# Welfare implications of the 1995-1998 yen depreciation on Asia

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December 24, 2000

## 1 Introduction

Some economists have argued that the depreciation of the Japanese yen since 1995[1] was partly responsible for triggering the Asian currency crisis in 1997. According to those views, the yen depreciation made East Asian products much less competitive in the global market, and put great pressures on Asian countries to devalue their own currencies. In that sense, the yen depreciation was a kind of a "*beggar thy neighbor*" policy. The problem with this type of view is that it only looks at the producer side of the economy. Economic welfare depends not only on income generated from production but also on the amount of consumption people can enjoy. From the viewpoint of consumers, the yen depreciation actually could have been beneficial to Asian countries: through terms of trade improvement, consumers in those countries could enjoy cheaper imports from Japan. Simply looking at the effects on the production side of the economy does not tell us the whole story.

The above argument indicates that a complete analysis of the effects of the yen depreciation has to be *welfare-based*. We have to rely on a model that postulates an explicit social welfare function for each nation. The welfare function has to take into account not only costs of the yen depreciation (i.e. lower production) but also its benefits (i.e. terms of trade improvement), in a way they can be compared directly. For that purpose, this report utilizes a general equilibrium model with optimizing agents, in

[1] In April 1995, the yen was at the historically highest level of 1$=83.67¥. Since then, the yen depreciated rapidly, to 1$=101.85¥ in December. The yen continued to depreciate, and reached the level of 1$=125.51¥ in April 1997, just before the beginning of the Asian currency crisis. In August 1998, it hit the lowest value since mid 1990 at 1$=144.67¥. (All the numbers are monthly averages.)

which nation's welfare can be calculated explicitly from the agents' utility. The model is based on a theoretical framework developed by Corsetti, et. al. (1999), but is modified to meet our specific concerns.

The main conclusions are as follows. First, effects of the yen depreciation is likely to have varied from country to country, depending on each country's trade relationship with Japan and US. Second, welfare evaluation of the yen depreciation depends crucially on our judgement on the true cause of the depreciation. If it was caused by Japanese monetary expansion, as is popularly believed, the welfare cost to Asian nations may not have been large. If, however, it was due to a negative supply shock to Japan, such as a productivity slowdown, the impact is likely to have been negative and large. Thus, taken together, analysis in this report reveals that it is dangerous to try to arrive at a general conclusion that is applicable to all the Asian countries in all cases. A very careful empirical analysis is required to correctly evaluate the impact of the yen depreciation, on a case-by-case basis.

The rest of the report is organized as follows. Section 2 explains why the report pays special attention to the three key elements of the analysis: namely, trade relationship, type of underlying shocks, and exchange rate regimes. Section 3 describes the theoretical framework. Section 4 derives conclusions assuming that an Asian country fixes money supply constant and let the exchange rates fluctuate freely. Section 5 considers what happens if the country adopts a different exchange rate regime, to see if the country has an incentive to abandon the dollar peg. Section 6 performs an empirical study to see which of two models proposed in this report is more realistic. Section 7 summarizes conclusions from the theoretical analysis. Finally, section 8 discusses some of the aspects of the yen depreciation which are not captured well with the model.

## 2 Focus of the analysis

### 2-1 Trade relationship

This report argues that the impact of the yen depreciation is likely to have varied from country to country. It depended crucially on each Asian nation's trade relationship with

Japan and the US. As was discussed in the introduction, when the yen depreciated in 1995, Asian countries paid costs in the form of lost output, but also received benefits in the form of cheaper imports. Whether the costs dominated the benefits should have depended on the trade relationships of the Asian countries with Japan and other countries (most notably the US). Intuitively, if a country's products are competing bitterly with Japanese products in the world market, the costs of the yen depreciation could have been large. If a country is importing a lot of Japanese products, on the other hand, the benefits could have outweighed the costs. One of the purposes of this report is to give a firm theoretical foundation to these intuitions. To that end, this report develops two types of models that are meant to capture different trade relationships between Asian countries, Japan and the US. The models help us understand exactly what kind of trade relation is likely to convey a strong negative impact of the yen depreciation.

### 2-2 Type of shocks

Those who argue that the Japanese depreciation was a kind of a beggar thy neighbor policy implicitly assume that it was caused by policy. This view is not totally unfounded. During the year of 1995, the Japanese interbank interest rate (the over-night call rate) decreased from 2.25 in January to 0.46% in December. It is possible that the yen depreciation was one of the consequences of such monetary loosening. However, it is also possible that the depreciation was caused by another type of shock to the Japanese economy. As an alternative candidate for the cause of the depreciation, this report considers a negative productivity shock. From this view, the reduction of the Japanese call rate can be considered as a passive response from the Bank of Japan to the lower productivity.

### 2-3 Exchange rate regimes

The report also considers the roles of exchange rate arrangements. Most Asian countries, prior to the Asian crisis, were fixing their exchange rates against the US dollars. We investigate the hypothesis that the yen depreciation since 1995 made it more costly for Asian countries to maintain this fixed exchange rate system. In our bench mark case, we assume that the Asian country fixes its exchange rate against the US dollars. Then we derive welfare changes when the country moves to the free float system: namely, when the country keeps its money supply constant and let the market determine the equilibrium exchange rate. This report shows that welfare could improve or deteriorate, depending on the trade relationship with Japan.

The above two exchange rate arrangements are not the only possibilities. In recent years, trade with Japan has gained its importance for those countries[2]. As a consequence. some argue that those countries should move to a new exchange rate system, under which the value of the local currency is fixed against a basket of the US dollar and the Japanese yen. This report asks if Asian countries could have mitigated the impact of the yen depreciation by adopting such a new exchange rate regime. This report shows that, again, the answer to the question also becomes country/case specific. Under certain conditions (but by no means always), a country may want to partly insulate itself from an excessive impact of the yen depreciation, by moving to the new system.

## 3 Description of the theoretical approach

### 3-1 Related work

The model considered in this paper builds on the framework of Corsetti et al. (1999). Their model in turn is based on a multi country equilibrium model of Obstfeld and Rogoff (1995 and 1996). In the Obstfeld-Rogoff model, each country produces one type of goods. In each country, there are consumers who live for infinite number of periods. They decide today's consumption and labor supply so as to maximize their life-time utility, taking into account the intertemporal budget constraint. The model is characterized by *nominal rigidity*: Nominal prices are assumed to be set in advance, and stays unchanged during one period. This means that a pure monetary expansion could have real effects and could change the utility level of locals and foreigners as well.

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[2] According to Ueda (1998), exports from Japan to Asia increased from 47 billion dollars in 1985 to 193 billion dollars in 1995. During the same period, exports from the US to this area increased from 21 billion dollars to 45 billion dollars, which is less impressive. At the same time, exports from Asia to Japan increased from 9 billions dollars to 69 billion dollars, while exports to the US increased from 54 billion dollars to

Corsetti et. al. (1999) develops a three country version of the Obstfeld-Rogoff model. In their model, there are two "periphery" countries and one "center" country. The two periphery countries produce goods that are similar in their characteristics (they give examples of shirts and sweaters), or, using economics terminology, close substitutes. The center country, on the other hand, produces goods that are less similar (computers, for example), or less close substitutes. In this framework they study effects of a monetary expansion by one of the "periphery" countries on the other "periphery".

### 3-2 Our approach

In this report, reflecting varying types of trade relationship of Asian countries with Japan, two types of models are proposed. **Model 1** is a *"DC-LDC model"*. In this model, there are two developed countries (DCs), called US and Japan, and they produce goods that are close substitutes (say, big cars vs. small cars). There is also one less developed country (LDC), called Asia, and it produces very different type of goods (say bicycles) that are less substitutable with each type of the DC goods. This model is similar to the original model of Corsetti et. al., but, instead of having one "center" country and two "periphery" countries, we have two "centers" and one "periphery". This seems to be a natural extension of the original model, given that our purpose is to analyze effects of Japanese depreciation on Asia.

The above theoretical specification, however, may not capture the reality of some of the Asian countries very well. It should be noted that, in some Asian countries, most notably NIES, industrial structure is quite similar to Japan. This is partly due to direct investment from Japan. According to sources cited in Ueda (1998), between 1985 and 1995, Japan accounted for about 30% of FDIs into Asian NIES (Korea, Taiwan, and Singapore) and 23.5% of those flowing into Malaysia, Thailand, Philippines and Indonesia. Many Japanese manufacturers own plants both in Japan and in Asian countries. In many cases, Japanese plants and Asian plants produce goods that are similar to each other. Moreover, products from Asian plants of Japanese manufacturers

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183 billion dollars.

have a high propensity of being exported to other countries[3]. As a consequence, their presence among exports from those countries is much greater than their share in total domestic production. In such a situation, Japanese products and Asian products may be best considered as very close substitutes. To capture this situation, the report proposes **Model 2**, or the *"East-West Model"*. In this model, the two eastern countries (Japan and Asia) produce goods that are close substitutes (say the same small cars with different colors). And the western country (US) produces goods that are less substitutable (say big cars).

It turns out that the results from Model 2 depend crucially on the elasticity of substitution between Japanese products and Asian products. Below, we distinguish two cases depending on the value of this elasticity. In the first case, this elasticity is assumed to be not so high. This case is called Model 2-MS (MS stands for medium substitution). In the second case, this elasticity is very high. This case is called Model 2-HS (HS for high substitution).

### 3-3 Objectives

Using those two models, the report considers effects of two types of shocks: (A) a monetary expansion by Japan, and (B) a negative productivity shock to Japan. Their effects obviously differ depending on the specific exchange rate arrangements adopted by each of the three countries. In the models, US and Japan are always assumed to adopt the flexible exchange rate regime: the central bank fixes money supply, and the market determines the equilibrium exchange rate. For Asia, with each of the two models, three types of exchange rate arrangements are considered.

① Our base-line case is the "dollar peg" case. In this case, the Asian country adjusts its money supply in such a way that the exchange rate against US stays unchanged.

② Next, we ask what happens if the Asian country moves to the "free float" system. Under this regime, in the face of a shock to the Japanese economy, the Asian

[3] According to sources cited in Ueda (1998), Asian affiliates of the Japanese multinational companies export 26.8% of its production to outside Asia. In contrast, their affiliates in North America export only 8.4% of its production to outside North America.

country fixes money supply and let the market determine the new equilibrium exchange rate.

③ Finally, we ask what happens to the Asian country's welfare if the country chooses to fix its exchange rate against a basket of US and Japanese currencies, rather than just against US dollars. This is called the "basket peg" regime. If welfare turns out to be higher under this regime than under the "dollar peg" regime, the Asian country might prefer to switch to this kind of exchange rate system.

Before we move on to the analysis, we need to make a few remarks on the issue of exchange rate pass-through. In building a multi-country model with nominal rigidity, we have to decide how the rigidity enters the model. We could assume that prices are pre-set in the units of sellers' currency. Alternatively, we could assume that they are pre-set in the units of buyers' currency. Here, we take the first approach and assume that they are pre-set in the units of sellers' currencies. Thus, fluctuations in prices that buyers pay are in one-to-one relationship with those of the exchange rate between the seller's country and the buyer's country. In other words, we assume 100% exchange rate pass-through. Note that, for arguments such as "Japan took over markets from Asian countries by depreciating its currency" to make any sense, we have to assume at least some degree of exchange rate pass-through.

## 4 Model

The world consists of three countries, US (denoted by *U*), Japan (denoted by *J*), and Asia (denoted by *A*). Each country is inhabited by a continuum of households. The numbers of households in US, Japan, and Asia are all constant, and are denoted by $\gamma_U$, $\gamma_J$, and $\gamma_A$, respectively. I normalize the total number of population to unity, so that $\gamma_U + \gamma_J + \gamma_A = 1$ holds. Time is discrete and households live for infinite periods of time. There is free flow of goods and bonds between the countries.

### 4-1 Household

Each household produces one type of goods. Goods produced by different households are imperfect substitutes. This means that US produces $\gamma_U$ varieties of goods, while Japan and Asia produce $\gamma_J$ and $\gamma_A$ varieties of goods, respectively. There is no investment, which means that all the goods are consumer goods. We make an assumption on the utility function (which will be discussed later) so that all the households decide to consume all the goods produced by households all over the world.

Each period, each household obtains utility from consuming a bundle of consumer goods. It derives disutility from working to produce its own brand of consumer goods. It also derives utility from holding real money balance. The objective function of the household *x* in country *j* in period *t* is assumed to take the following form:

$$U_t^j(x) = E_t \sum_{s=0}^{\infty} \beta^s \left( \ln C_{t+s}^j(x) - \frac{\kappa_{t+s}^j}{2} \left( Y_{t+s}^j(x) \right)^2 + \chi \cdot \ln \left( \frac{M_{t+s}^j(x)}{P_{t+s}^j} \right) \right)$$

In the above, the utility function is assumed to take a time additively-separable form. The subjective discount factor, $\beta$, takes a value between 0 and 1. Inside the brackets, the first part of the periodic utility function represents utility from consumption. The variable $C_t^j(x)$ is the bundle of consumer goods (or the "composite consumption index") consumed by this household in period *t*. The exact definition of this index will be specified later. The second part represents the disutility of work. The variable $Y_t^j(x)$ is the amount of output produced by this household in period *t*, using labor as the sole input. The potentially time-varying parameter $\kappa$ (which is assumed to be positive) describes how work effort is related to output: when its value if high, it means that productivity is low (more work effort is needed to produce the same amount of output). The third part corresponds to the utility from money holding, where $M_t^j(x)$ is the amount of cash held by this household, denoted in the unit of the local currency, while $P_t^j$ is the average price level of country *j*, to be specified exactly later. The parameter $\chi$ is assumed to be positive. The household maximizes the above life time utility subject to a series of the following kind of periodic budget constraint (plus the initial as well as the no-Ponzi game condition):

$$\frac{E_t^j B_{t+1}^j(x)}{P_t^j} + \frac{M_t^j(x)}{P_t^j} + C_t^j(x) = (1+i_t)\frac{E_t^j B_t^j(x)}{P_t^j} + \frac{M_{t-1}^j(x)}{P_t^j} + \frac{P_t^j(x) \cdot Y_t^j(x)}{P_t^j} - \frac{T_t^j}{P_t^j}$$

In the above, $E_t^j$ is the exchange rate of country *j* (*j*=*U*, *J*, or *A*) in period *t*. We shall take the US dollar as the numereire so that $E_t^U = 1$. The other exchange rates are defined as the value of a US dollar in the units of local currency, so an *increase* in this variable means a *depreciation* of the local currency against the US dollars. $B_{t+1}^{j}(x)$ is the amount of bond held by this household at the end of period *t*, measured in US dollars. The nominal interest rate that accrues to holding this bond between periods *t-1* and *t* is denoted by $i_t$, and this is also measured in the US dollars. The assumption of free financial capital mobility implies that this value will always the same across the countries. $P_t^j(x)$ is the price of the goods produced by this household, defined in the units of the local currency. Due to the monopolistically competitive setup, this price is set by the household. And this price times output gives us the sales revenue earned by this household[4]. Finally, $T_t^j$ is the lump sum transfer from the government, also defined in the units of the local currency. It is assumed that all households in a given country obtains the same amount of transfers in a lump sum manner, and therefore the expression "*(x)*" is dropped from this variable.

Also, note that, as a producer, each household faces a downward sloping demand curve, as different varieties of goods are assumed to be imperfect substitutes. We shall specify exactly how those varieties of goods enter into each household's utility. For the moment, it suffices to know that each household faces the demand curve of the following kind:

$$Y_t^j(x) = \left[P_t^j(x)\right]^{-\theta} \cdot Z_t^j$$

where $\theta$ is a constant larger than one, whose role in the utility function will be spelled out later. And $Z_t^j$ is some variable that is beyond the control of each household.

### 4-2 Equilibrium conditions (country aggregates)

Here, we will discuss what kind of conditions have to be satisfied for aggregate variables in equilibrium. For example, define the "aggregate" consumption of country *j* in period *t* as the integral of $C_t^j(x)$ over all x in the country, divided by the population size. Denote such a variable as $C_t^j$. Define the aggregate output, $Y_t^j$, aggregate money

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[4] In this equation, I am using the result that, in equilibrium, the "law of one price" has to hold even in the short run. This is because prices are assumed to be rigid in seller's

holding (which is equal to aggregate money supply determined by the government), $M_t^j$, and aggregate bond holding, $B_t^j$, in analogous ways. Then, note that, in the previous sub-section, we assumed all the households in a given country to be symmetric. Moreover, it will be assumed later that all the goods produced in the same country enter into the utility function of the households in a symmetric manner. This implies that the following relationship has to hold in equilibrium:

$$C_t^j = C_t^j(x),\ \ Y_t^j = Y_t^j(x),\ \ M_t^j = M_t^j(x),\ \ B_t^j = B_t^j(x), \text{ for all } x, j \text{ and } t.$$

Also, the average price index for the goods produced and sold in country j (which will be specified later), $P_t^j$, will be equal to individual price $P_t^j(x)$, because the index treats all the goods involved symmetrically. Hence, in equilibrium, the following three conditions that are derived from individual household's optimization conditions have to be satisfied at the country aggregate level. First, the following Euler equation has to be satisfied:

$$\frac{C_{t+1}^j}{C_t^j} = \beta(1+i_{t+1})\frac{P_t^j / E_t^j}{P_{t+1}^j / E_{t+1}^j} \qquad \text{(for all } t \text{ and } j\text{)}$$

Second, the following "money demand" relationship has to be satisfied:

$$\frac{M_t^j}{P_t^j} = \chi C_t^j \frac{(1+i_{t+1})E_{t+1}^j}{(1+i_{t+1})E_{t+1}^j - E_t^j} \qquad \text{(for all } t \text{ and } j\text{)}$$

The previous two conditions have to be satisfied at all times. When prices are flexible, the following optimality condition for the consumption-leisure choice will have to be met as well:

$$\frac{P_{j,t}^j}{P_t^j} = \frac{\theta \cdot \kappa_t^j}{\theta - 1} C_t^j \cdot Y_t^j \qquad \text{(for all } t \text{ and } j\text{)}$$

In the following analysis, it is assumed that the economy starts from a flexible price equilibrium in which the above condition is satisfied. However, in the short run, the prices are rigid, and the economy might deviate from the above condition. In such a case, as long as the size of the disturbance is not too large, output will be demand determined. After one period, the economy goes back to a flexible price equilibrium in which the above condition is satisfied again.

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currency (a 100% exchange rate pass through).

Next, the government's budget constraint has to be satisfied in equilibrium. In this paper, it is assumed that the government's only role is to print money and to distribute it equally across households in a lump sum fashion. This implies:

$$M_t^j - M_{t-1}^j + T_t^j = 0 \qquad \text{(for all } t \text{ and } j\text{)}$$

Then the aggregate resource constraint for country $j$ can be written as:

$$E_t^j (B_{t+1}^j - B_t^j) = SR_t^j + i_t E_t^j B_t^j - P_t^j C_t^j \qquad \text{(for all } t \text{ and } j\text{)}$$

The world wide net supply of bonds has to be equal to zero:

$$\gamma_U B_t^U + \gamma_J B_t^J + \gamma_A B_t^A = 0 \qquad \text{(for all } t\text{)}$$

For each country, the amount of output produced by each household of the country has to equal demand from each country for that country's output:

$$Y_t^j(x) = D_{j,t}^U(x) + D_{j,t}^J(x) + D_{j,t}^A(x) \qquad \text{(for all } x, t \text{ and } j\text{)}$$

where $D_{j,t}^U(x)$, $D_{j,t}^J(x)$, and $D_{j,t}^A(x)$ are demand for output produced by household $x$ in country $j$ that come from the US, Japan, and Asia, respectively. Those demands will be specified in detail later.

## 4-3 Composite consumption indices (1)

Now we move on to specify contents of each consumption index. Note that the number of varieties of products over the whole world is equal to the world population, which is 1. We make a correspondence between each variety of goods to a point in a real line segment [0,1], so that the first [0, $\gamma_U$] part of the segment corresponds to the goods produced in the US, the next [$\gamma_U$, $\gamma_U + \gamma_J$] part corresponds to the Japanese goods, and the last [$\gamma_U + \gamma_J$, 1] part corresponds to the Asian goods.

It is assumed that the US goods enter into the utility of each household (in any country) through the following Dixit-Stiglitz type composite consumption index:

$$C_U^j(x) = \left[ \gamma_U^{-1/\theta} \cdot \int_0^{\gamma_U} \left( C_U^j(z,x) \right)^{(\theta-1)/\theta} dz \right]^{(\theta-1)/\theta}$$

The variable $C_i^j(z,x)$ inside the brackets denotes consumption by household $x$ (that lives in country $j$) of the $z$th good (produced in country $i$). In the above, $\theta$ denotes the elasticity of substitution between different varieties of the US goods. This is what appeared in equation (?) above. It is assumed to be greater than 1. Likewise, the

Japanese and the Asian composite consumption indices can be written as:

$$C_J^j(x) = \left[ \gamma_J^{-1/\theta} \cdot \int_{\gamma_U}^{\gamma_U+\gamma_J} \left( C_J^j(z,x) \right)^{(\theta-1)/\theta} dz \right]^{(\theta-1)/\theta},$$

and $$C_A^j(x) = \left[ \gamma_A^{-1/\theta} \cdot \int_{\gamma_U+\gamma_J}^{1} \left( C_A^j(z,x) \right)^{(\theta-1)/\theta} dz \right]^{(\theta-1)/\theta}$$

## 4-4 Composite consumption indices (2): Model 1 vs. Model 2

Up to here, model 1 and model 2 are completely the same. In both models, the three composite consumption indices are aggregated in certain ways to form the aggregate consumption composite indices, $C_t^j(x)$. The difference between the two comes from how this aggregate index is formed.

***Model 1 (DC-LDC model)***

In model 1, the US goods and the Japanese goods are assumed to be closer substitutes. The aggregate consumption composite index is defined in the following manner:

$$C_{DC}^j(x) = \left[ \left( \frac{\gamma_U}{\gamma_U + \gamma_J} \right)^{1/\psi} \cdot \left( C_U^j(x) \right)^{(\psi-1)/\psi} + \left( \frac{\gamma_J}{\gamma_U + \gamma_J} \right)^{1/\psi} \cdot \left( C_J^j(x) \right)^{(\psi-1)/\psi} \right]^{\psi/(\psi-1)},$$

and $$C^j(x) = \left[ (\gamma_U + \gamma_J)^{1/\rho} \cdot \left( C_{DC}^j(x) \right)^{(\rho-1)/\rho} + \gamma_A^{1/\rho} \cdot \left( C_A^j(x) \right)^{(\rho-1)/\rho} \right]^{\rho/(\rho-1)}$$

We omit time subscripts for simplicity here. The first equation defines the "DC" composite consumption index. It is a composite of the US and the Japanese goods. The parameter $\psi$ is the elasticity of substitution between the US goods and the Japanese goods. Based on the first equation, the second one defines the overall aggregate consumption index, which is defined as a composite of the "DC" consumption index and the Asian ("LDC") consumption index. Here, $\rho$ denotes the elasticity of substitution between those two. It is assumed that $\psi > \rho$, that is, the elasticity of substitution within DC is higher than that between DC and LDC. It is further assumed that $\theta > \psi > \rho$, that is, the elasticity of substitution within a country is higher than those between countries.

***Model 2 (East-West model)***

In model 2, the Japanese goods and the Asian goods are assumed to be closer substitutes. The aggregate consumption composite index is defined in the following manner:

$$C^j_{EAST}(x)=\left[\left(\frac{\gamma_J}{\gamma_J+\gamma_A}\right)^{1/\phi}\cdot\left(C^j_J(x)\right)^{(\phi-1)/\phi}+\left(\frac{\gamma_A}{\gamma_J+\gamma_A}\right)^{1/\phi}\cdot\left(C^j_A(x)\right)^{(\phi-1)/\phi}\right]^{\phi/(\phi-1)}$$

and $$C^j(x)=\left[\left(\gamma_J+\gamma_A\right)^{1/\lambda}\cdot\left(C^j_{EAST}(x)\right)^{(\lambda-1)/\lambda}+\gamma_U{}^{1/\lambda}\cdot\left(C^j_U(x)\right)^{(\lambda-1)/\lambda}\right]^{\lambda/(\lambda-1)}$$

The first equation defines the "East" composite consumption index. It is a composite of the Japanese and the Asian goods. The parameter $\phi$ is the elasticity of substitution between the Japanese goods and the Asian goods. Based on the first equation, the second one defines the overall aggregate consumption index, which is defined as a composite of the "East" consumption index and the US ("West") consumption index. Here, $\lambda$ denotes the elasticity of substitution between those two. It is assumed that $\phi>\lambda$, that is, the elasticity of substitution within East is higher than that between East and West. Unlike in model 1, in this model, we would like to consider the possibility that $\phi$, the "within East" elasticity, may be greater than $\theta$, the "within country" elasticity. That is, Asian goods may be closer substitutes for a variety of Japanese goods than other Japanese goods are. On the other hand, it is assumed that $\theta>\lambda$.

## 4-5 Price indices and demand functions

The above definitions of consumption indices allow us to appropriately define composite price indices. Also, we can derive demand functions that each household faces as a producer of goods. Those are summarized in mathematical appendix 1.

## 4-6 Comparative dynamics

We shall consider two types of perturbations to the above model. In both cases, it is assumed that, prior to the shock, the world economy was in a flexible price (long run) equilibrium. It is assumed that the countries were symmetric, in the sense that aggregate money supply and productivity were the same across the countries. It is also assumed that the countries had zero foreign debt at the outset: $B_t^U = B_t^J = B_t^A = 0$. Note that, in such a situation, the world economy would be in a symmetric steady state equilibrium: every household in every country would be balancing its expenditure with income, and would have identical spending pattern all over the world. Starting from this situation, we assume that there was a shock to Japan in period *t*. In the "monetary shock" case, in the current period, the Japanese money supply, $M_t^J$, increases permanently. In the "productivity shock" case, the parameter $\kappa_t^J$ increases permanently (corresponds to a permanent negative productivity shock for Japan). In both cases, during the current period, there is *nominal rigidity*: prices are preset in the units of *seller's currency*, and cannot change. Output is demand determined. After one period, prices become flexible, and will jump to the new equilibrium level. The world economy arrives at a new flexible price equilibrium.

We conduct comparative dynamic analysis of the effects of the above two types of shocks. Details of the approach as well as analytical results can be found in mathematical appendix 2. We consider three possibilities for the monetary policy stance of Asia. In the "peg to US" case, the monetary authority adjusts its money supply in such a way that the exchange rate against the US remains unchanged. In the "free float" case, the Asian monetary authority leaves its money supply unchanged after the shocks hit the Japanese economy. In the "basket peg" case, the Asian monetary authority acts in such a way that the value of its currency is fixed against a weighted average of the US and the Japanese currencies.

## 5 Main findings from the "free float" case

Here, we shall summarize the results shown in appendix 2 in tables and discuss the implications. Unfortunately, some of the results depend on values of a set of parameters. In such a case, we plug in parameter values that we consider realistic to obtain some kind of predictions. In the tables, those results that are derived from such a numerical simulation are shown inside brackets. On the other hand, those results that can be derived analytically, under three assumptions discussed on appendix 2, are shown without brackets. Details of the numerical exercise, including some results, are described in appendix 3.

We first discuss the case in which the Asian country adopts the “free float” regime. We start with this case because it is the simplest case to analyze. In the next section, we will discuss the roles of different exchange rate arrangements. Our main findings for the “free float” case are summarized in Table 1 and Table 2. The tables show how Asian money supply, welfare, and current account respond to each type of shocks in each model. Table 1 deals with the case of a Japanese monetary expansion. Table 2 studies the case of a negative productivity shock to Japan. Note that, in this report, the exchange rates are defined so that increases in their values mean “depreciation”.

### 4-1 Japanese monetary expansion

Under Model 1 or the “DC-LDC” model, in response to a Japanese monetary expansion, Asian currency appreciates against the US dollar. This is because the depreciation of the yen pulls down the currency value of the US, which produces goods that are similar to the Japanese goods. Next, as the yen depreciation makes the Japanese goods cheaper compared to Asian goods, Asia loses its market, and thus output decreases. On the other hand, Asia experiences a consumption boom, as Asian consumers can buy Japanese goods temporarily at a lower price. As a consequence of those two effects, Asia experiences a current account deficit. However, in terms of welfare, Asia *gains* from the Japanese monetary expansion. This is because Asia can now enjoy higher consumption with less work effort.

On the other hand, in Model 2 or the “East-West” model, Asia’s exchange rate depreciates against the US dollars, because now the drop in the value of the Japanese yen pulls down the value of Asian currency more strongly. This is because, in this model, Asia is the one that produces goods that are similar to Japanese goods. After some calculation, it can be shown that current account deteriorates. Result on welfare depends crucially on the degree of substitutability between the Japanese goods and the Asian goods. This is because the elasticity determines how much of the market Japan can take away from Asia by depreciating its currency. The low substitutability (LS) case is similar to Model 1, in the sense that welfare improves as a result of the Japanese monetary expansion. Welfare is reduced only in the high substitutability (HS) case. Only in this case, the argument that the yen depreciation was a beggar-thy-neighbor policy can be given a firm theoretical foundation.

### 4-2 Negative Productivity Shock to Japan

In the previous sub-section, we saw it is difficult to find a case in which a Japanese monetary expansion results in Asian welfare reduction. This is partly because a Japanese monetary expansion is beneficial to the world as a whole: as the initial situation of the model is characterized by under-production, it is welfare improving to stimulate output. And this world wide gain is spread to Asia as well. Things are different in the negative productivity shock case. In this case, the yen depreciation is accompanied by a world wide decrease in demand and hence it results in a world wide welfare reduction. And this negative effect spreads to Asia. This is why Asia is more likely to lose when the depreciation is triggered by a negative productivity shock.

As a consequence, welfare consequences of a negative productivity shock to Japan are likely to be negative. In Model 1, as long as $\beta > 0.5$, the effect is negative. In Model 2, as long as the elasticity of substitution between Eastern goods and Western goods are not too high, the effect is negative.[5]. On the other hand, Asian current account deteriorates.

## 5 Consequences of adopting different exchange rate arrangements

### 5-1 Does the Asian country gain by abandoning the peg?

Now we consider what happens to welfare when the Asian country adopts the "dollar peg" regime. We are going to ask the following question: Suppose that the Asian country in this model had the "dollar peg" regime at the beginning (as most Asian

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[5] In the case of a negative productivity shock to Japan, a high substitutability between Japan and Asia means less welfare reduction for Asia. This is opposite to the case of a Japanese monetary expansion. This is because, when the goods produced by the two countries are highly substitutable, there is more room for Asia to take over the market from Japan, taking advantage of the lower Japanese productivity.

countries did prior to 1997). What will happen to Asia if it abandons this system and moves to the "free float" regime? This question can be answered by investigating how changes in welfare etc. differ between the two regimes.

First of all, what happens to Asian money supply when it moves from the "dollar peg" regime to the "free float" regime? Let us start from the case of Japanese monetary expansion. We learned in the previous section that, without any reaction from monetary policy authority, the Asian currency appreciates against the US dollars in Model 1 and depreciates against it in Model 2. This means that, to maintain this exchange rate to be fixed, the Asian money has to increase in Model 1 and has to decrease in Model 2. The opposite is true in the case of a negative productivity shock to Japan. Asian money decreases in Model 1 and increases in Model 2[6].

Hence, the effect of abandoning the "dollar peg" regime is equivalent to that of a decrease in Asian money supply in Model 1 in the Japanese monetary shock case and in Model 2 in the Japanese productivity shock case. It is equivalent to an increase in Asian money supply in the other two cases.

The question is how those changes in money supply affect welfare of Asia. This depends on the model and the parameters. The effects are summarized in Table 3. It is noteworthy that, both in Model 1 and Model 2-LS case, an increase in Asian money *decreases* its welfare. Using the terminology of Corsetti et. al. (1999), the increase in money has a *beggar-thyself* effect. This is because, in those cases, an increase of money supply causes a welfare loss to Asia due to a terms of trade deterioration, which outweighs welfare gains. Only in Model 2-HS case, an increase in Asian money can improve Asian welfare through a sufficient gain in competitiveness.

Table 4 analyzes welfare consequences of moving from the "dollar peg" regime to the

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[6] Note that, if this reduction in money supply is accomplished through a foreign exchange market intervention, this policy is going to decrease the Asian foreign exchange reserves, and could put a strain on the sustainability of the fixed exchange rate regime.

"constant money" regime. Note that the table shows how welfare *changes* between the two regimes. The first row of the table summarizes the above argument on how money supply changes by moving from the "dollar peg" to the "constant money " regime. The second row shows resulting welfare changes. Let us start with the case of a Japanese monetary expansion. Note that, in Model 1 and in Model 2-HS, Asia can gain welfare by abandoning the fixed exchange rate system. Hence, in those two cases, the Japanese yen depreciation might have put pressure on Asian countries to abandon its dollar peg policy. But, as we have already seen, in Model 1, abandoning the "dollar peg" means an appreciation of the Asian currency. Model 2-HS is the only case in which a popular statement like "the yen depreciation put a pressure on Asian countries to abandon the fixed exchange rate regime to *depreciate* their currencies" can be true.

Now we move onto the case of a negative productivity shock to Japan. In this case, only in Model 2-LS, the Asian country has an incentive to abandon the "dollar peg" regime and to move to the "constant money" regime. In this case, however, abandoning the "dollar peg" results in an appreciation of the Asian currency. So the popular statement, "the yen depreciation put a pressure on Asian countries to abandon the fixed exchange rate regime to *depreciate* their currencies". In conclusion, although a negative productivity shock in Japan is very likely to reduce Asian welfare and cause pains, it does not give a temptation for the Asian monetary authority to abandon a fixed exchange rate regime to *reduce* its currency value.

To summarize, it is very hard to find a case in which the Asian welfare is improved by abandoning the fixed exchange rate regime in a situation it would mean a depreciation of its currency. We could find only one case out of six in total. That one case requires that the source of the yen depreciation to be a monetary expansion by the Japanese authority; it also requires that the elasticity of substitution between Japan and Asia be extremely high.

### 5-2 Is there an incentive to move to a new exchange rate system?

We finally consider what happens when the Asian country abandons the "dollar peg" regime and tries to fix its exchange rate against a basket of the US dollar and the

Japanese yen. In all the cases considered, this would result in larger money supply than under the "dollar peg" regime. This is because, under the "dollar peg" regime, the yen always depreciates against the Asian currency. The question is if the Asian country wants to see its own money supply increase. As was discussed in the previous sub-section, an increase in money supply leads to an increase in the country's welfare only in Model 2-HS. Hence, only in this case, the Asian country might want to abandon the "dollar peg" regime and move to the new "basket peg" regime.

## 6 Some empirical evidence: which of the two models is more plausible?

Hence, our theory suggests that whether the yen depreciation really put a pressure on Asian countries to devalue their own currencies, or even to abandon the fixed exchange rate system depends on which case is more relevant (though it should be kept in mind that only in Model 2-HS, we find support for the above possibility). The question now is which case really is the most plausible one empirically. In this section, we will try to determine which one of the two models proposed above, Model 1 and Model 2, is the more realistic one, through inspecting the data. (Note that, if Model 1 is rejected by data, we can safely disregard the controversial Model 2-HS case.) One striking difference between the two models is the following. In Model 1 (DC-LDC model), in response to an increase (a decrease) in Japanese money, the Asian exchange rate against the US appreciates (depreciates) in the "free float" regime. In the "dollar peg" regime, instead, Asian money increases (decreases). On the other hand, in Model 2 (East-West model), in response to an increase (a decrease) in Japanese money supply, Asian exchange rate against the US depreciates (appreciates) under the "free float" regime. Under the "dollar peg" regime, Asian money decreases (increases) instead.

We would like to see which one of the above predictions is supported by data. To that end, we estimate a simple VAR (vectorautoregression) model to determine responses of Asian exchange rate and money to a shock to Japanese monetary policy. We estimate the same kind of model that involves three countries, the US, Japan, and an Asian country, for five Asian countries: Indonesia, Korea, Malaysia, Singapore, and Thailand.

Our VAR model consists of seven variables: the US Federal Funds Rate (FFR), the dollar-yen exchange rate (XJ), Japanese money supply (MJ), Japanese short rate (RJ), the exchange rate between one of the Asian countries and the US (XA), money supply of the Asian country (MA), and the short rate of the Asian country (RA). Precise definitions of the variables are given in the Data Appendix at the end. Sample period is January 1977-December 1996 for Malaysia, Singapore and Thailand, May 1986-December 1996 for Thailand, and January 1980-December 1996. For all the countries, we avoid using the crisis period after 1997 to avoid a potential problem of structural breaks. We use a shorter sample for Indonesia due to data availability. For Korea, we start the sample from 1980 because, after inspecting a plot of the exchange rate series, we suspected presence of a structural break prior to this period. The length of lags is set to six for all the countries. Monthly dummies are included in all the regressions. In all the cases, we use a Bayesian prior to reduce standard errors of the estimates (parameter values are those suggested by RATS manual).

We identify a Japanese monetary policy shock in the following way. We do not impose any restriction on the medium to long run dynamics of the economies: that is, we estimate an unrestricted VAR model. Japanese policy shock is identified solely by imposing restrictions on the short run structure of the model, or the contemporaneous relationship between innovations of the seven variables. We are going to assume the short run structure of the model is block recursive. Specifically, we assume that the economy can be broken into three blocks, (FFR, XJ, MJ) block, (RJ) block, and (XA, MA, RA) block. We also assume that Wold causal ordering runs from the first block to the third block: that is, shocks to the first block affect the second and third blocks contemporaneously. Shocks to the second block have contemporaneous impact on the third block but not on the first block. Shocks to the third block have no contemporaneous consequences on neither the first nor the second block. And finally, we are going to identify shocks to RJ (the second block) as Japanese monetary policy shocks. This means that, like many authors in the field of monetary policy identification, we are going to assume that shocks to monetary policy first appear as innovations in the short term interest rate.

In Figure 1-5, we show responses of XA and MA to one standard deviation increase in RJ. As this is an increase in the interest rate, it should be considered as a contractionary monetary policy. We are going to assume that each of the five Asian countries was somewhere between the pure "free float" regime and the complete "dollar peg" regime. Hence, if Model 1 is the right model, in response to a contractionary Japanese monetary policy, we would expect XA to go up (a depreciation) and MA to go down. Model 2 predicts the opposite. By seeing which types of responses are found in the data, we can see which type of models is more applicable.

In the figures, the solid line shows the point estimates of the impulse response function. The dotted lines are the *one* standard error bands[7]. Note that Malaysia and Singapore clearly show patterns that are consistent with Model 1: XA goes up and MA goes down. Thailand, on the other hand, shows a pattern consistent with Model 2: MA goes up, and XA virtually says the same (the response is even significantly negative for just one month). Korea shows a puzzling result (from the perspective of our theory) because both variables go down in response to a tight Japanese monetary policy. The case of Indonesia is very difficult to judge because responses fluctuate quite a bit, changing signs every few months. This is probably because of the short sample we used for this country.

To summarize, results change depending on countries, unfortunately. We would however like to emphasize the fact that we found a clear support for Model 2 only for one country out of five: Thailand. For all the other four, evidence is inconsistent with the model. And Model 2-HS, the most important case in our analysis, is an "extreme" version of Model 2, so to speak. We therefore think that the empirical evidence casts doubt on the applicability of this Model 2-HS case. Hence, the popular belief that "the yen depreciation put a pressure on Asian countries to abandon the fixed exchange rate regime to depreciate their currencies" does not seem to get much support from the data.

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[7] As VAR imposes relatively few restrictions on the parameters, standard errors around the estimates tend to be large. For that reason we think use of the conventional two standard error bands could be too strict. Hence, following Sims and Zha (199?), we make use of the one standard error bands.

It might still be true for Thailand, but does not seem to match empirical evidence from the four other countries.

## 7 Conclusions

For the moment, let us take a position that the yen depreciation since 1995 was caused by a Japanese monetary expansion. Our Model 1 implies that, for countries that produce goods that are not highly substitutable with Japanese goods (such as Vietnam), the depreciation could *not* have had a negative impact on nation's welfare. Thus, it is impossible to argue that those countries were under pressure to devalue their own currencies. On the other hand, our Model 2-HS indicates that, for countries that export goods that are very highly substitutable with Japanese exports, a Japanese monetary expansion could have hurt their welfare. It has been shown that welfare of those countries could be improved by abandoning the dollar peg regime and depreciating their currencies. Hence, for those countries, and for those countries *only*, we can say that a Japanese monetary expansion could have been a part of the causes of the 1997 Asian currency crisis.

Our empirical study, though admittedly preliminary, does not support Model 2 for four out of five countries we investigated. Only for Thailand we found support for such a model. As Model 2-HS is an "extreme version" of Model 2, we doubt if this Model 2-HS has a wide applicability to most Asian countries.

Equally importantly, it is not clear if the yen depreciation was a consequence of a Japanese monetary expansion. Instead, it may have been a reflection of some other type of shocks. In this report, as an alternative candidate, we considered a negative productivity shock to Japan. Such a shock, too, can cause the Japanese yen to depreciate. And, in this case, it is much more likely that the yen depreciation accompanied a reduction in Asian welfare. It is, however, less clear if Asian countries might have responded to such a shock by depreciating their currencies. Theory suggests that there is no case in which Asia would find it beneficial to respond to such a shock by abandoning a fixed exchange rate regime and to pursue a depreciation of its currency.

Taking all the evidence presented in this report together, what does the welfare-based analysis say about the effect of the yen depreciation since 1995 on Asia? If the depreciation was caused by a Japanese monetary expansion, as is popularly believed, it is likely to have been beneficial to Asia (that is one of the predictions from Model 1). If the cause of the depreciation was actually a negative productivity shock to Japan, it would have also reduced Asian welfare. Even in this case, however, theory says Asia would not have benefited from abandoning a fixed exchange rate regime in favor of a currency depreciation.

## 8 Caveats

It should be kept in mind that the analysis in this report, though quite promising, still misses some potentially important elements of the Asia-Japan relationship. We will discuss three factors missing from the analysis. First, in reality, Japan extends various yen-denominated loans to Asian countries. Fluctuations in the value of the Japanese yen inevitably affect the values of those loans. This type of effect has not been investigated in this report. This is because, to make the analysis tractable, the models assume that countries start from a situation of zero net foreign debt outstanding. Relaxing this assumption would be a challenging topic for future research. Second, foreign direct investment (FDI) is missing from the analysis. The rapid decline in the value of the Japanese yen surely would have affected location decisions of Japanese plants and offices. Most notably, some large Japanese banks withdrew their operations from this area around this period. Third, in this report, 100% exchange rate pass-through was always assumed. Corsetti et. al. (1999) show that the effect of a currency devaluation hinges crucially on the extent of exchange rate pass-through. Theoretical implications could even be reversed under different assumptions. Our preliminary data analysis also indicates that the degree of exchange rate pass-through is far less than perfect between the US, Japan, and Asian countries. We intend to take up this issue in our future work.

## Data Appendix

**Data for the US**

FFR: Federal Funds Rate, taken from *International Financial Statistics* (IFS) of IMF.

**Data for Japan**

XJ: IFS, code 158..RF.ZF…

MJ: M2+CD, seasonally adjusted, from the Bank of Japan web site

RJ: call rate, with collateral, monthly average, from the Bank of Japan web site

**Data for Asia** (all the series are from IFS)

Indonesia (sample period: May 1986-December 1996)

- XA: Market rate (536..RF.ZF…)
- MA: sum of Money (53634…ZF…) and Quasi-Money (53635…ZF)
- RA: Call market rate (53660B..ZF…)

Korea (sample period: January 1980-December 1996)

- XA: Market rate (542..RF.ZF…)
- MA: sum of Money (54234…ZF…) and Quasi-Money (54235…ZF)
- RA: Money market rate (54260B..ZF…)

Malaysia (sample period: January 1977-December 1996)

- XA: Official rate (548..RF.ZF…)
- MA: sum of Money (54834…ZF…) and Quasi-Money (54835…ZF)
- RA: Money market rate (54860B..ZF…)

Singapore (sample period: January 1977-December 1996)

- XA: Market rate (576..RF.ZF…)
- MA: sum of Money (57634…ZF…) and Quasi-Money (57635…ZF)
- RA: 3 month interbank rate (57660B..ZF…)

Thailand (sample period: January 1977-December 1996)

- XA: Official rate (578..RF.ZF…)
- MA: sum of Money (57834…ZF…) and Quasi-Money (57835…ZF)
- RA: Money market rate (57860B..ZF…)

## Tables

Notes:

(1) "+" for exchange rate means depreciation, while "-" means appreciation.

(2) Those signs that are determined only from numerical examples are shown inside parentheses. The other results are determined analytically, under Assumptions 1 to 3 in Mathematical Appendix 2.

Table 1: Effects of a Japanese monetary expansion on Asia
("free float" regime)

| | Model 1 | Model 2 | |
|---|---|---|---|
| | | LS | HS |
| Exchange rate against US | - | + | + |
| Output | - | ??? | ??? |
| Current Account | - | - | - |
| Welfare | + | + | - |

Table 2: Effects of a negative productivity shock to Japan on Asia
(the dollar peg regime)

| | Model 1 | Model 2 | |
|---|---|---|---|
| | | LS | HS |
| Exchange rate against US | + | - | - |
| Output | - | + | + |
| Current Account | - | - | - |
| Welfare | (-) | (-) | (-) |

Table 3: Effects of an Asian monetary expansion on Asia

| | Model 1 | Model 2 | |
|---|---|---|---|
| | | LS | HS |
| Welfare | - | - | + |

Table 4: *Changes* when Asia moves from the "dollar peg" regime to the "free float" regime (for Asia)

A: Case of Japanese monetary expansion

| | Model 1 | Model 2 | |
|---|---|---|---|
| | | LS | HS |
| Money | ↓ | ↑ | ↑ |
| Welfare | ↑ | ↓ | ↑ |

B: Case of a negative productivity shock to Japan

| | Model 1 | Model 2 | |
|---|---|---|---|
| | | LS | HS |
| Money | ↑ | ↓ | ↓ |
| Welfare | ↓ | ↑ | ↓ |

Table 5: *Changes* when Asia moves from the "dollar peg" regime to the "basket peg" regime (for Asia)

For both cases (Japanese monetary expansion and negative productivity shock to Japan)

| | Model 1 | Model 2 | |
|---|---|---|---|
| | | LS | HS |
| Money | ↑ | ↑ | ↑ |
| Welfare | ↓ | ↓ | ↑ |

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# Mathematical Appendix for
# "Welfare implications of the 1995-1998 yen depreciation for Asia"

Etsuro Shioji (December 25, 2000)

## Mathematical Appendix 1

- **Price Index and Demand Functions**

In this appendix, we specify the price indices that are appropriately defined from the specification of the utility function in the main text. From the utility function, we also derive the demand functions explicitly.

### 1 Utility based price indices

These are the price indices for goods that are *produced* in each country, U, J, and A.

$$P_U^j(x) = \left[ \frac{1}{\gamma_U} \cdot \int_0^{\gamma_U} \left( P_U^j(z,x) \right)^{1-\theta} dz \right]^{1/(1-\theta)},$$

$$P_J^j(x) = \left[ \frac{1}{\gamma_J} \cdot \int_{\gamma_U}^{\gamma_U+\gamma_J} \left( P_J^j(z,x) \right)^{1-\theta} dz \right]^{1/(1-\theta)},$$

and $$P_A^j(x) = \left[ \frac{1}{\gamma_A} \cdot \int_{\gamma_U+\gamma_J}^{1} \left( P_A^j(z,x) \right)^{1-\theta} dz \right]^{1/(1-\theta)}.$$

Those definitions are common to both models. The two models differ in how they are aggregated into the aggregate price index. We shall explain that part below.

(I) DC-LDC model

In this model, first, the US goods prices and the Japanese goods prices are aggregated into the "DC" goods price index:

$$P_{DC}^j = \left[ \frac{\gamma_U}{\gamma_U + \gamma_J} \cdot \left( P_U^j \right)^{1-\psi} + \frac{\gamma_J}{\gamma_U + \gamma_J} \cdot \left( P_J^j \right)^{1-\psi} \right]^{\psi/(\psi-1)}.$$

Next, this is combined with the Asian goods price index to give the overall price index:

$$P^j = \left[ (\gamma_U + \gamma_J) \cdot \left( P_{DC}^j \right)^{1-\rho} + \gamma_A \cdot \left( P_A^j \right)^{1-\rho} \right]^{1/(1-\rho)}.$$

(II) EAST-WEST model

In this case, first, the Japanese goods price index and the Asian goods price index are aggregated into the "East" price index:

$$P_{EAST}^{j} = \left[ \frac{\gamma_J}{\gamma_J + \gamma_A} \cdot \left(P_J^j\right)^{1-\phi} + \frac{\gamma_A}{\gamma_J + \gamma_A} \cdot \left(P_A^j\right)^{1-\phi} \right]^{\phi/(\phi-1)} .$$

Then that is combined with the US goods price index to get the overall price index:

$$P^j = \left[ (\gamma_J + \gamma_A) \cdot \left(P_{EAST}^j\right)^{1-\lambda} + \gamma_U \cdot \left(P_U^j\right)^{1-\lambda} \right]^{1/(1-\lambda)} .$$

**2 Demand Functions**

By solving the utility maximization problem based on the utility function specified in the text, we can derive the demand functions for goods produced in each country. Here, as an example, we shall discuss the case of Asian goods. The cases of the US and Japan can be expressed in similar ways.

The following are the demand from country $k$ for goods that are produced by household $x$ that live in Asia.

(I) DC-LDC model

$$D_A^k = \left[ \frac{P_A^k(x)}{P_A^k} \right]^{-\theta} \cdot \left[ \frac{P_A^k}{P^k} \right]^{-\rho} \cdot \gamma_k \cdot C^k \text{ , } k\text{=}U, J \text{ or } A.$$

(II) EAST-WEST model

$$D_A^k = \left[ \frac{P_A^k(x)}{P_A^k} \right]^{-\theta} \cdot \left[ \frac{P_A^k}{P_{EAST}^k} \right]^{-\phi} \cdot \left[ \frac{P_{EAST}^k}{P^k} \right]^{-\lambda} \cdot \gamma_k \cdot C^k \text{ , } k\text{=}U, J \text{ or } A.$$

## Mathematical Appendix 2
### Analytical results of the models

In this appendix, we report results from the comparative dynamics exercises. We It is assumed that the world economy was in a flexible price equilibrium and that both money supply and productivity was the same across countries, prior to period *t* when Japan is hit by a shock. Our approach, which is based on that of Corsetti et. al. (1999), involves log-linearization around this symmetric, flexible price equilibrium. As a general rule, lower-case letters are gong to denote a percentage deviation from this equilibrium. Suppose, for example, that there was a variable called $X_t$. Then,

$$x_t \equiv \frac{X_t - X_0}{X_0}$$

An exception to this general rule is bond holding. As the amount of bonds outstanding is assumed to be zero at the beginning, we cannot use the above definition. Instead, we denote:

$$b_t^j \equiv \frac{B_t^j}{P_0^U \cdot C_0}$$

That is, it is defined as a ratio to initial national consumption level, evaluated at the US price.

To facilitate expositions, we introduce the following functions, for values of *x* which is greater than 1:

$$\Pi(x) \equiv \frac{1}{x} \cdot \frac{1-\beta + x(1+\beta)}{1+\beta + x(1-\beta)} > 0 \qquad (\Pi'(x) < 0),$$

$$\Omega(x) \equiv \frac{2\beta(x-1)}{1+\beta+(1-\beta)x} > 0,$$

$$\Lambda(x) \equiv \frac{\theta - x}{x} \cdot \frac{1+x}{1+\beta+x(1-\beta)} \qquad (>0, \text{ as long as } \theta > x)$$

$$\Sigma(x) \equiv \frac{x-1}{x} \cdot \frac{1-\beta}{1+\beta+x(1-\beta)} > 0 \quad (\text{also note } \Sigma(x) < 1),$$

$$\Psi(x) \equiv \frac{\theta-1}{\theta} \cdot \frac{\beta + x(1-\beta)}{1+\beta+x(1-\beta)} > 0 \quad (\text{note } \Psi'(x) > 0),$$

and $$\tilde{\Pi}(\rho,\psi) \equiv \frac{\Pi(\rho) - \Pi(\psi)}{\Pi(\rho)} \quad (\text{between 0 and 1}).$$

Below, we start with the case of a monetary shock to Japan, and then move on to analyze effects of a negative productivity shock to Japan. We shall focus on the responses of the variables within one period (short run effects). We shall pay most of our attention on Asian variables.

## I Money shock

In this case, Japanese money supply increases permanently. That is,

$$m^J > 0 .$$

Unlike in the main text, we start from the case of "free float" (monetary stabilization) and then move onto the case of "peg to US", because the former case is easier to analyze. We will briefly mention the "basket peg" case, in which the value of the Asian currency is fixed against a weighted average of the US and Japanese currencies.

### (I-1) DC-LDC model

For the sake of simplicity of exposition, define the following variable:

$$\tilde{\gamma}_J \equiv \frac{\gamma_J}{\gamma_J + \gamma_U} .$$

Note we have assumed $\theta > \psi > \rho > 1$.

#### <I-1-1> Free float

- **Exchange rates**

Exchange rate of Japan against the US:

$$e^J = \Pi(\psi) \cdot m^J > 0 \text{ (depreciate).}$$

Exchange rate of Asia against the US:

$$e^A = -\tilde{\gamma}_J \cdot (\Pi(\rho) - \Pi(\psi)) \cdot m^J < 0 \text{ (appreciate).}$$

Exchange rate of Asia against Japan:

$$e^{A/J} = -\left(\Pi(\rho)\tilde{\gamma}_J + \Pi(\psi)(1-\tilde{\gamma}_J))\right) \cdot m^J < e^A < 0 \quad \text{(appreciate).}$$

- **Asian output**

$$y^A = \left(1 - \rho\Pi(\rho)\right) \cdot \gamma_J \cdot m^J < 0.$$

- **Asian current account**

$$b^A = -\Omega(\rho) \cdot \gamma_J \cdot m^J < 0.$$

- **Asian welfare**

$$u^A = \frac{1}{\theta} \cdot \left(1 + \Lambda(\rho)\right) \cdot \gamma_J \cdot m^J > 0$$

**<I-1-2> Peg to US**

- **Basic Fact**

In this model, monetary expansion by a country can be harmful to its own welfare. Suppose that there was an Asian monetary expansion. Then,

$$u^A = \frac{1}{\theta} \cdot \left[\gamma_A - (\gamma_U + \gamma_J) \cdot \Lambda(\rho)\right] \cdot m^A .$$

The above coefficient can be positive or negative. In the case of Asia, its share in population, $\gamma_A$, is likely to be small. In the following welfare discussions, we are going to assume

**Assumption 1**: $\gamma_A - (\gamma_U + \gamma_J) \cdot \Lambda(\rho) < 0$ .

This means that an expansionary monetary policy is a *beggar-thyself* policy, as Corsetti et. al. note.

- **Asian money**

In this case, Asian money supply becomes endogenous. Its response is:

$$m^A = -\tilde{\Pi}(\rho, \psi) \cdot \tilde{\gamma}_J \cdot m^J > 0$$

- **Exchange rates**

Exchange rate of Japan against the US

$e^J = \Pi(\psi) \cdot m^J > 0$ (depreciate)

Exchange rate of Asia against the US

$e^A = 0$ (by assumption)

Exchange rate of Asia against Japan

$e^{A/J} = -e^J < 0$ (appreciate)

- **Asian output**

$$y^A = \left[\left(1-\rho\Pi(\psi)\right)\cdot\gamma_J + \tilde{\Pi}(\rho,\psi)\cdot\gamma_A\cdot\tilde{\gamma}_J\right]\cdot m^J \quad \text{(cannot be signed)}$$

- **Asian current account**

$$b^A = -\Omega(\rho)\cdot(\gamma_U+\gamma_J)\cdot\left[1-\tilde{\Pi}(\rho,\psi)\right]\cdot m^J < 0$$

- **Asian welfare**

$$u^A = \frac{1}{\theta}\cdot\left(1+\Lambda(\rho)\right)\cdot\gamma_J\cdot m^J + \frac{1}{\theta}\cdot\left[\gamma_A-(\gamma_U+\gamma_J)\cdot\Lambda(\rho)\right]\cdot m^A$$

$$= \frac{1}{\theta}\cdot\gamma_J\cdot\left[\left(1-\tilde{\Pi}(\rho,\psi)\right)\cdot\left(1+\Lambda(\rho)\right)+\tilde{\Pi}(\rho,\psi)\right]\cdot m^J > 0$$

Under <u>Assumption 1</u>, this welfare gain is smaller than in the case of free float.

**<I-1-3> Basket peg**

Note that Asian currency appreciates against the Japanese currency even under the "peg to US" regime. This means that, if any weight is given to the Japanese currency in the Asian exchange rate management, Asian money would have to increase further. However, in this Model 1, Asian monetary expansion is harmful to Asian welfare (under <u>Assumption 1</u>). Hence, Asian welfare will decrease further, even compared to the "peg to US" case.

## (I-2) East-West model

For this model, we define:

$$\hat{\gamma}_J \equiv \frac{\gamma_J}{\gamma_J+\gamma_A}.$$

Note that we have assumed $\theta > \lambda > 1$, but we allow for the possibility that $\phi$ is greater or smaller than $\theta$. It is always greater than $\lambda$.

**<I-2-1> Free float**

- **Exchange rates**

Exchange rate of Japan against the US

$$e^J = \left[\Pi(\lambda)\cdot\hat{\gamma}_J + \Pi(\phi)\cdot\left(1-\hat{\gamma}_J\right)\right]\cdot m^J > 0 \text{ (depreciate)}$$

Exchange rate of Asia against the US

$$e^A = \left[\Pi(\lambda) - \Pi(\phi)\right]\cdot\hat{\gamma}_J \cdot m^J > 0 \text{ (depreciate)}$$

Exchange rate of Asia against Japan

$$e^{A/J} = -\Pi(\phi)\cdot m^J < 0 \text{ (appreciate)}$$

The important result is that, in this case, Japan "drags" Asia into depreciation against the US.

- **Asian output**

$$y^A = \left[\gamma_J + \gamma_A + \gamma_U \cdot \lambda\Pi(\lambda) - \phi\Pi(\phi)\right]\cdot\hat{\gamma}_J \cdot m^J \text{ . (cannot be signed)}$$

- **Asian current account**

$$b^A = \left[\gamma_U \cdot \Omega(\lambda) - \Omega(\phi)\right]\cdot\hat{\gamma}_J \cdot m^J < 0. \text{ (after some calculation)}$$

- **Asian welfare**

$$u^A = \frac{1}{\theta}\cdot\Psi_J \cdot m^J,$$

where $\Psi_J = \left[\gamma_J + \gamma_A - \gamma_U \cdot \Lambda(\lambda) + \Lambda(\phi)\right]\cdot\hat{\gamma}_J$

The sign of this coefficient is indeterminate, unlike in the case of model 1.

Hence, we are going to distinguish two cases below. In (case **HS-1**), $\phi$ is so high that the above expression $\Psi_J$ is negative (as long as $\phi$ is not too small, $\Lambda(\phi)$ is a decreasing function). In (case **LS-1**), the opposite is true.

### <I-2-2> Peg to US

- **Basic fact**

Effect of Asian monetary expansion on Asia is given by

$$u^A = \frac{1}{\theta}\cdot\Psi_A \cdot m^A.$$

where $\Psi_A = (1-\hat{\gamma}_J)\cdot\left[\gamma_J + \gamma_A - \gamma_U \cdot \Lambda(\lambda)\right] - \hat{\gamma}_J \cdot \Lambda(\phi)$

It is not possible to sign this coefficient. If $\phi$ is quite high, this coefficient can be positive. Note that, if $\phi \geq \theta$, then $\Lambda(\phi) \leq 0$. In such a case, as we make Asia gradually smaller compared to Japan (i.e., $\hat{\gamma}_J \to 1$), this coefficient will turn positive at some point.

Hence, we shall distinguish between two cases below. In (case **HS-2**), the above coefficient $\Psi_A$ is positive. In (case **LS-2**), the coefficient is negative.

Note that (case **HS-1**) is obtained if and only if

$$-[\gamma_J + \gamma_A - \gamma_U \cdot \Lambda(\lambda)] > \Lambda(\phi),$$

while (case **HS-2**) is obtained if and only if

$$\frac{1-\hat{\gamma}_J}{\hat{\gamma}_J} \cdot [\gamma_J + \gamma_A - \gamma_U \cdot \Lambda(\lambda)] > \Lambda(\phi).$$

In the main text, case (HS) refers to the case in which both of the above conditions are satisfied. Note this is possible only if $\Lambda(\phi)<0$, which means $\phi > \theta$. Case (LS) refers to the situation in which neither of the two conditions are satisfied.

- **Asian money**

$$m^A = -\frac{\Pi(\lambda) - \Pi(\phi)}{\hat{\gamma}_J \Pi(\phi) + (1-\hat{\gamma}_J)\Pi(\lambda)} \cdot \hat{\gamma}_J \cdot m^J < 0$$

To offset the effect of depreciation of its own currency, Asia has to contract its money supply.

- **Exchange rates**

Exchange rate of Japan against the US:

$$e^J = \frac{\Pi(\lambda) \cdot \Pi(\phi)}{\Pi(\phi) \cdot \hat{\gamma}_J + \Pi(\lambda) \cdot (1-\hat{\gamma}_J)} \cdot m^J > 0 \text{ (depreciate).}$$

Exchange rate of Asia against the US:

$e^A = 0$ (by assumption).

Exchange rate of Asia against Japan:

$e^{A/J} = -e^J < 0$ (appreciates even more strongly than under "free float").

- **Asian output**

$$y^A = [(\lambda - \phi)\Pi(\lambda) - (\gamma_J + \gamma_A)(\lambda \Pi(\lambda) - 1)] \cdot \frac{\hat{\gamma}_J \Pi(\phi)}{\hat{\gamma}_J \Pi(\phi) + (1-\hat{\gamma}_J)\Pi(\lambda)} \cdot m^J$$

(cannot be signed)

- **Asian current account**

$$b^A = \left[\gamma_U \cdot \Omega(\lambda) \cdot \Pi(\phi) - (1-\hat{\gamma}_J) \cdot \Omega(\phi) \cdot \Pi(\lambda)\right] \cdot \frac{\hat{\gamma}_J}{\hat{\gamma}_J \cdot \Pi(\phi) + (1-\hat{\gamma}_J) \cdot \Pi(\lambda)} \cdot m^J$$

(cannot be signed)

- **Asian welfare**

$$u^A = \frac{1}{\theta} \cdot \left[\Psi_J \cdot m^J + \Psi_A \cdot m^A\right]$$

In (case **HS-2**), this will be smaller than under “free float”. In (case **LS-2**), this will be greater than under “free float”.

### <I-2-3> Basket peg

Note that Asian currency appreciates against the Japanese currency under the “free float” regime, and also does so, even more strongly, under the “dollar peg” regime. This means that, if any weight is given to the Japanese currency in the Asian exchange rate management, Asian money would not decrease as much as in the “peg to US” case. It is conceivable Asia would experience a net increase in money supply. Whether moving from the “dollar peg” regime to the “basket peg” regime benefits or hurts Asia depends on whether Asian welfare is increasing or decreasing in its own money supply. In (case **HS-2**), Asia will benefit by moving to “basket peg”. In (case **LS-2**), Asia is better off staying with “dollar peg”.

## II Productivity shock

Next, we consider a case in which Japanese productivity decreases permanently. That is, the parameter $\kappa^J$ increases permanently. Let us denote

$$a_t^J \equiv -\frac{\kappa_t^J - \kappa_0^J}{\kappa_0^J}$$

as the (log linearized) productivity increase for Japan. Then, the case under consideration is:

$$a^J < 0.$$

Below, the signs refer to the direction of the effects (that is, the coefficient times $a^J$, note that the latter is a negative number), not the signs of coefficients per se.

A crucial relationship in the case of this shock turns out to be the shape of the function $\Sigma(x)$. It is generally not possible to determine whether it is an increasing or a decreasing function. Numerical examples show that, for a wide range of parameter values that are relevant, this is an increasing function. Hence, we shall assume the following:

> **<u>Assumption 2</u>**: The function $\Sigma(x)$ is increasing in *x* (in the relevant range of value of *x*).

## (II-1) DC-LDC model

### <II-1-1> Free float

- **Exchange rates**

Exchange rate of Japan against the US:

$e^J = -\Sigma(\psi)\cdot a^J$ >0 (depreciation).

Exchange rate of Asia against the US:

$e^A = \left(\Sigma(\rho) - \Sigma(\psi)\right)\cdot \tilde{\gamma}_J \cdot a^J$ .

(Under <u>Assumption 2</u>, this is positive, which means depreciation.)

Exchange rate of Asia against Japan

$e^{A/J} = \left(\left(1-\tilde{\gamma}_J\right)\cdot \Sigma(\psi) + \tilde{\gamma}_J \cdot \Sigma(\rho)\right)\cdot a^J$ <0 (appreciation).

- **Asian output**

$y^A = \rho \cdot \Sigma(\rho) \cdot \gamma_J \cdot a^J$ <0.

- **Asian current account**

$\frac{b^A}{\gamma_A} = \rho \cdot \Sigma(\rho) \cdot \tilde{\gamma}_J \cdot a^J$ <0 (deficit).

- **Asian welfare**

$$u^A = \left[\frac{1}{2}\cdot\frac{\beta+\theta-1}{\theta(1-\beta)} - \left(\frac{\rho-1}{\rho} + \frac{\theta-1}{\theta}\cdot\left(\beta+\rho-\rho\beta\right)\right)\cdot\frac{1}{1+\beta+\rho(1-\beta)}\right]\cdot\gamma_J\cdot a^J$$

It can be shown that this is negative as long as $\beta > 0.5$.

<II-1-2> **Dollar peg**

- **Asian money**

$$m^A = -\frac{1}{\Pi(\rho)} \cdot (\Sigma(\rho) - \Sigma(\psi)) \cdot \tilde{\gamma}_J \cdot a^J$$

(Under <u>Assumption 2</u>, this is negative.)

- **Exchange rates**

Exchange rate of Japan against the US

$e^J = -\Sigma(\psi) \cdot a^J > 0$ (depreciation)

Note that the effect is the same as in the "free float" case.

Exchange rate of Asia against the US

$e^A = 0$ (by definition)

Exchange rate of Asia against Japan

$e^{A/J} = -e^J < 0$ (appreciation).

- **Asian output**

$$y^A = y^A_{FREE} + \left[ (\gamma_A + (\gamma_U + \gamma_J) \cdot \rho \cdot \Pi(\rho)) \right] \cdot m^A .$$

It is larger than under "free float" (under <u>Assumption 2</u>). It is not clear if it is positive.

- **Asian current account**

$$\frac{b^A}{\gamma_A} = \frac{b^A_{FREE}}{\gamma_A} + \Omega(\rho) \cdot m^{ASIA} .$$

Hence, under Assumption 2, the deficit increases in comparison to the "free float" case.

- **Asian welfare**

Denote welfare change under "free float" as $u^A_{FREE}$ .

$$u^A = u^A_{FREE} + \frac{1}{\theta} \cdot \left( \gamma_A - (\gamma_U + \gamma_J) \cdot \Lambda(\rho) \right) \cdot m^A$$

If both <u>Assumption 1</u> and <u>Assumption 2</u> hold, this welfare is larger than under "free float".

<II-1-3> **Basket peg**

Note that Asian currency appreciates against the Japanese currency even more strongly under the "dollar peg" regime. This means that, if any weight is given to the Japanese currency in the Asian exchange rate management, Asian money would not decrease as much (or might even increase). However, in this Model 1, Asian monetary expansion is harmful to Asian welfare (under Assumption 1). Hence, Asian welfare will decrease compared to the "dollar peg" case. Or it might decrease even below the "free float" case.

## (II-2) East-West model

### <II-2-1> Free float

- **Exchange rates**

Exchange rate of Japan against the US

$$e^J = -\left(\left(1-\hat{\gamma}_J\right)\cdot\Sigma(\phi)+\hat{\gamma}_J\cdot\Sigma(\lambda)\right)\cdot a^J > 0 \text{ (depreciation)}$$

Exchange rate of Asia against the US

$$e^A = -\left(\Sigma(\lambda)-\Sigma(\phi)\right)\cdot\hat{\gamma}_J\cdot a^J$$

Under Assumption 2, this effect is negative (appreciation).

Exchange rate of Asia against Japan

$$e^{A/J} = \Sigma(\phi)\cdot a^J < 0 \text{ (appreciation).}$$

- **Asian output**

$$y^A = \left[\phi\cdot\Sigma(\phi)-\gamma_U\cdot\lambda\cdot\Sigma(\lambda)\right]\cdot\hat{\gamma}_J\cdot a^J < 0$$

- **Asian current account**

$$b^A = \left[\phi\cdot\Sigma(\phi)-\gamma_U\cdot\lambda\cdot\Sigma(\lambda)\right]\cdot\hat{\gamma}_J\cdot a^J < 0 \text{ (deficit)}$$

- **Asian welfare**

$$u^A = \left[\frac{1}{2}\cdot\frac{\beta+\theta-1}{\theta(1-\beta)}-\frac{1}{1-\beta}\left(\gamma_U\cdot\Sigma(\lambda)+\Sigma(\phi)\right)+\left(\Psi(\phi)-\gamma_U\Psi(\lambda)\right)\right]\cdot\hat{\gamma}_J\cdot a^J$$

The first term inside the brackets is positive, the second negative, the third positive. We cannot determine the sign of the effect. If the positive terms dominate, the total effect is negative.

### <II-2-2> Dollar peg

As the effects become rather complicated, we need to introduce a short hand notation. As a general rule, denote the percentage change of a variable *X* under the "free float" regime as $x_{FREE}$.

- **Asian money**

$$m^A = \frac{\left(\Sigma(\lambda) - \Sigma(\phi)\right) \cdot \hat{\gamma}_J}{\Pi(\lambda) \cdot (1 - \hat{\gamma}_J) + \Pi(\phi) \cdot \hat{\gamma}_J} \cdot a^J$$

Under Assumption 2, this is positive.

- **Exchange rates**

(1) Exchange rate of Japan against the US

$$e^J = e^J_{FREE} - \Pi(\phi) \cdot m^A$$

It appreciates in comparison to the "free float" case (under Assumption 2). It is not possible to determine the sign of the total effect in a general way. We assume the following:

Assumption 3: The above $e^J$ is positive.

This means depreciation.

(2) Exchange rate of Asia against the US

$e^A = 0$ , by assumption.

(3) Exchange rate of Asia against Japan

$$e^{A/J} = -e^J$$

It depreciates in comparison to the "free float" case (under Assumption 2). On the other hand, Assumption 3 implies that it appreciates in comparison to the "free float" case.

- **Asian output**

$$y^A = y^A_{FREE} + \left[(\gamma_J + \gamma_A + \gamma_U \cdot \lambda\Pi(\lambda)) \cdot (1 - \hat{\gamma}_J) + \phi\Pi(\phi) \cdot \hat{\gamma}_J\right] \cdot m^A$$

The expression inside the brackets is positive. Hence, under Assumption 2, output increases even more than it does in the "free float" case.

- **Asian current account**

$$b^A = b^A_{FREE} + \left[\hat{\gamma}_J \cdot \Omega(\phi) + (1-\hat{\gamma}_J)\cdot \gamma_U \cdot \Omega(\lambda)\right]\cdot m^A$$

The expression inside the brackets is positive. Hence, it increases in comparison to the "free float" case. The total effect is unknown.

- **Asian welfare**

$$u^A = u^A_{FREE} + \frac{1}{\theta}\cdot \Psi_A \cdot m^A$$

So, in the (case **HS-2**), welfare goes up in comparison to the "free float" case. The total effect is unknown. In the (case **LS-2**), welfare goes down in comparison to the "free float" case. The total effect is also unknown.

**<II-2-3> Basket peg**

Note that Asian currency appreciates against the Japanese currency even under the "dollar peg" regime (under Assumption 3). This means that, if any weight is given to the Japanese currency in the Asian exchange rate management, Asian money would have to increase further (under Assumption 2). This is beneficial to Asia in (case **HS-2**) but is harmful in (case **LS-2**).

# Mathematical Appendix 3
## Numerical Examples

In this appendix, we perform some numerical calculations. Through this exercise, we can determine signs of the effects that are indeterminate analytically, at least for those "representative" cases. Also, we can get a feel for the magnitudes of the effects, rather than just their directions.

We set the parameter values in the following way.

Relative sizes of the countries: $\gamma_U$ =40/61, $\gamma_J$ =20/61, and $\gamma_A$ =1/61.

Subjective discount factor: $\beta$ =0.9 (this roughly corresponds to interpreting "one period" in the model as two years. Note that "one period in the model corresponds to length of a period for which prices are sticky.)

Elasticities: For all the cases, we set $\theta$ =4.

(Model 1: DC-LDC model) $\psi$ =3, and $\rho$ =2.

(Model 2: East-West model) $\lambda$ =2. For $\phi$, we consider two cases:
(LS) $\phi$ =3,
and (HS) $\phi$ =5.

In all the cases considered, we set the absolute size of the shock to be one. That is, in the monetary shock case, we set $m^J$ =1. For the productivity shock case, we set $a^J$ =-1.

Table A-1 summarizes the effects of a Japanese monetary shock on Asia when Asia adopts the "free float" regime. Table A-2 shows the same things under the "dollar peg" regime. Table A-3 looks at the differences between the two cases and asks what happens if Asia moves from the second regime to the first one. Table A-4 to 6 do the same for the case of a negative productivity shock to Japan.

Table A-1 Effects of a positive money shock to Japan

(1) Free float

| | Model 1 | Model 2 | |
|---|---|---|---|
| | | LS | HS |
| Money Supply | 0.000 | 0.000 | 0.000 |
| X against US | -0.017 | 0.047 | 0.122 |
| X against Japan | -0.895 | -0.879 | -0.800 |
| Output | -0.281 | -1.023 | -2.322 |
| Current Account | -0.005 | -1.023 | -2.322 |
| Welfare | 0.199 | 0.013 | -1.040 |

Table A-2 Effects of a positive money shock to Japan

(2) dollar peg

| | Model 1 | Model 2 | |
|---|---|---|---|
| | | LS | HS |
| Money Supply | 0.018 | -0.054 | -0.152 |
| X against US | 0.000 | 0.000 | 0.000 |
| X against Japan | -0.879 | -0.926 | -0.922 |
| Output | -0.248 | -1.162 | -2.912 |
| Current Account | -0.798 | -1.108 | -2.760 |
| Welfare | 0.193 | 0.021 | -1.057 |

Table A-3 Difference between the two regimes

dollar peg → free float

| | Model 1 | Model 2 | |
|---|---|---|---|
| | | LS | HS |
| X against US | -0.017 | +0.047 | +0.122 |
| Welfare | +0.006 | -0.008 | +0.017 |

Table A-4 Effects of a negative productivity shock to Japan

(1) free float

| | Model 1 | Model 2 | |
|---|---|---|---|
| | | LS | HS |
| Money Supply | 0.000 | 0.000 | 0.000 |
| X against US | 0.002 | -0.006 | -0.009 |
| X against Japan | -0.028 | -0.030 | -0.033 |
| Output | -0.016 | -0.057 | -0.129 |
| Current Account | -0.000 | -0.057 | -0.129 |
| Welfare | -1.805 | -4.444 | -4.430 |

Table A-5 Effects of a negative productivity shock to Japan

(2) dollar peg

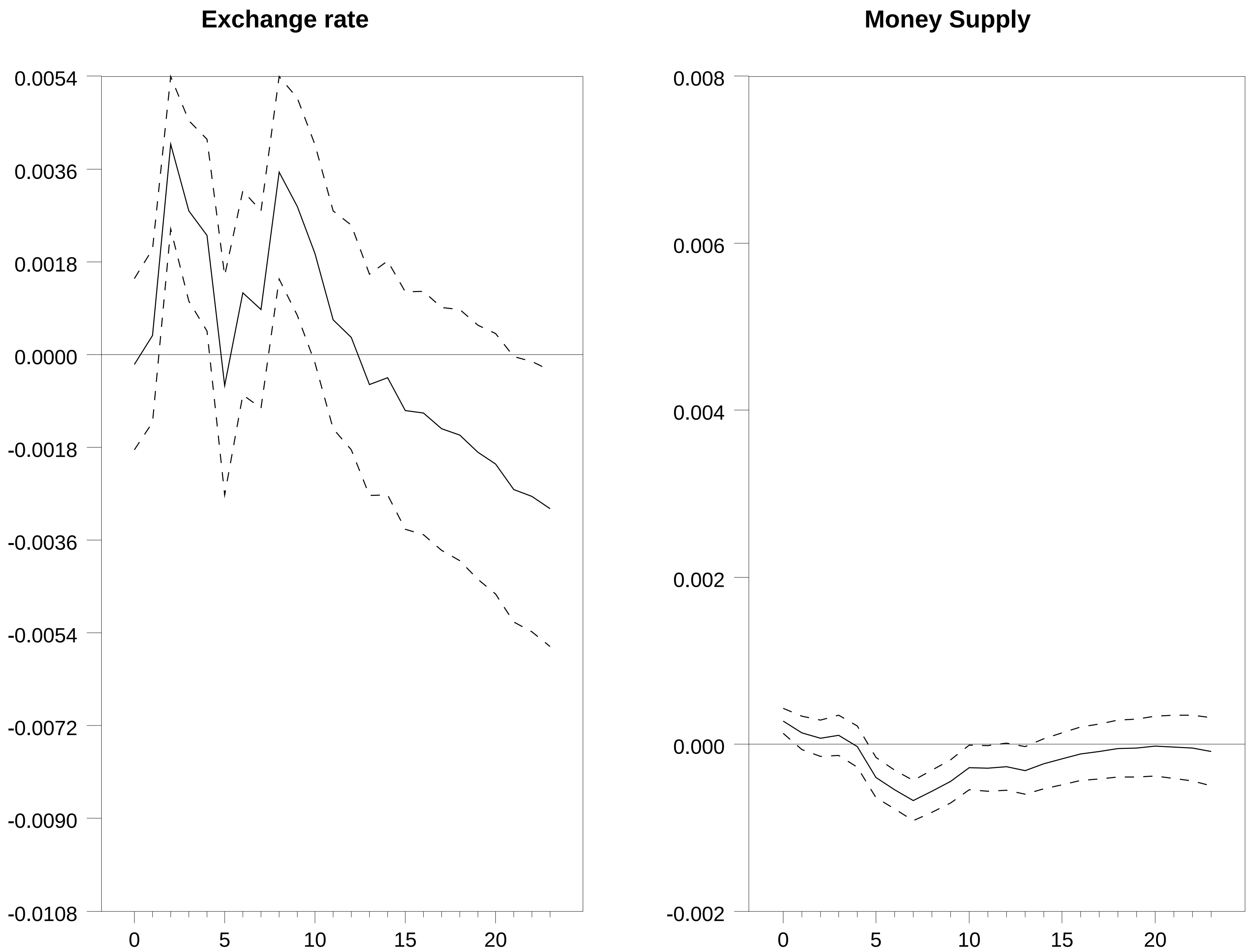
| | Model 1 | Model 2 | |
|---|---|---|---|
| | | LS | HS |
| Money Supply | -0.002 | 0.007 | 0.011 |
| X against US | 0.000 | 0.000 | 0.000 |
| X against Japan | -0.030 | -0.036 | -0.042 |
| Output | -0.016 | -0.039 | -0.085 |
| Current Account | -0.000 | -0.046 | -0.097 |
| Welfare | -1.804 | -4.445 | -4.428 |

Table A-6 Difference between the two regimes

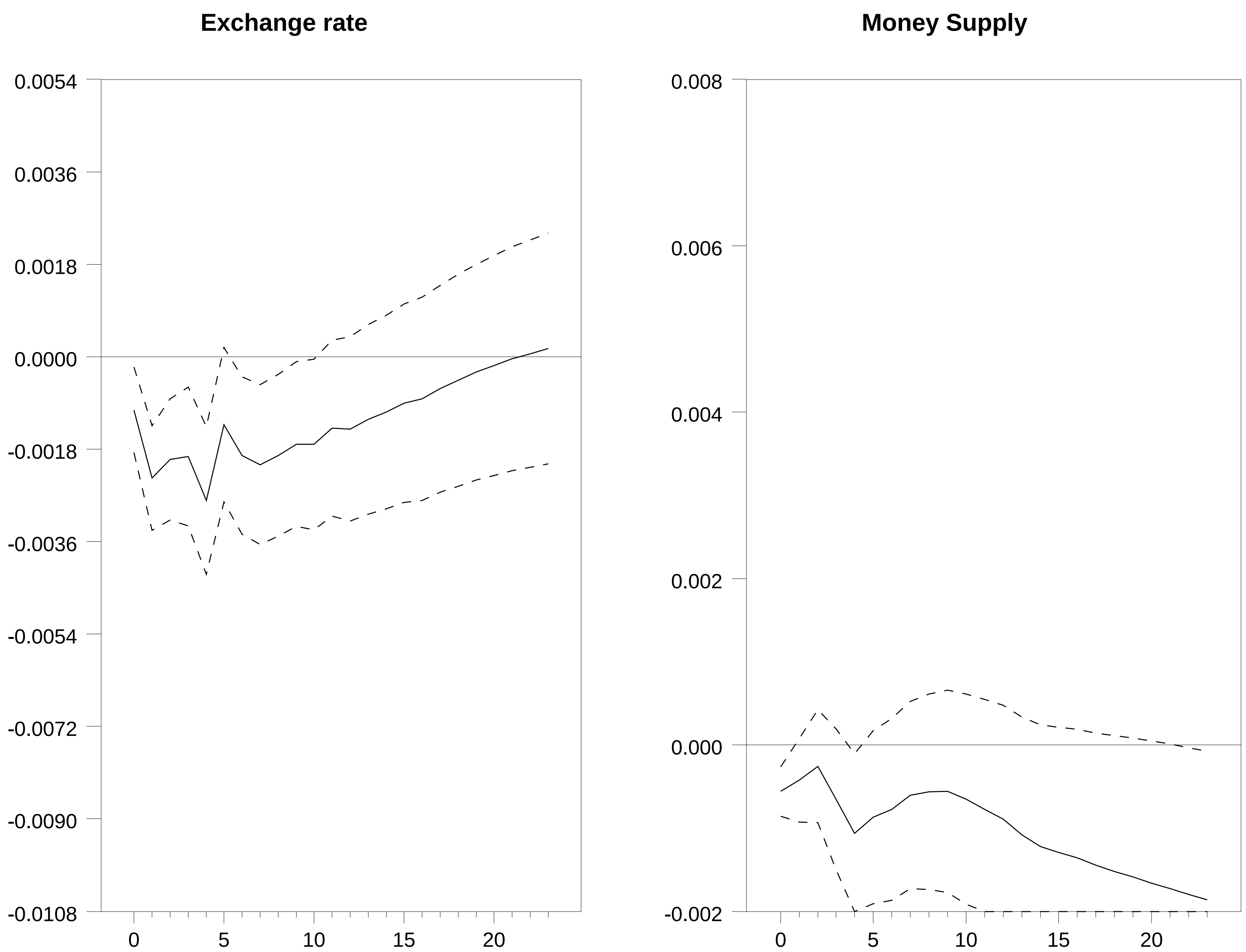
dollar peg → free float

| | Model 1 | Model 2 | |
|---|---|---|---|
| | | LS | HS |
| X against US | 0.002 | -0.006 | -0.009 |
| Welfare | -0.001 | +0.001 | -0.002 |

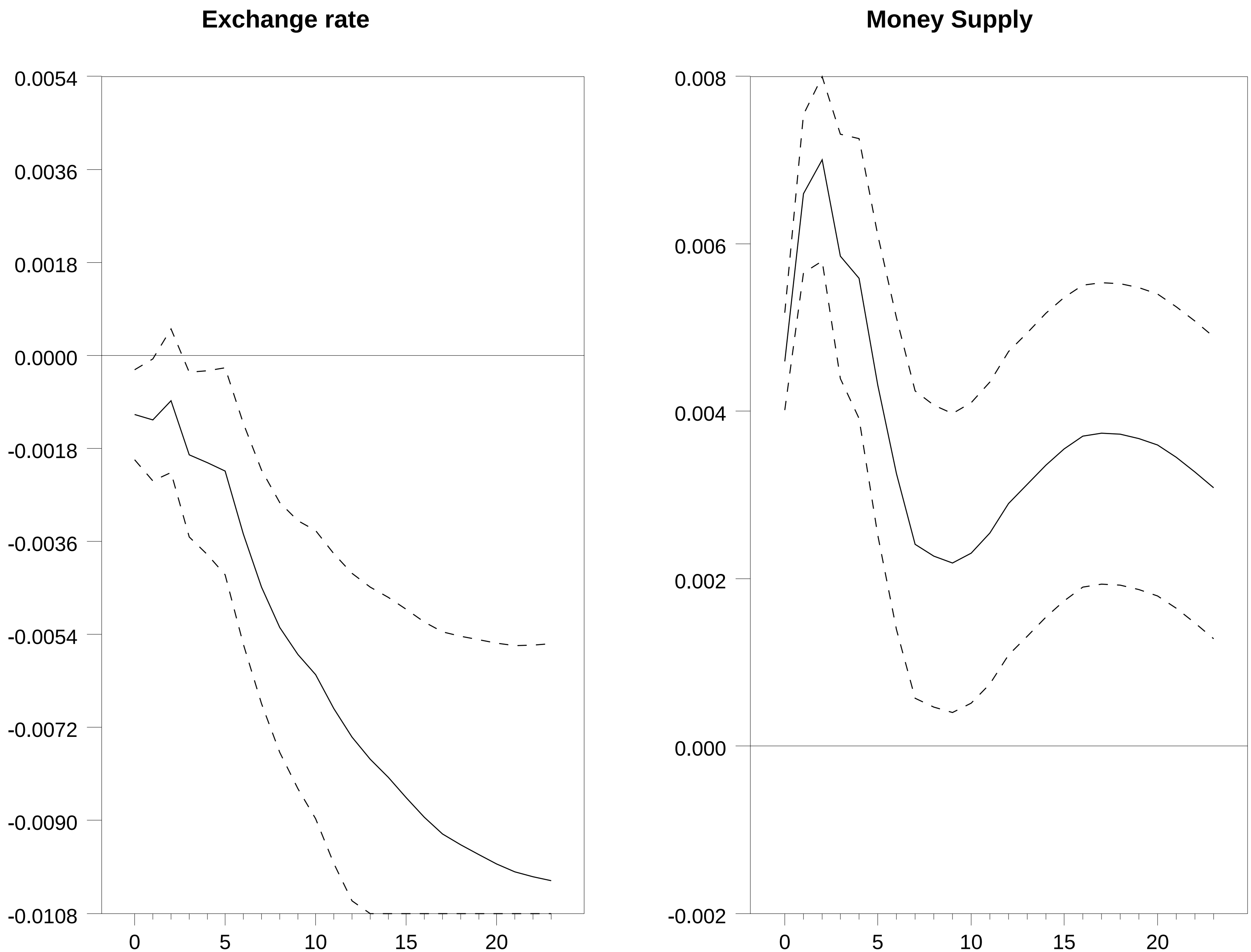
# Figure 1: Indonesia



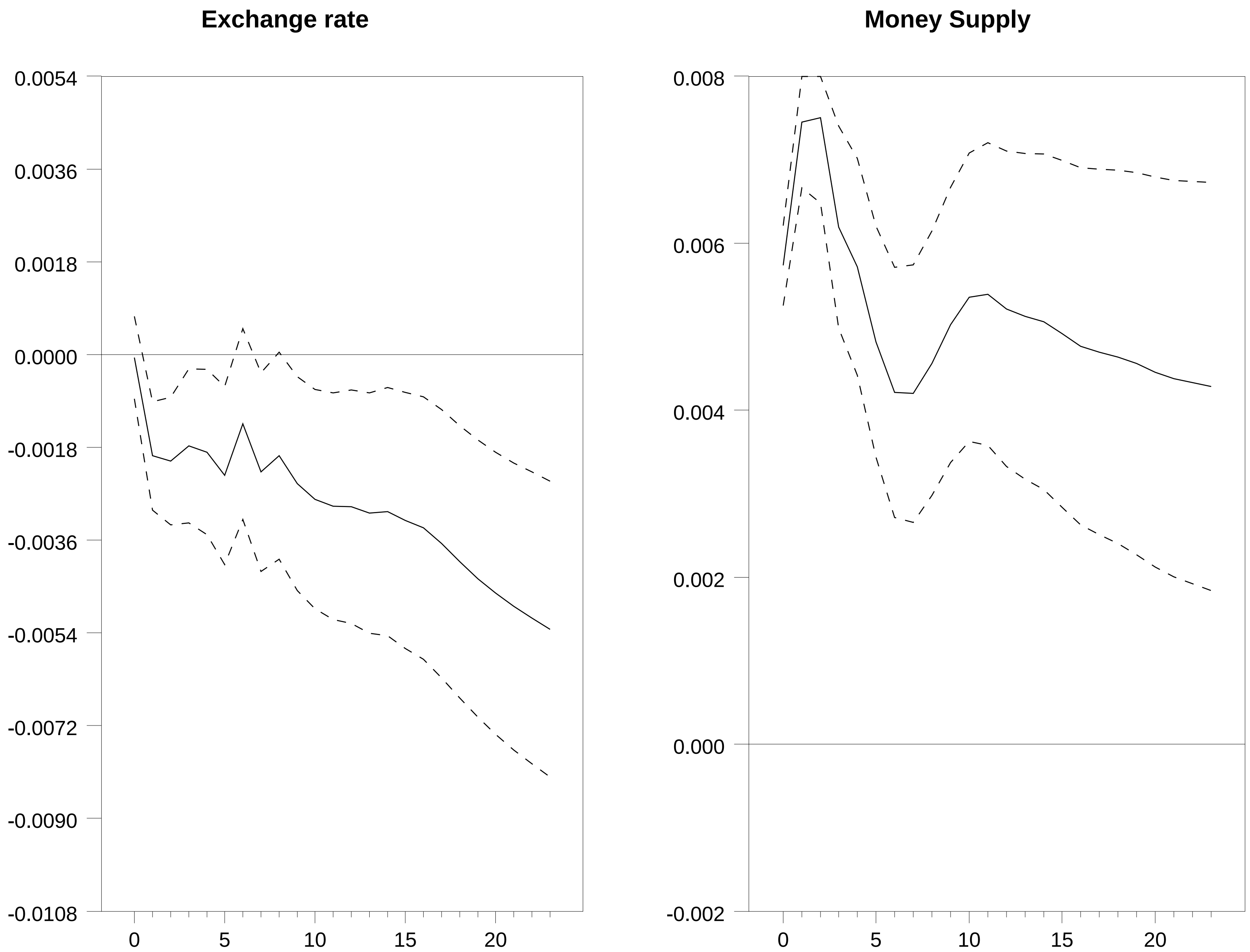
# Figure 2: Korea



# Figure 3: Malaysia



# Figure 4: Singapore



# Figure 5: Thailand