TH}, z_{TH}^{k,s}) + g(z_{TH}^{k,s})\right] + (1-n)\left[c(x^{JP}, z_{JP}^{k,s}) + g(z_{JP}^{k,s})\right] \qquad (13)$$

with $c(x^j, z_j^{k,s})$ and $g(x^j, z_j^{k,s})$ given in (6) and (9).

3.4 The Firm

We consider the problem of a firm representative of all firms in both countries and both sectors, i.e. firm z in sector k of country j. The firm is assumed to have the following production function,

$$y(z^{k,j}) = A_{k,j}[h(z^{k,j})]^{\alpha_{k,j}} \qquad (14)$$

It is worth noting that, the differences between firms by sector and by country are in their technology levels $A_{k,j}$ and the coefficients regarding labor input $\alpha_{k,j}$. These differences will play a crucial role to generate various asymmetric responses to shocks as will be seen later. For now it is sufficient for us to work with the representative firm.

The firm's revenue comes from sales at home and abroad. It also has to pay costs for using labor. Thus, the profit of the firm is,

$$\Pi(z^{k,j}) = p(z_j^{k,j})y(z_j^{k,j}) + S^{j/f} p(z_f^{k,j})y(z_f^{k,j}) - W^j h(z^{k,j}) \qquad (15)$$

Here f denotes the foreign country from the point of view of country j, and $S^{j/f}$ is the price of one unit currency of country f measured in country j's currency. The firm's optimization problem is to maximize profit $\Pi(z^{k,j})$ in (15) given the production in (14) and demand for its good at home and abroad as in (13). Solving this problem yields the optimal prices at home and abroad, as well as the labor demand function of the firm[13].

[13] Though not shown here, the results of this will be provided upon request.

3.5 Market Equilibria

3.5.1 Labor markets

Labor is assumed to be mobile domestically, but not internationally. We emphasize here the importance of labor mobility in this model in that the movement of labor across sectors and the adjustment of labor markets are important channels through which shocks affect the whole economy. This point will be clear later in the calibration section.

In each country, the movement of labor across sectors causes the equalization of wages between sectors, and labor supply and demand to be equal,

$$h(x^j) = \gamma_{T,j} h(z^{T,j}) + (1-\gamma_{T,j}) h(z^{M,j}) \qquad (16).$$

The left-hand side of (16) are labor demand from sectors T and M, while the right hand side is labor supply of the household (in per capita term).

3.5.1 Asset markets

Assume that there is no restriction or obstacle to capital flow so the world capital market is fully integrated. The uncovered interest parity holds,

$$1+i_t^j = \frac{S_{t+1}^{j/f}}{S_t^{j/f}}(1+i_t^f) \qquad (17)$$

while interest rates in each country satisfy the Fisher equation,

$$1+i_t^j = \frac{P_{t+1}^j}{P_t^j}(1+i_t^f) \qquad (18),$$

where i and r are nominal and real interest rates, respectively. Also, the world bond holdings must satisfy the zero net supply condition at each period of time,

$$nB^{TH} + (1-n)B^{JP} = 0 \qquad (19)$$

3.6 The common currency regime

In a monetary union the currencies of the countries in the union are replaced by a common currency and there is only one exchange rate which is eternally fixed at the rate 1:1. Hence,

$$S_t^{j/f} = 1 \qquad (20)$$

for all t and any pair of j and f.

3.7 Closing the Model and the Zero Steady State

As in Obstfeld and Rogoff (1995), putting all equations derived above we are able to solve for the steady state in which the amounts of bond holdings in the two countries are both zero. However, because of the nonlinearity in the production function and the differences between sectors and between countries that we introduce in this model, it is difficult to solve for the steady state analytically. Thus we adopt a numerical method to find the solutions. The numerical method we adopt here has a strong point in that it allows us to solve for the solutions without linearizing. Having obtained the steady state, we will start from it to see the effects of various kinds of shocks to the two economies.

3.8 The Adjustment of the Two Economies to a Shock

When a shock occurs, the dynamics of the two economies to that shock can be described completely by three periods. At period 0 the two economies are at their steady states. At the beginning of period 1 the shock occurs and the two economies will adjust during this period. We call it the short run. When period 2 comes, the world moves to a new steady state which we call the long run.

In the short run there are nominal rigidities. However, as discussed in section 2, the degrees to which prices are rigid are different between agricultural and industrial goods. The former are much more flexible than the latter. Thus, for the sake of simplicity, we assume a nominal rigidity only for industrial goods, while agricultural goods prices are flexible[14]. Also, this assumption allows us to capture more precisely the dynamic movement of labor across sectors in each country in the presence of shocks, which is often been observed in East Asian countries during their process of development.

Concerning the price setting behavior of firms in different markets (i.e. at home and abroad), it is possible to adopt different assumptions such as price settings that follow the law of one price (LOOP), pricing-to-market (PTM)[15] or invoicing based on some third currency. These are important and of great interest because to what currency goods prices are set and thus may be rigid in the short run will affect the transmission mechanism of the shock. However, since our focus is on the common currency regime[16] and there are only two countries, all of these settings are identical[17]. That is, because the exchange rate is eternally fixed at the rate 1:1, prices set at home and foreign market are always the same for each good.

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[14] Under the model of this class (with effectively three periods) it is difficult for a more flexible setting (i.e. prices of T goods less rigid than that of M goods, but not perfectly flexible). But it is possible in a fully dynamic framework.

[15] See Betts and Devereux (2000).

[16] I also conduct a calibration for the case of the flexible exchange rate regime (with LOOP and PTM) but the results are not shown and discussed here because of the limited space of the paper.

[17] This will not be the case when we incorporate one more country.

4. Calibration and Results

Table 1 shows how parameters are set. The elasticity of substitution within agricultural goods is greater than that of industrial goods as discussed in section 2. The populations of the two countries are set to be the same.

Since the structure of the model is complicated, to firmly understand the effects of shocks we will start from a simple version and then step by step introduce various kinds of asymmetries. The calibration is conducted with four kinds of shocks, namely money supply and government spending shocks, and technology shocks to sectors T and M. All shocks generated are *permanent*, *positive* and *symmetric* (with an amount of *one percent*) to the two countries. Our main interest is in the effects on two of the most important macro variables, (real) GDP and the price level, but we need to also look at the responses of other variables to specify the mechanisms behind.

4.1. Case1: All symmetric

In this case the parameters regarding the production function are set as follows: $A_{T,TH} = A_{T,JP} = A_{M,TH} = A_{M,JP} = 1$, $\alpha_{T,TH} = \alpha_{T,JP} = \alpha_{M,TH} = \alpha_{M,JP} = 1$. With this, the structure of TH and JP is completely the same. The two sectors in each economy have the same technology level and linear production function. They are only different in the rigidities of prices and the elasticities within goods ($\theta_T > \theta_M$) which also reflects the monopoly power in each sector (firms in sector M have more monopoly power, or in other words, sector T is more competitive). This, given the same production function and the symmetric way that T and M goods enter the utility function, results in a smaller quantity produced and thus the labor input in sector M as compared to sector T. In fact, in our calibration, the ratio of labor input between sectors M and T is roughly 1/1.7, and the ratio of output is 1/1.3 for both countries at the steady state.

Now, we will look at the effects of each kind of shocks in detail. The results are reported in Table 2-1.

For a monetary shock, it should be noted that because of the symmetry of shocks, in the long run money will be neutral (or approximately neutral in some cases that follows, due to asymmetries), so GDP is unaffected and the prices will change in proportion to the change of money supply, which will be symmetric in both countries. Hence, we confine our interest to the short run. When money supply increases, demand in both countries increases, and in the short run the transmission mechanism would prevail as follows. Facing fixed prices and demand increasing both at home and abroad, firms in sector M raise their output and demand more labor, causing wages to rise. In contrast, prices in sector T rise to respond quickly to increasing demand. This causes the relative price of T goods to M goods to rise and thus to some extent shifts demand from T goods to M goods. The effects of wage rising and demand shift will bring about a decrease in output of firms in sector T and a shift of labor from sector T to sector M in each country. Given prices in sector M unchanged, the increase in prices in sector T raises the price level, but to a lesser degree. The part of aggregate demand that is not adjusted by the change in the price level will be met by a rise in output. People work more and have more income and thus consumption increases.

Now we turn on the effects of an increase in technology level in sector M of both countries. In the short run, firms in sector M cannot change their prices, and given the demand for their goods unchanged (for the moment), will reduce labor demand, causing wages to fall. Labor moves from sector M to sector T. The prices of T goods fall proportionally to wages[18]. This causes the relative price of T goods to M goods to fall, and shifts demand from M goods to T goods. As a result, output decreases in sector M while increases in sector T. This is a quite surprising result in that a *positive* shock to sector M reduces its output in the short run. Also note that, the fall of wages lowers production costs of firms in sector T, and given their flexible prices, increases their output from the supply side. The price level will fall due to the fall in prices of T goods. The shock will cause income to rise in the long run, thus consumption rises from the short run (and the long run too) due to consumption-smoothing behavior of households. This causes aggregate demand, and thus GDP to rise. In the long run, all prices are flexible and the technology shock will have its full effects: GDP increases more and price level falls more. Also note that, in the long run, the relative price of T goods rises (by the same amount with the shock, 1%[19]) so demand and thus labor will shift from sector T to sector M.

Next, we move on to investigate the effects of a positive technology shock to sector T of both countries. The logic is quite similar with the case of a technology shock to sector M discussed above, however the results are different due to the assumption of flexible prices in sector T. In the short run, prices in sector T fall quickly in response to the shock. As a result, price level falls, and so does the relative price of T goods,

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[18] Because in this case, the monopolistic firm in sector T of both countries faces a linear production function, and thus will set the price with a fixed markup rate over the wage.

[19] From the markup principle, the changes of prices in sectors T and M are set as follows: $\%\Delta p(z_T) = \%\Delta W$, $\%\Delta p(z_M) = \%\Delta W - \%\Delta A_M$ so $\%\Delta[p(z_T)/p(z_M)] = \%\Delta p(z_T) - \%\Delta p(z_M) = \%\Delta A_M$.

which in turn causes demand and labor to shift from sector M to sector T. Output increases in sector T, while decreases in sector M. It is worth noting that, also this result as well as the adjustment of the relative price and the shift of labor across sectors look similar in this case and the case of a shock to technology level of sector M seen above, there is a big difference between the two which lies in the cause of labor shift from sector M to sector T. The cause in the former is the decrease in labor demand of firms in sector M, while the cause in the latter is the increase in labor demand of firms in sector T. Consumption increases because households know that their future income will rise, thus aggregate demand and GDP increase. The effects in the long run on GDP and the price level are quite similar to the above case, but to a larger degree. This is because sector T, where firms have less monopoly power, is larger in size than sector M.

In the last part of this sub-section, we will see the effects of a symmetric government spending shock to both countries. A permanent government shock raises GDP even in the long run, the period in which all prices are flexible. This is because of the substituting between work and leisure of households, i.e. an increase in government means an increase in tax on households, which will reduce their consumption and raise their working hours. In the short run, in addition to this effect, given the rigidity of M goods, only a part of the increasing aggregate demand is adjusted by a rise in the price level so the rest must be met by an increase in output. From the sectoral view point, the prices in sector T rise quickly in response to increasing demand, the relative price of T goods rises, demand and labor shift from sector T to sector M.

To summarize this sub-section, we have seen the effects and the transmission mechanisms of four types of (symmetric) shocks to the two economies. The movement of labor across sectors and the changes of relative prices play a crucial role in this model. Although different depending on the type of shocks, the effects of shock on real GDP and the price level (as well as on other variables) are completely symmetric due to the symmetric structure of the two economies, which we set in this sub-section.

Below, we will introduce various kinds of differences between the two countries that we discussed in section 2.

4.2. Case 2: Asymmetric in technology levels

In this case, parameters are the same as Case 1 except for technology levels which are reset as follows, $A_{T,TH} = \exp(0), A_{T,JP} = \exp(1.2), A_{M,TH} = \exp(1.0), A_{M,JP} = \exp(2.8)$.

With this setting, JP has an advantage in M goods and TH in T goods and thus the ratio (size of sector M/size of sector T) is greater in JP than in TH. In fact, in our calibration, the numbers at the steady state for JP and TH respectively are 1/0.2 and 1/1.4 in terms of labor input, and 1/0.2 and 1/1.2 in terms output. This will be important in our analysis below. The calibration results are shown in Table 2-2.

For the case of a monetary shock, again, we focus on the short run. The mechanisms are basically similar to Case 1. There is, however, a new thing. That is the change in relative price of T goods in JP to T goods in TH. An increase in money supply in both countries will raise this price because wages rise more in JP than in TH[20], which in turn is the result of the adjustment in the labor market when labor demand increases in sector M of both countries, given the higher share of sector M's

[20] Note that in this setting, in sector T, the production function of firms is linear, and thus the price is set with a fixed markup rate over the wage and changes of the two are proportional.

labor input in JP than in TH. Thus, people in both countries will shift their demand from T goods of JP to that of TH[21], this results in a more severe decrease in output of sector T in JP, and lesser in TH. The increase in output in sector M remains the same in both countries. Nevertheless, because sector M is relatively larger in JP than in TH, an expansion in its output contributes more to GDP, so GDP rises more in JP than in TH.

In the case of a positive technology shock to sector M in both countries, again we see a sharper response of wages in JP than in TH because relatively more labor flows from sector M to sector T in JP than in TH due to the decrease in labor demand of firms in sector M. The result is that the relative price of T goods in JP to T goods in TH falls, and demand shifts from T goods of TH to that of JP, so we can see a sharp increase in output of sector T in JP, while that of TH is milder. The gap between changes in GDP of TH and JP also depends on the degree to which GDP in sector M falls (which is the same in both countries). In this case GDP of JP rises more compared to that of TH. In the long run, all prices are flexible, labor moves to sector M which has a higher technology level. The shock has a stronger effect to push GDP in JP than in TH because of the relatively larger size of sector M in JP.

We move on to see the case of an increase in technology level in sector T in both countries. Here too, we can confirm the difference in responses of wages in the two countries. In the short run, similar to Case 1, in response to the shock prices in sector T fall quickly, causing the relative price of T goods to fall and demand to shift from M to T goods. A fall in demand in sector M will have a stronger impact to reduce labor demand (the rate is the same but the amount is larger) and thus to

[21] Al so note that, given the same change in relative price, the shift in demand is larger within T goods than between T goods and M goods because $\theta_T > \theta_M$.

reduce wages more in JP than TH. In TH we observe a slight increase in wages which is possibly because the effects of the increasing in labor demand in sector T overwhelm the effects of the decreasing labor demand in sector M and the decreasing labor supply (due to the substituting between work and leisure of households). Thus, the relative price of T goods of JP and TH falls, demand shifts from T goods of TH to that of JP. This, however, has a small effect on GDP of JP (due to the relatively small size of sector T in JP). Nevertheless, the effect of the shock to raise output in sector T (which is relatively large) in TH is still large, and together with the fall in output of sector M which will have more impact in JP, causes GDP of TH to rise more than that of JP. The results on GDP in the long run are quite similar. We confirm that (in the long run) a technology shock to the sector where the country has a relative advantage, will have a stronger impact to that country compared to the other.

The effects of a symmetric government spending shocks are almost similar to Case 1 in the long run. In the short run, there does exist some asymmetric responses of labor supply and wages and thus prices and demand for T goods, however they are quite small.

Also note that, in all types of shocks have completely symmetric effects on price levels in the two countries. This can be explained as follows. In the long run, the optimal prices of firms are set according to the law of one price due to the optimization behavior of firms. In the short run, this holds for firms in sector T (because they are free to set their prices), and also holds for firms in sector M because their prices are fixed at the steady state level at which the law of one price holds too. Hence, the result is that PPP always holds, and given the fixed exchange rate, changes in price levels of the two countries must be the same. This result for the price level will remain to hold in the cases that follow.

3. Case 3: Asymmetric in α (the coefficient regarding labor input in the production function)

In this case, parameters are the same as Case 1 except for α which are re-set as follows, $\alpha_{T,TH} = 1, \alpha_{T,JP} = \alpha_{M,TH} = \alpha_{M,JP} = 0.5$. With this setting, although the technology level is the same, firms in sector T of TH will have a production function with fixed marginal costs, while firms in sector M of TH and sectors M and T of JP will face a production function with increasing marginal costs. Thus we have the same results as Case 2 that the ratio (size of sector M/size of sector T) is greater in JP than in TH. The steady state numbers for JP and TH respectively are 1/1.1 and 1/5.1 in terms of labor input, and 1/0.9 and 1/1.2 in terms of output.

From the difference in relative size between sectors of the two economies, we can predict that the asymmetry in responses to a shock in this case is similar to Case 2. The results shown in Table 2-3 confirm this. In the short run GDP of JP rises more to a positive monetary shock, and less to a positive technology shock to sector T. In the long run, JP's GDP rises more to a positive technology shock to sector M, and less to a positive technology shock to sector T. The difference from Case 3 is that in JP due to the nonlinear form of the production function, labor demand responses more strongly to changes in demand, and changes in prices of firms in sector T and changes in wages are less proportional[22]. Hence, when a positive technology shock

[22] From the production function of firms, we have the demand elasticity of labor demand equal to $1/\alpha_{k,JP}$, which is now larger than that in Case 2 (where $\alpha_{k,JP} = 1$). Also note that, from the price set by firms in Sector T of JP now is also affected by the change in marginal costs.

hits sector T in both countries, the relative price of T goods in JP and TH changes less, so less demand shift from T goods of TH to that of JP. In addition, firms in sector in JP now faces increasing marginal costs, so their output increases less than it would be in the case of a linear production function. As a result we see in the table that the increases in GDP of TH and JP become closer. A symmetric government spending shock causes a larger difference on labor supply in short run and a slight difference in GDP between the two countries in the long run.

4. Case 4: All asymmetries together

In this case we put together the asymmetries between the two countries, which we discussed in Cases 2 and 3. In addition, in order reflect better the difference often observed in reality between the developed and developing countries in relative size of sectors M and T, the numbers of firms in the two countries are reset such that $\gamma_{T,TH} = 0.5, \gamma_{T,JP} = 0.2$. In this case, the relative size of sector M (to sector T) is dominantly larger in JP than in TH. The numbers at the steady state for this relative size are 1/0.1 and 1/5.4 in terms of labor input, and 1/0.1 and 1/2.3 in terms of output.

The calibration results are reported in Table 2-4. We confirm all the asymmetric effects observed in the previous cases but to a larger degree. Three things are worth noting. First, in the presence of a positive monetary shock in the short run, GDP of TH falls slightly while increases in JP, which can be explained as follows. The effect of demand shift away from T goods of TH (to M goods of TH and JP, due to the increase in the relative price) exceeds the effect of demand shift to M goods of TH, demand shift from T goods of JP to that of TH and the increase in consumption world wide. In contrast, in JP because of the large size of sector M, the effects of demand shift to M goods and the increase in consumption are large enough to dominate other opposite effects. Second, a positive technology shock to sector T causes GDP to fall slightly in JP, while increases in TH. This is because, relatively, the decrease in output of sector M (due to a higher relative price between M and T goods) is large and the increase in output of sector T is small, while the opposite occurs in TH. The third thing is that, a positive technology shock to sector M raises GDP more in TH than in JP in the short run. This is quite different from Case 2. The reason is that firms in sector T of JP now face increasing marginal costs when they raise their output. Thus, in the presence of the shock, their output increases less (than when their marginal costs are fixed), and this in turn brings about a less increase in GDP of JP.

Some words are added to summarize this section. Throughout the section we have seen in detail how the differences in technology level, and the coefficient concerning labor input in the production function of firms play their role to generate asymmetric responses to various kinds of symmetric shocks to the developed and developing countries. These differences not only give rise to the difference in the relative size of the industrial sector to the agricultural sector of the two countries, but also affect the transmission mechanism of the shock through the allocation of resources (labor) between sectors which is crucial in this paper. In all cases of calibration, the results of the long run are predictable (for example, monetary shocks have no effect to real variables, or symmetric technology shocks to a sector have stronger effects on output of the country where that sector' relative size is large). The results in the short run in some cases are surprising (for example, a positive symmetric shocks to the industrial sector could cause GDP to increase more in the developing country than in the developed one in Case 4).

5. Conclusion Remarks

Extending the framework of Obstfeld and Rogoff (1995) and referring to the structure of economies in East Asia, this paper incorporates the difference in development stages into a two-country two-sector model to analyze how this difference affects the responses of various economic variables in the developed and developing countries to symmetric shocks. The model allows us to see not only the effects of the shocks, but also the mechanisms behind them.

The paper finds that, due to the difference in the relative size of sectors, the degree of price rigidity a symmetric shock can have asymmetric effects on the developed and developing countries, although these effects are different between the short and long runs. In particular, in the short run, a symmetric increase in money supply can cause GDP to rise sharply the developed country and to fall in the developing country, while a symmetric technology shock to the agricultural sector has opposite effects. In addition, a symmetric positive technology shock to the industrial sector could raise GDP more in the developing country than in the developed country.

The results suggest that the difference in development stages is important because it affects the costs of monetary union.

Admittedly, to firmly understand the interaction between economies and sectors in the presence of shocks, some parts of the model are made simple. Also, parameters are set mainly for an illustrative purpose. In the future work, I shall try to extend the framework to a three-country version with full dynamics and use data to estimate parameters such that they reflect better the reality in East Asia.

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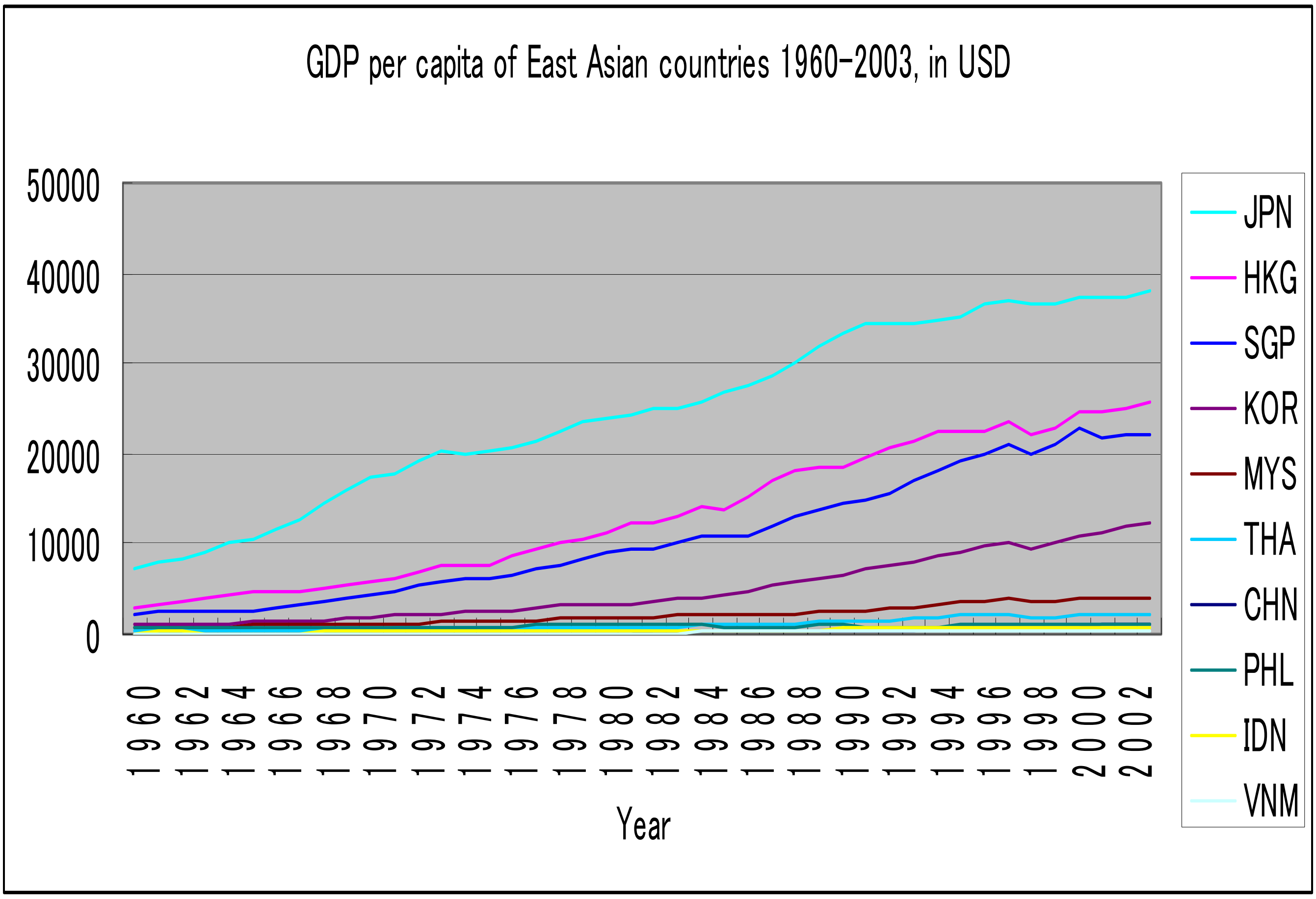
Figure 1



Note: East Asian countries here are Japan, Hong Kong, Singapore, Korea, Malaysia, Thailand, China, Philippines, Indonesia and Vietnam.

Source: World Development Indicators, 2005.

Figure 2

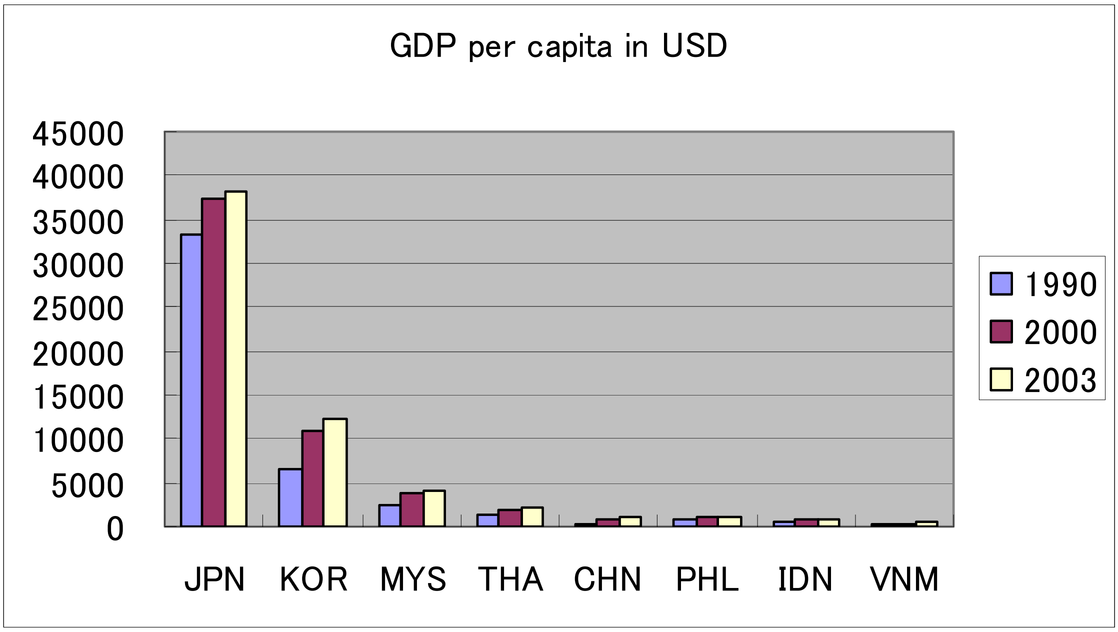


Figure 3

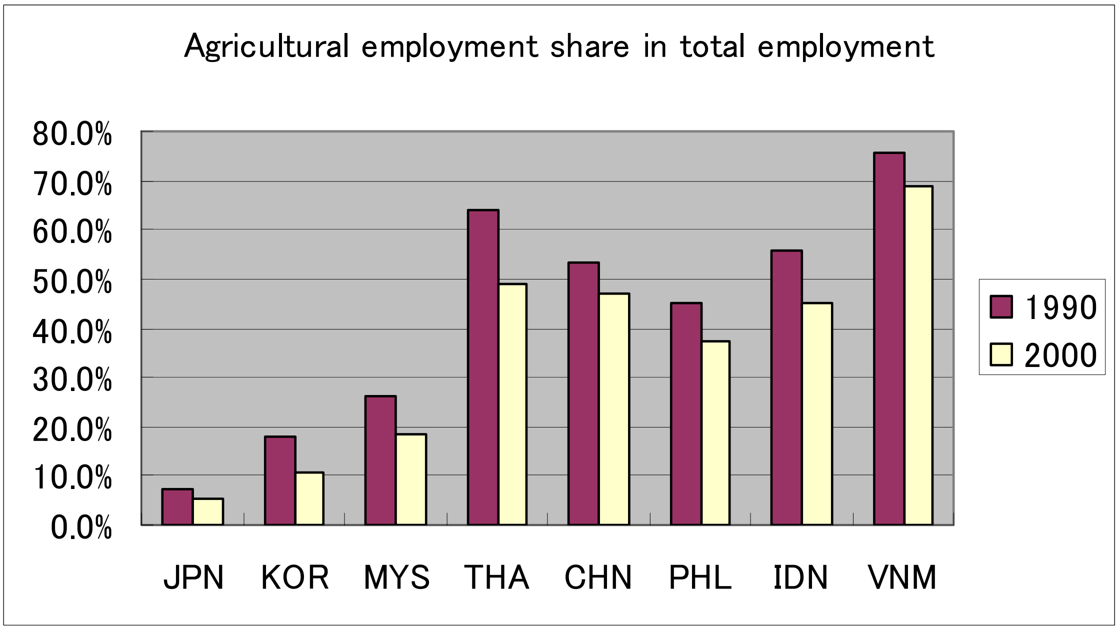


Figure 4

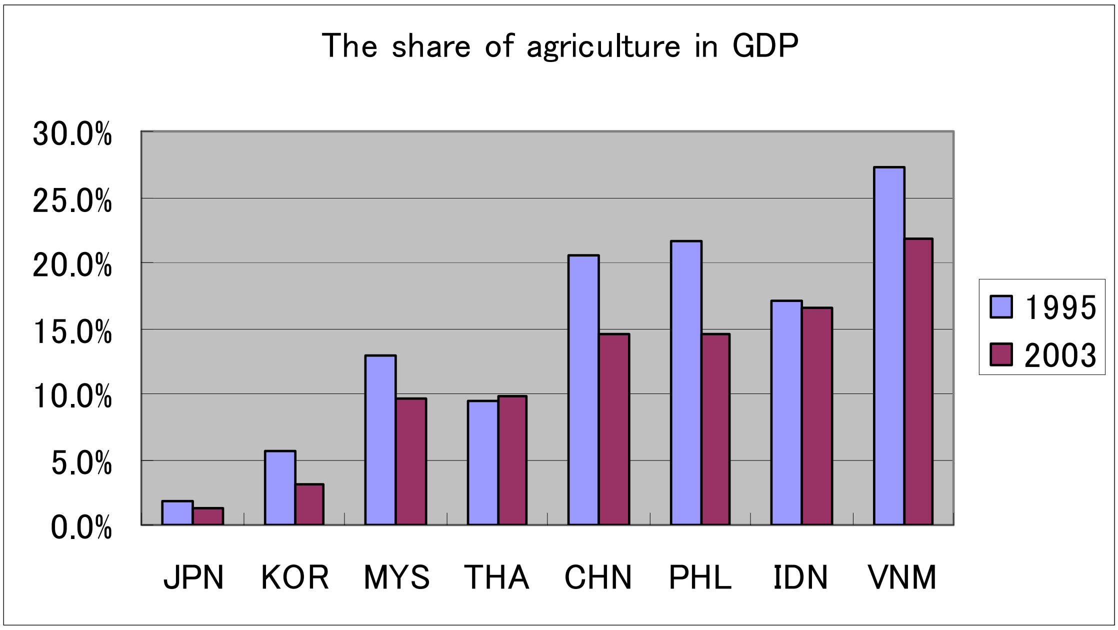


Figure 5

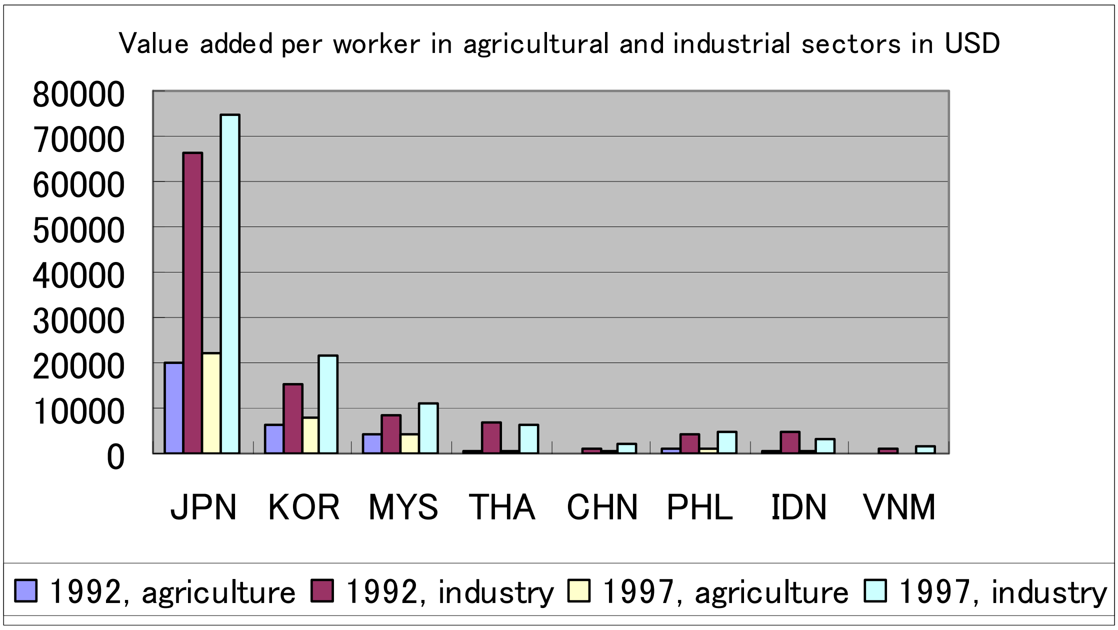


Table 1

Parameter values used for calibration

Parameters	Values
Discount factor (β)	0.96
Disutility of work parameter (κ)	1
Money in the utility parameter (χ)	1
Elasticities of substitution	
between T and M goods (ρ)	2
within T goods (θ_T)	10
within M goods (θ_M)	4
Population share	
of TH in the world (n)	0.5
Numbers of firms	
in sector T in TH ($\gamma_{T,TH}$)	0.5
in sector T in JP ($\gamma_{T,JP}$)	0.5
The shares in GDP of government spending-consumption ratios in	
TH	0.25
JP	0.25

Percentage deviations from the steady state when permanent symmetric shocks hit both countries

Table 2-1 **Case1: All symmetric**

	1% of money supply Shock		1% of technology Shock in sector M		1% of technology shock in sector T		1% of gov. spending shock	
	SR	LR	SR	LR	SR	LR	SR	LR
Exchange rate	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Current account of TH	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Real GDP of TH	0.26%	0.00%	0.11%	0.39%	0.49%	0.50%	0.14%	0.11%
Real GDP of JP	0.26%	0.00%	0.11%	0.39%	0.49%	0.50%	0.14%	0.11%
Price level TH	0.68%	1.00%	−0.14%	−0.49%	−0.61%	−0.63%	0.08%	0.11%
Price level JP	0.68%	1.00%	−0.14%	−0.49%	−0.61%	−0.63%	0.08%	0.11%
Consumption of TH	0.32%	0.00%	0.14%	0.49%	0.61%	0.63%	−0.08%	−0.11%
Consumption of JP	0.32%	0.00%	0.14%	0.49%	0.61%	0.63%	−0.08%	−0.11%
Output of firm in T,TH	−0.71%	0.00%	0.31%	−0.44%	1.36%	1.33%	0.03%	0.11%
Output of firm in M,TH	1.61%	0.00%	−0.17%	1.56%	−0.73%	−0.67%	0.29%	0.11%
Output of firm in T,JP	−0.71%	0.00%	0.31%	−0.44%	1.36%	1.33%	0.03%	0.11%
Output of firm in M,JP	1.61%	0.00%	−0.17%	1.56%	−0.73%	−0.67%	0.29%	0.11%
Labor demand of firm in T,TH	−0.71%	0.00%	0.31%	−0.44%	0.36%	0.33%	0.03%	0.11%
Labor demand of firm in M,TH	1.61%	0.00%	−1.17%	0.56%	−0.73%	−0.67%	0.29%	0.11%
Labor demand of firm in T,JP	−0.71%	0.00%	0.31%	−0.44%	0.36%	0.33%	0.03%	0.11%
Labor demand of firm in M,JP	1.61%	0.00%	−1.17%	0.56%	−0.73%	−0.67%	0.29%	0.11%
Labor supply in TH	0.16%	0.00%	−0.24%	−0.07%	−0.05%	−0.04%	0.13%	0.11%
Labor supply in JP	0.16%	0.00%	−0.24%	−0.07%	−0.05%	−0.04%	0.13%	0.11%
Wage in TH	1.16%	1.00%	−0.24%	−0.07%	−0.05%	−0.04%	0.13%	0.11%
Wage in JP	1.16%	1.00%	−0.24%	−0.07%	−0.05%	−0.04%	0.13%	0.11%
Price of T,TH firm set in TH market	1.16%	1.00%	−0.24%	−0.07%	−1.05%	−1.04%	0.13%	0.11%
Price of M,TH firm set in TH market	0.00%	1.00%	0.00%	−1.07%	0.00%	−0.04%	0.00%	0.11%
Price of T,JP firm set in JP market	1.16%	1.00%	−0.24%	−0.07%	−1.05%	−1.04%	0.13%	0.11%
Price of M,JP firm set in JP market	0.00%	1.00%	0.00%	−1.07%	0.00%	−0.04%	0.00%	0.11%
Price of T,TH firm set in *JP market*	1.16%	1.00%	−0.24%	−0.07%	−1.05%	−1.04%	0.13%	0.11%
Price of M,TH firm set in *JP market*	0.00%	1.00%	0.00%	−1.07%	0.00%	−0.04%	0.00%	0.11%
Price of T,JP firm set in *TH market*	1.16%	1.00%	−0.24%	−0.07%	−1.05%	−1.04%	0.13%	0.11%
Price of M,JP firm set in *TH market*	0.00%	1.00%	0.00%	−1.07%	0.00%	−0.04%	0.00%	0.11%

Table 2-2

Case 2: Asymmetric in technology levels ($A_{T,TH} = \exp(0), A_{T,JP} = \exp(1.2), A_{M,TH} = \exp(1.0), A_{M,JP} = \exp(2.8)$)

	1% of money supply shock		1% of technology shock in sector M		1% of technology shock in sector T		1% of gov. spending shock	
	SR	LR	SR	LR	SR	LR	SR	LR
Exchange rate	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Current account of TH	0.18%	0.18%	−0.21%	−0.21%	0.02%	0.02%	0.02%	0.02%
Real GDP of TH	0.33%	0.00%	0.01%	0.41%	0.52%	0.49%	0.15%	0.11%
Real GDP of JP	0.58%	0.00%	0.14%	0.76%	0.11%	0.13%	0.18%	0.11%
Price level TH	0.35%	1.00%	−0.13%	−0.85%	−0.25%	−0.26%	0.04%	0.11%
Price level JP	0.35%	1.00%	−0.13%	−0.85%	−0.25%	−0.26%	0.04%	0.11%
Consumption of TH	0.66%	0.00%	0.07%	0.79%	0.31%	0.32%	−0.04%	−0.11%
Consumption of JP	0.65%	0.00%	0.15%	0.87%	0.24%	0.25%	−0.04%	−0.11%
Output of firm in T,TH	−0.42%	0.00%	0.15%	−0.44%	1.21%	1.34%	0.06%	0.11%
Output of firm in M,TH	1.21%	0.00%	−0.16%	1.40%	−0.30%	−0.51%	0.25%	0.11%
Output of firm in T,JP	−2.60%	0.00%	1.60%	−1.10%	2.13%	1.98%	−0.18%	0.11%
Output of firm in M,JP	1.21%	0.00%	−0.16%	1.14%	−0.30%	−0.25%	0.25%	0.11%
Labor demand of firm in T,TH	−0.42%	0.00%	0.15%	−0.44%	0.21%	0.34%	0.06%	0.11%
Labor demand of firm in M,TH	1.21%	0.00%	−1.16%	0.40%	−0.30%	−0.51%	0.25%	0.11%
Labor demand of firm in T,JP	−2.60%	0.00%	1.60%	−1.10%	1.13%	0.98%	−0.18%	0.11%
Labor demand of firm in M,JP	1.21%	0.00%	−1.16%	0.14%	−0.30%	−0.25%	0.25%	0.11%
Labor supply in TH	0.26%	0.00%	−0.39%	−0.09%	0.00%	−0.01%	0.14%	0.11%
Labor supply in JP	0.48%	0.00%	−0.62%	−0.10%	−0.02%	−0.01%	0.16%	0.11%
Wage in TH	1.26%	1.00%	−0.45%	−0.15%	0.05%	0.04%	0.14%	0.11%
Wage in JP	1.48%	1.00%	−0.60%	−0.09%	−0.04%	−0.02%	0.16%	0.11%
Price of T,TH firm set in TH market	1.26%	1.00%	−0.45%	−0.15%	−0.95%	−0.96%	0.14%	0.11%
Price of M,TH firm set in TH market	0.00%	1.00%	0.00%	−1.15%	0.00%	0.04%	0.00%	0.11%
Price of T,JP firm set in JP market	1.48%	1.00%	−0.60%	−0.09%	−1.04%	−1.02%	0.16%	0.11%
Price of M,JP firm set in JP market	0.00%	1.00%	0.00%	−1.09%	0.00%	−0.02%	0.00%	0.11%
Price of T,TH firm set in *JP market*	1.26%	1.00%	−0.45%	−0.15%	−0.95%	−0.96%	0.14%	0.11%
Price of M,TH firm set in *JP market*	0.00%	1.00%	0.00%	−1.15%	0.00%	0.04%	0.00%	0.11%
Price of T,JP firm set in *TH market*	1.48%	1.00%	−0.60%	−0.09%	−0.0104	−1.02%	0.16%	0.11%
Price of M,JP firm set in *TH market*	0.00%	1.00%	0.00%	−1.09%	0	−0.02%	0.00%	0.11%

Table 2-3

Case 3: Asymmetric in the coefficient regarding labor input ($\alpha_{T,TH} = 1, \alpha_{T,JP} = \alpha_{M,TH} = \alpha_{M,JP} = 0.5$)

	1% of money supply shock		1% of technology shock in sector M		1% of technology shock in sector T		1% of gov. spending shock	
	SR	LR	SR	LR	SR	LR	SR	LR
Exchange rate	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Current account of TH	−0.08%	−0.08%	0.06%	0.06%	0.03%	0.03%	−0.01%	−0.01%
Real GDP of TH	0.14%	0.00%	0.12%	0.25%	0.62%	0.65%	0.12%	0.10%
Real GDP of JP	0.49%	0.00%	0.10%	0.50%	0.29%	0.44%	0.13%	0.06%
Price level TH	0.63%	1.00%	−0.14%	−0.46%	−0.59%	−0.69%	0.09%	0.15%
Price level JP	0.63%	1.00%	−0.14%	−0.46%	−0.59%	−0.69%	0.09%	0.15%
Consumption of TH	0.36%	0.00%	0.07%	0.39%	0.63%	0.74%	−0.07%	−0.13%
Consumption of JP	0.37%	0.00%	0.22%	0.54%	0.53%	0.63%	−0.11%	−0.17%
Output of firm in T,TH	−0.53%	0.00%	0.25%	−0.23%	1.23%	1.10%	0.04%	0.13%
Output of firm in M,TH	1.56%	0.00%	−0.16%	1.28%	−0.70%	−0.31%	0.31%	0.03%
Output of firm in T,JP	−0.70%	0.00%	0.38%	−0.18%	1.35%	1.13%	−0.06%	0.05%
Output of firm in M,JP	1.56%	0.00%	−0.16%	1.13%	−0.70%	−0.20%	0.31%	0.07%
Labor demand of firm in T,TH	−0.53%	0.00%	0.25%	−0.23%	0.23%	0.10%	0.04%	0.13%
Labor demand of firm in M,TH	3.12%	0.00%	−2.33%	0.55%	−1.40%	−0.62%	0.62%	0.06%
Labor demand of firm in T,JP	−1.39%	0.00%	0.76%	−0.37%	0.71%	0.27%	−0.11%	0.10%
Labor demand of firm in M,JP	3.12%	0.00%	−2.33%	0.26%	−1.40%	−0.40%	0.62%	0.13%
Labor supply in TH	0.07%	0.00%	−0.16%	−0.10%	−0.03%	−0.02%	0.13%	0.12%
Labor supply in JP	0.78%	0.00%	−0.70%	−0.07%	−0.29%	−0.05%	0.24%	0.12%
Wage in TH	1.07%	1.00%	−0.23%	−0.17%	0.02%	0.03%	0.15%	0.14%
Wage in JP	1.78%	1.00%	−0.62%	0.01%	−0.35%	−0.11%	0.21%	0.09%
Price of T,TH firm set in TH market	1.07%	1.00%	−0.23%	−0.17%	−0.98%	−0.97%	0.15%	0.14%
Price of M,TH firm set in TH market	0.00%	1.00%	0.00%	−0.89%	0.00%	−0.28%	0.00%	0.17%
Price of T,JP firm set in JP market	1.09%	1.00%	−0.24%	−0.17%	−1.00%	−0.97%	0.16%	0.15%
Price of M,JP firm set in JP market	0.00%	1.00%	0.00%	−0.85%	0.00%	−0.31%	0.00%	0.16%
Price of T,TH firm set in *JP market*	1.07%	1.00%	−0.23%	−0.17%	−0.98%	−0.97%	0.15%	0.14%
Price of M,TH firm set in *JP market*	0.00%	1.00%	0.00%	−0.89%	0.00%	−0.28%	0.00%	0.17%
Price of T,JP firm set in *TH market*	1.09%	1.00%	−0.24%	−0.17%	−0.01	−0.97%	0.16%	0.15%
Price of M,JP firm set in *TH market*	0.00%	1.00%	0.00%	−0.85%	0.00%	−0.31%	0.00%	0.16%

Table 2-4

Case 4: All asymmetries together （$A_{T,TH} = \exp(0), A_{T,JP} = \exp(1.2), A_{M,TH} = \exp(1.0), A_{M,JP} = \exp(2.8)$，

$\alpha_{T,TH} = 1, \alpha_{T,JP} = \alpha_{M,TH} = \alpha_{M,JP} = 0.5$， $\gamma_{T,TH} = 0.5, \gamma_{T,JP} = 0.2$）

	1% of money supply shock		1% of technology shock in sector M		1% of technology shock in sector T		1% of gov. spending shock	
	SR	LR	SR	LR	SR	LR	SR	LR
Exchange rate	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Current account of TH	−0.28%	−0.28%	0.25%	0.25%	0.07%	0.07%	−0.06%	−0.06%
Real GDP of TH	−0.01%	0.00%	0.20%	0.22%	0.71%	0.68%	0.09%	0.10%
Real GDP of JP	0.83%	0.00%	0.02%	0.86%	−0.04%	0.08%	0.21%	0.06%
Price level TH	0.23%	1.00%	−0.08%	−0.88%	−0.18%	−0.28%	0.02%	0.16%
Price level JP	0.23%	1.00%	−0.08%	−0.88%	−0.18%	−0.28%	0.02%	0.16%
Consumption of TH	0.77%	−0.01%	−0.17%	0.62%	0.42%	0.53%	0.00%	−0.14%
Consumption of JP	0.78%	0.00%	0.17%	0.96%	0.10%	0.21%	−0.03%	−0.17%
Output of firm in T,TH	−0.50%	0.00%	0.33%	−0.26%	1.12%	1.12%	0.04%	0.13%
Output of firm in M,TH	1.07%	0.00%	−0.10%	1.28%	−0.21%	−0.32%	0.23%	0.04%
Output of firm in T,JP	−1.56%	0.00%	1.19%	−0.36%	1.56%	1.32%	−0.27%	0.04%
Output of firm in M,JP	1.07%	0.00%	−0.10%	0.99%	−0.21%	−0.05%	0.23%	0.06%
Labor demand of firm in T,TH	−0.50%	0.00%	0.33%	−0.26%	0.12%	0.12%	0.04%	0.13%
Labor demand of firm in M,TH	2.14%	0.00%	−2.20%	0.57%	−0.42%	−0.64%	0.46%	0.07%
Labor demand of firm in T,JP	−3.11%	0.00%	2.38%	−0.72%	1.13%	0.64%	−0.54%	0.08%
Labor demand of firm in M,JP	2.14%	0.00%	−2.20%	−0.02%	−0.42%	−0.10%	0.46%	0.12%
Labor supply in TH	−0.08%	0.00%	−0.06%	−0.13%	0.04%	0.00%	0.09%	0.12%
Labor supply in JP	1.57%	0.00%	−1.68%	−0.10%	−0.25%	−0.01%	0.42%	0.12%
Wage in TH	0.91%	1.00%	−0.32%	−0.39%	0.28%	0.25%	0.11%	0.14%
Wage in JP	2.57%	1.00%	−1.59%	−0.02%	−0.33%	−0.09%	0.41%	0.11%
Price of T,TH firm set in TH market	0.91%	1.00%	−0.32%	−0.39%	−0.72%	−0.75%	0.11%	0.14%
Price of M,TH firm set in TH market	0.00%	1.00%	0.00%	−1.10%	0.00%	−0.07%	0.00%	0.18%
Price of T,JP firm set in JP market	1.02%	1.00%	−0.40%	−0.38%	−0.76%	−0.77%	0.14%	0.15%
Price of M,JP firm set in JP market	0.00%	1.00%	0.00%	−1.03%	0.00%	−0.14%	0.00%	0.17%
Price of T,TH firm set in *JP market*	0.91%	1.00%	−0.32%	−0.39%	−0.72%	−0.75%	0.11%	0.14%
Price of M,TH firm set in *JP market*	0.00%	1.00%	0.00%	−1.10%	0.00%	−0.07%	0.00%	0.18%
Price of T,JP firm set in *TH market*	1.02%	1.00%	−0.40%	−0.38%	−0.76%	−0.77%	0.14%	0.15%
Price of M,JP firm set in *TH market*	0.00%	1.00%	0.00%	−1.03%	0.00%	−0.14%	0.00%	0.17%

Note: The results for current account of TH are calculated as the *ratio to consumption* of TH at the steady state.