Invoicing Currency and the Optimal Basket Peg for East Asia: A New Open Economy Macroeconomics Perspective

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Abstract: This paper analyzes the relationship between East Asia's choice of currency regime and transmission of foreign shocks to this area. For that purpose, I develop a three country model that consists of East Asia, Japan, and the US, which is in the tradition of the "new open economy macroeconomics" literature. Using numerical simulations, this paper derives the optimal weight attached to the Japanese yen in East Asia's currency basket to which this region pegs its own currency, where optimality is defined with respect to stabilization of its trade balance (or other measures). In particular, this paper takes into account the reality that most international transactions are invoiced in the US dollar, and asks how incorporating that fact into the model changes the conclusion about the optimal basket weights.

1 Introduction

In recent years, some economists have proposed that East Asian countries should adopt basket peg regimes with more weights attached to currencies other than US dollars (see Williamson (1996), for example). Behind this argument is the empirical finding that those countries are adopting *de facto* dollar pegs (see Fukuda and Cong (2001), for example) and, at the same time, they are trading heavily with countries other than the US, such as Japan. For example, according to Fukuda and Cong (2001), in 1999, the US's share in Thailand's trade was 32.12 percent, while that of Japan was 34.54 percent. Based on this kind of facts, it is argued that, through stabilizing their currencies to a basket of currencies weighted by trade shares, East Asian countries could hope to stabilize their trade balances against changes in macroeconomic policies of their trade partners. Ito, Ogawa and Sasaki (1998) provide extensive theoretical and empirical studies on this matter[1]. Trade shares, however, may not be the only important factor that determines the optimal weights, even if the sole objective of adopting basket pegs is to stabilize trade balance. It is worth noting that, although Japan takes up a sizable share in East Asia's trade volumes, when it comes to the currencies used for transaction, the US dollar still dominates the Japanese yen, even in trade between East Asia and Japan. It seems likely that this fact would change the way we calculate the true optimal basket weights between the US dollar and the Japanese yen for East Asia. Thus, we need a framework that enables us to compute the optimal basket weights, taking into account explicitly the fact that the US dollar is the dominant currency used for invoicing in international trade.

In this paper, optimality of an exchange rate regime is defined mainly in terms of trade balance stabilization. But the paper also takes into consideration the possibility that

[1] Ogawa and Ito (2000) characterize the situation in which governments, which take currency regimes of each other as given, falls into an inferior Nash equilibrium in which all currencies are pegged to a single currency.

trade balance stabilization may not be the only concern for the central banks[2]. Some of them may be more concerned with dampening short run fluctuations in GDP. Others may genuinely be concerned with welfare of the people. This paper will also study how East Asia's GDP and welfare respond to foreign shocks under different exchange rate regimes and discuss a better choice of exchange rate regime from those viewpoints.

This paper achieves this objective by building a new open macroeconomic model in which invoicing currencies play important roles. It builds on a developed by Shioji (2004), which is a three country model in the tradition of New Open Economy Macroeconomics[3]. The three countries, called East Asia, Japan and the US, produce three types of goods: one type of nontradable goods and two types of tradable goods. One type of the tradable goods is characterized by a high elasticity of substitution between different brands within the same type (and thus a more fierce price competition), and the other is characterized by a low elasticity. Compared to the three country model of Corsetti et. al. (2000), in which the three countries are assumed to produce different types of goods, this model can incorporate much more realistic features of international trade. In the model, it is assumed that short run nominal rigidity occurs to prices quoted in the units of currencies used for invoicing. This will be called *invoicing currency pricing*[4]. This case will be contrasted with the case of *producer currency pricing* (meaning that prices are rigid in the units of the producer country's currency), which is a more typical assumption made in the theoretical literature (see, for example, Obstfeld and Rogoff (1995)). I shall also consider the cases of *US currency pricing* in which prices are rigid in the units of the US currency

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[2] Yoshino, Kaji and Suzuki (2004) consider various alternative objectives for the exchange rate policy and show that, depending on the objective, the optimal basket weights can be different. Sasaki (2001) studies the relationship between the basket weights and capital flows. This paper focuses mainly on trade balance stabilization because, as a practical matter, many developing countries have limited foreign reserves, and thus have to worry about taming fluctuations in trade balance.

[3] Otani (2001, written in Japanese) offers a good survey on this literature, with a special emphasis on the issue of pricing.

[4] Sasaki (2000, Chapter 3) provides some evidence consistent with this assumption. In this paper, the choice of invoicing currency itself is taken as exogenous. Oi, Otani and Shirota (2004) develop a theory in which currencies used for invoicing are determined endogenously. Also, Ohno and Fukuda (2004) develop a model in which pricing in dollars emerges as a consequence of

(i.e., the dollars) and *local currency pricing* in which prices are rigid in the short run in the units of the currency of the buyer (as in Devereux and Engel (1998) and Betts and Devereux (2000)). I study how the choice of optimal basket weights changes under different assumptions about pricing behaviors.

The rest of the report is organized as follows. Section 2 provides an overview of the related literature. Section 3 describes the basic theoretical framework. Section 4 presents the model. Section 5 presents the results of numerical simulations. Section 6 concludes.

2 Overview of the model

The model considered in this paper builds on the framework of Corsetti et al. (2000). Their model in turn is based on a two country equilibrium model of Obstfeld and Rogoff (1995 and 1996). In Obstfeld and Rogoff's "redux" model, each country produces one type of goods (which consists of many varieties). 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. Unlike the international real business cycle models (see, for example, Backus, Kehoe and Kydland (1992), this model is characterized by *nominal rigidity*: Nominal prices are assumed to be set in advance, and stay unchanged during one period. This means that a pure monetary expansion could have real effects and could change the utility level of the locals and foreigners.

Corsetti et. al. (2000) develop a three country version of the Obstfeld-Rogoff model. In their model, each country is specialized in the production of just one type of products (each of which consists of many varieties) and those goods are traded internationally. Consumers live for infinite periods and maximize their life time utility. They do not face any borrowing constraint. Their preferences are assumed to be "symmetric" across countries, in the sense that consumers in any country spend the same fraction of their

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coordination failure.

expenditure on goods produced in a particular country. Firms are monopolistically competitive and set nominal prices one period in advance.

Shioji (2001) develops a modified version of this model and analyzes the welfare effect of a Japanese monetary expansion on Asia. He finds that the overall welfare effect was *positive*. Shioji (2002) generalizes this model by incorporating home bias in consumer preference and a fraction of agents that are myopic (that is, they simply maximize their periodic utility each period). He finds that the welfare implication of the previous paper is weakened but remains qualitatively similar.

The assumption that each country specializes in production of just one type of product, however, may not be particularly realistic. Some type of goods produced by one country may be better substitutes for certain type of goods produced by another country than another type of goods produced by that country. For example, towels exported from China to Japan are probably better substitutes for Japanese towels than, say, Japanese TV games. To better reflect the reality of the trade structure, this paper abandons the "one country, one type of goods" specification. Instead, the model in this paper has three types of goods that are produced in all three countries. They are called "high-tech tradables", "low-tech tradables", and "non-tradables". Countries differ in the relative shares of each of those three types of products in overall production, consumption, exports, and imports[5].

The model inherits an important feature of the model of Shioji (2002): it allows for a possible asymmetry in preferences across countries. For example, utility might be characterized by "home bias": spending shares may be higher for domestically produced goods than foreign goods.

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[5] After I finished writing the first draft of Shioji (2005), which uses the same theoretical framework explained above, I found Teo (2005) on the web. Like this paper, Teo asks how the choice of invoicing currency affects the optimal basket weights. Unlike this paper, however, Teo assumes that all the nominal prices are pegged in the units of the US dollar, rather than using the actual shares of currencies used for transaction, as is done in this paper. More importantly, Teo's model is a straightforward extension of Corsetti et. al. (2000) in which different countries are assumed to produce different types of products. I believe that my way of modeling, in which different countries produce the same (though differentiated) two types of products and nontradable goods play an important role, can capture more realistic features of production and trade between the economies.

3 The Model

The world consists of three countries, US (denoted by *U*), Japan (denoted by *J*), and East Asia ("Asia" for short from now on, 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 γ_U, γ_J, and γ_A, respectively. Time is discrete and households live for infinite periods of time. There is free flow of goods and bonds between the countries.

3-1 Type of Goods

Goods are classified into three "types", called "high-tech tradables" (denoted by subscript *H*), "low-tech tradables" (*L*), and "non-tradables" (*N*). Those three are imperfect substitutes. As the names suggest, *H* goods and *L* goods are traded internationally while *N* goods are consumed locally. Each of the three countries produces all three types of goods. Each type of goods consists of many "brands", that are imperfect substitutes between each other. Each household specializes in production of just one brand of goods, over which it has a monopoly right to produce. This means that the number of brands produced is always equal to the number of households.

There is no investment and all the goods are final consumer goods. We make an assumption on the utility function so that all the households decide to consume all brands of goods available to them, that is, all brands of tradable goods as well as all non-tradable goods produced in the country they live in.

3-2 Households

In 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 one-period utility of the household *x*, that produces type *k* goods (*k*=*H*, *L*, or *N*) in country *j* in period *t* is assumed to take the following form:

$$u_t^{jk}(x) = \ln C_t^{jk}(x) - \frac{\kappa^{jk}}{2}\left(Y_t^{jk}(x)\right)^2 + \chi \cdot \ln\left(\frac{M_t^{jk}(x)}{P_t^j}\right) \qquad (1)$$

The first part represents utility from consumption. The variable $C_t^{jk}(x)$ is a 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 $Y_t^{jk}(x)$ is the amount of output produced by this household in period *t*, using labor as the sole input. The parameter κ (which is assumed to be positive) describes how work effort is related to output: when its value is 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 $M_t^{jk}(x)$ 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 χ is assumed to be positive. The periodic budget constraint takes the following form:

$$\frac{E_t^j B_{t+1}^{jk}(x)}{P_t^j} + \frac{M_t^{jk}(x)}{P_t^j} + C_t^{jk}(x) = (1+i_t)\frac{E_t^j B_t^{jk}(x)}{P_t^j} + \frac{M_{t-1}^{jk}(x)}{P_t^j} + \frac{SR_t^{jk}(x)}{P_t^j} - \frac{T_t^{jk}(x)}{P_t^j} \qquad (2)$$

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 numeraire 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. $B_{t+1}^{jk}(x)$ 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 US dollars. The assumption of free financial capital mobility implies that this value will always be the same across the countries. $SR_t^{jk}(x)$ is the revenue from sales of the goods produced by this household, defined in the units of the local currency. In a flexible price equilibrium (long run), law of one price holds, and the sales revenue is equal to the price of this brand of goods charged by this monopolistically competitive household (which will be denoted by $P_t^{jk}(x)$), times the quantity of the goods sold world-wide ($SR_t^{jk}(x) = P_t^{jk}(x) \cdot Y_t^{jk}(x)$). In a fixed price equilibrium (short run), the domestic price is fixed, while sales prices abroad vary depending on the pass-through rate between the seller's country and the buyer's country. Finally, $T_t^{jk}(x)$ is lump sum tax imposed by the government, also defined in the units of the local currency.

Also, note that, as a producer, each household faces a downward sloping demand curve, as different brands of goods are assumed to be imperfect substitutes. Later, we shall specify exactly how those varieties of goods enter into each household's utility. For the moment, it suffices to know that, in a flexible price equilibrium (long run), each household faces the demand curve of the following kind:

$$Y_t^{jk}(x) = P_t^{jk}(x)^{-\theta_x} \cdot Z_t^{jk}, \qquad (3)$$

where θ_x is a sector-specific constant larger than one, whose role in the utility function will be spelled out later. And Z_t^{jk} is some variable that is beyond the control of each household.

Households are forward looking and maximize the following life time utility:

$$U_t^{jk}(x) = E_t \sum_{s=0}^{\infty} \beta^s u_{t+s}^{jk}(x), \qquad (4)$$

(where β is the subjective discount factor) subject to the periodic budget constraint and a non-Ponzi game condition.

3-3 Equilibrium conditions

Here, I will discuss equilibrium conditions for the households as a whole. For example, define the average consumption of households producing type *k* goods in country *j* in period *t* as the integral of $C_t^{jk}(x)$ over all *x*. Denote such a variable as C_t^{jk}. Define Y_t^{jk}, M_t^{jk}, and B_t^{jk}, in analogous ways for output, money holdings, and bond holdings, respectively. Then, by the assumption of symmetry within each household group, we obtain

$$C_t^{jk} = C_t^{jk}(x), \quad Y_t^{jk} = Y_t^{jk}(x), \quad M_t^{jk} = M_t^{jk}(x), \quad B_t^{jk} = B_t^{jk}(x), \qquad (5)$$

for all *j*, *k* and *t*.

In equilibrium, the following three conditions that are derived from individual forward looking household's optimization conditions have to be satisfied at the aggregate level. First, the following Euler equation has to be satisfied:

$$\frac{C_{t+1}^{jk}}{C_t^{jk}} = \beta\left(1+i_{t+1}\right)\frac{P_t^j / E_t^j}{P_{t+1}^j / E_{t+1}^j} \qquad \text{(for all } t, j, \text{ and } k\text{).} \qquad (6)$$

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

$$\frac{M_t^{jk}}{P_t^j} = \chi C_t^{jk} \frac{(1+i_{t+1})E_{t+1}^j}{(1+i_{t+1})E_{t+1}^j - E_t^j} \qquad \text{(for all } t, j, \text{ and } k\text{).} \qquad (7)$$

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:

$$\frac{P_{j,t}^{jk}}{P_t^j} = \frac{\theta \cdot \kappa^{jk}}{\theta - 1} C_t^{jk} \cdot Y_t^{jk} \qquad \text{(for all } t, j, \text{ and } k\text{),} \qquad (8)$$

where $P_{j,t}^{jk}$ is the average price index for the type *k* goods produced and sold in country *j* by households in country *j* (which will be equal to individual price $P_t^{jk}(x)$, by symmetry).

3-4 Equilibrium conditions (government)

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 across households in a lump sum fashion. This implies:

$$M_t^j - M_{t-1}^j + T_t^j = 0 \qquad \text{(for all } t \text{ and } j\text{),} \qquad (9)$$

where M_t^j and T_t^j are money supply and transfer, respectively, in country *j* in period *t*. I assume that the government supplies the same amounts of money and transfers to households within the same category, i.e., those who produce the same type of goods and have the same utility function. Then, writing such money supply and transfers per capita to households producing type *k* goods as M_t^{jk} and T_t^{jk}, and the population of households producing type *k* goods in country *j* as π^{jk}, we can write

$$M_t^j = \sum_k \pi^{jk} M_t^{jk} \qquad (10)$$

and $$T_t^j = \sum_k \pi^{jk} T_t^{jk} \,. \qquad (11)$$

3-5 Equilibrium conditions (resource constraint)

The aggregate resource constraint for country *j* can be written as:

$$E_t^j(B_{t+1}^j - B_t^j) = SR_t^j + i_t E_t^j B_t^j - P_t^j C_t^j \qquad \text{(for all } t \text{ and } j\text{)}, \qquad (12)$$

where B_t^j , SR_t^j , and C_t^j are aggregate bond holding, sales revenue, and consumption, respectively. That is,

$$B_t^j = \sum_k \pi^{jk} B_t^{jk} , \qquad (13)$$

$$SR_t^j = \sum_k \pi^{jk} SR_t^{jk} \qquad (14)$$

(where SR_t^{jk} is sales revenue for households producing type *k* goods in country *j*),

and $$C_t^j = \sum_k \pi^{jk} C_t^{jk} . \qquad (15)$$

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

$$B_t^U + B_t^J + B_t^A = 0 \qquad \text{(for all } t\text{)}. \qquad (16)$$

The amount of output produced by each type of household has to equal the demand for the good. That is,

$$Y_t^j(x) = D_{U,t}^j(x) + D_{J,t}^j(x) + D_{A,t}^j(x) \qquad \text{(for } k{=}H \text{ or } L\text{, for all } x, t \text{ and } j\text{)}, \quad (17a)$$

for tradable goods,

and $$Y_t^j(x) = D_{j,t}^j(x) \qquad \text{(for all } x, t \text{ and } j\text{)}, \qquad (17b)$$

for non-tradable goods, where $D_{U,t}^j(x)$, $D_{J,t}^j(x)$, and $D_{A,t}^j(x)$ 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.

3-6 Composite consumption indices

Now I move on to specify contents of each consumption index. In this section, time subscript t is omitted for the sake of exposition. The overall consumption index, $C^{jk}(x)$, is assumed to take the following form:

$$C^{jk}(x) = \left[{\omega_{HL}^j}^{1/\rho} \left(C_{HL}^{jk}(x) \right)^{(\rho-1)/\rho} + {\omega_N^j}^{1/\rho} \left(C_N^{jk}(x) \right)^{(\rho-1)/\rho} \right]^{\rho/(\rho-1)}, \qquad (18)$$

where $C_{HL}^{jk}(x)$ is itself a composite consumption index of *H* goods and *L* goods, and $C_N^{jk}(x)$ is an index of non-tradable goods consumption. The parameter ρ is the elasticity of substitution between tradable goods as a whole and non-tradable goods, and ω's are the expenditure share parameters. The index $C_{HL}^{jk}(x)$ is defined as

and $$C_{HL}^{jk}(x) = \left[\omega_H^{j\,1/\psi} \left(C_H^{jk}(x) \right)^{(\psi-1)/\psi} + \omega_L^{j1/\psi} \left(C_L^{jk}(x) \right)^{(\psi-1)/\psi} \right]^{\psi/(\psi-1)}. \tag{19}$$

The parameter ψ is the elasticity of substitution between high-tech tradable goods as and low-tech tradable goods.

Each of the above indices are themselves composite consumption indices. For example, in the case of high-tech tradable goods,

$$C_H^{jk}(x) = \left[\omega_{H,U}^{j\ \ 1/\theta_H} \cdot C_{H,U}^{jk}(x) + \omega_{H,J}^{j\ \ 1/\theta_H} \cdot C_{H,J}^{jk}(x) + \omega_{H,A}^{j\ \ 1/\theta_H} \cdot C_{H,A}^{jk}(x) \right]^{\theta_H/(\theta_H-1)} \tag{20}$$

where θ_H is the elasticity of substitution between brands within type H goods, and $C_{H,i}^{jk}(x)$ (i=U, J, or A) is an index of consumption of high-tech tradable goods produced in country i :

$$C_{H,i}^{jk}(x) = \omega_{H,i}^{j\ \ -1/\theta_H} \cdot \sum_{z_{H,i}} \left(C_H^{jk}(z_{H,i}, x) \right)^{(\theta_H-1)/\theta_H} \tag{21}$$

where summation inside the brackets is taken over all the high-tech tradable brands produced in country *i*.

Likewise, for low-tech tradable goods, we define:

$$C_L^{jk}(x) = \left[\omega_{L,U}^{j\ \ 1/\theta_L} \cdot C_{L,U}^{jk}(x) + \omega_{L,J}^{j\ \ 1/\theta_L} \cdot C_{L,J}^{jk}(x) + \omega_{L,A}^{j\ \ 1/\theta_L} \cdot C_{L,A}^{jk}(x) \right]^{\theta_L/(\theta_L-1)}, \tag{22}$$

and $$C_{L,i}^{jk}(x) = \omega_{L,i}^{j\ \ -1/\theta_L} \cdot \sum_{z_{L,i}} \left(C_L^{jk}(z_{L,i}, x) \right)^{(\theta_L-1)/\theta_L} . \tag{23}$$

For non-tradable goods,

$$C_N^{jk}(x) = \left[\omega_N^{j\,-1/\theta_N} \cdot \sum_{z_N} \left(C_N^{jk}(z_N, x) \right)^{(\theta_N-1)/\theta_N} \right]^{\theta_N/(\theta_N-1)} . \tag{24}$$

3-7 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.

3-8 Long run vs. Short run equilibrium, and pricing regimes

In the long run, all the prices are assumed to be flexible and that all the markets clear. In such a case, the contemporaneous optimality conditions between consumption and leisure are satisfied for all the households: that is, equation (8) is satisfied. In the short run, prices are rigid in the sense that will be specified below, and output becomes demand-determined. As a consequence, equation (8) no longer holds.

In the short run, the nominal prices of domestically produced goods are assumed to be rigid (that is, the same as their values in the previous period) in the units of the domestic currency. As for the goods traded internationally, we consider four different types of pricing regimes.

- *Producer currency pricing* (*PCP*) In this case, the traded goods prices are rigid in the units of the currency of the country in which they are produced.
- *Local currency pricing* (*LCP*) Their prices are rigid in the units of the currency of the country in which they are sold.
- *US currency pricing* (*UCP*) Their prices are rigid in the units of the US dollar.
- *Invoicing currency pricing* (*ICP*) The units of the currencies in which the goods prices are rigid are determined by the shares of the currencies used for invoicing. To give an example, take the case of an H good produced in Asia, that is exported to Japan. Let us denote its sale price in Japan (measured in the yen unit) by $Q_{J,t}^{A,H}$, where $Q_{J,t}^{A,H} = \left(E_t^J / E_t^A\right) P_{J,t}^{A,H}$. Let the average shares of the Asian currency, the Japanese yen, and the US dollar in this type of transaction by s_A, s_J, and s_U, respectively ($s_A + s_J + s_U = 1$). Then,

$$\Delta \ln\left(Q_{J,t}^{A,H}\right) = s_A \cdot \left(\Delta \ln\left(E_t^J\right) - \Delta \ln\left(E_t^A\right)\right) + s_U \cdot \Delta \ln\left(E_t^J\right)$$

  where Δ denotes change from period t-1[6].

[6] It would be more realistic to assume that, for each transaction, single currency is used for invoicing, and that different transactions potentially involve different currencies. The above specification should be regarded as a simplification. Otani (2002) develops a model in which firms

4 Description of the Numerical Exercise

4-1 Dynamics of the Model

In the following analysis, it is assumed that the world economy starts from a flexible price equilibrium with constant money supply. It is also assumed that all households had zero foreign bonds or debt at the outset. All the countries are in the steady state in which all the variables remain constant over time. Then a permanent shock hits the Japanese economy. In the short run, there is price rigidity, as described in the previous section. As a consequence, the world economy deviates from the long run equilibrium. Output becomes demand determined. After one period, prices become fully flexible. The world economy arrives at a new flexible price equilibrium, which is likely to be different from the old one. In fact, the world economy will automatically jump to the new long run equilibrium immediately. This is the beauty of the approach of Corsetti, et.al. (2000): it converts an infinite period model into a virtual two period model, and researchers have to worry about only the "short run" (period 1) and the "long run" (period 2 onwards).

The effects of the policy change are analyzed by comparing the new equilibrium with the original steady state. As it is difficult to obtain analytical results, I report results from numerical exercises in the next section.

4-2 Calibration

The model is calibrated to fit characteristics of data for the US, Japan, and Asia on production and spending patterns, such as relative sectoral productivity and sectoral shares in expenditure. Data for Asia is computed by aggregating values for Hong Kong, Indonesia, Korea, Malaysia, the Philippines, Singapore, and Thailand (Taiwan is

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that set prices in the units of the producer's currency, and those that set prices in the units of the buyer's currency, coexist. Although a similar specification would be more realistic, it would increase the number of types of agents in the model to a level that is not manageable: there are three countries and three currencies here, as opposed to two in Otani's model. Also, goods are more heterogeneous in this paper's model.

omitted due to missing data). In computing sectoral statistics from data, I interpret "high-tech tradables" sector as the machinery (including transport equipment) industry, "low-tech tradables" sector as agriculture, mining and manufacturing (other than machinery), and "non-tradables" sector as the rest. The actual numbers employed are summarized in Table 1-3.

Population

World population is normalized to equal 1, and each country's population is chosen to match its actual share (among the three economies) in the number of persons employed, as is shown in Table 1[7].

Sectoral allocation of workers

Total population of a country is allocated to each sector so as to mimic actual sectoral allocation of labor in each country as shown in Table 1.

Productivity

The productivity parameters in the last row of Table 1 are chosen to match observed GDP per worker as well as data on relative sectoral productivity[8]. Productivity in the "non-tradables" sector in Asia is normalized to be 1. Note that Asia's "high-tech tradables" sector is much more productive than the other two sectors, especially in comparison with the "low-tech tradables" sector. On the other hand, GDP per worker is relatively similar across sectors in the US and Japan. This means that, in the model, Asia has a very strong comparative advantage in "high-tech tradables" sector.

Subjective Discount Factor and the Utility Weight on Money

As is shown in Table 2, I set the subjective discount factor at $\beta = 0.9$. The parameter for money in the utility, χ, is somewhat arbitrarily set at 1.

Elasticities

Assumptions on the elasticities of substitution are summarized in Table 2. High-tech goods tend to be highly differentiated, and thus the within-type elasticity tends to be

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[7] Total numbers and sectoral allocation of workers are estimated by combining information from the *Key Indicators* web site of the Asian Development Bank and the *INDSTAT3 2003 CD-ROM* (UNIDO). I use data from year 2000 whenever available.

[8] Labor productivity is estimated from combining information in *World Development Indicators 2002 CD-ROM* with that in Key Indicators and INDSTAT.

low. This idea is reflected in the small value of θ_H. On the other hand, low-tech goods and non-tradable goods are assumed to be highly substitutable with the other goods of the same type.

Exchange rate regimes

It is assumed that both Japan and the US are under flexible exchange rate regimes. Asia, on the other hand, employs a basket peg regime in which its nominal exchange rate is fixed against a weighted average of the Japanese yen and the US dollars. Later, implications of choosing different weights between the two currencies will be studied.

Invoicing currencies

For the case of "invoicing currency pricing" (ICP), it is necessary to obtain shares of the currencies used for invoicing for different types of trade. Table 3 shows estimates of the shares of Asian currencies, the Japanese yen, and the US dollars used for invoicing for trade classified by countries of origin and destination, computed from data provided in the web site of the Ministry of Finance of Japan. For example, the table shows that, in the total value of exports from Asia to Japan, 2% is mediated by Asian currencies, while the shares of the Japanese yen and the US dollars are 27% and 71%, respectively. In such a case, in the model, short run prices of goods exported from Asia to Japan would increase by 0.02 times the rate of depreciation of the Asian currency against the Japanese yen, plus 0.71 times the rate of depreciation of the US dollars against the Japanese yen. Due to the lack of data, those shares are assumed to be equal between "high-tech tradables" and "low-tech tradables".

Utility Weights

The values of the expenditure share parameters, ω's, are chosen to match the actual trade patterns between the three economies. The upper panels of Table 4 and 5 summarize the estimated trade structure between the three. Table 4 corresponds to the shares of goods and services produced by each economy that are purchased by different economies. Table 5 shows the shares of goods and services purchased by each economy that are produced by different economies[9] [10]. The expenditure share

[9] Output shares and expenditure shares in Table 4 and Table 5 are computed from the three sources

parameters are set to be equal to the actual spending shares summarized in the upper panel of Table 5. Note that countries tend to spend disproportionately large shares of their expenditure allocated to tradable goods on domestically produced tradables. This paper's flexible specification of preference makes it possible to incorporate such home bias into the model. An important exception to this general tendency is Asia's expenditure on "high-tech tradables". Asia purchases only a small fraction of high tech goods produced domestically, and buys far more high tech goods from abroad.

4-3 Steady State of the Model

I first derive values of various shares and ratios in the initial steady state with zero bond holding for the base-line case. By comparing those with actual statistics, we can study how closely the model replicates the actual patterns of production and spending. The lower panel of Table 4 reports the model's prediction for the sectoral composition of goods produced in each country as well as where those goods are sold to. Those values can be compared with the actual numbers presented in the upper panel of the same table. Also, the lower panel of Table 5 displays the predicted sectoral composition of expenditure on various types of goods as well as where the goods come from. Those numbers can be contrasted with the actual ones shown in the upper panel of the same table. In general, the model replicates the actual patterns very well.

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mentioned in the previous footnotes and the *COMTRADE* web site of the United Nations.

[10] In computing those shares, I ignore trade with the "rest of the world", such as EU and China. This has an inconvenient consequence that the importance of domestic consumption in the relative shares of spending is exaggerated. Another minor problem with this omission is that expenditure shares do not exactly add up to 100%, as can be seen in the upper panel of Table 5. In the calibration exercise, the share parameters are adjusted slightly so that they would always sum up to 100%.

Table 1: Parameter values for the calibration exercise (A)

Population and Productivity

(Sectoral variables are listed in the order of high-tech, low-tech, non-tradable.)

	Asia	Japan	US
Population	0.49	0.16	0.35
Population shares of sectors (%)	2.6, 49.8, 47.2	6.6, 18.6, 74.8	4.2, 12.4, 83.4
Sectoral Productivity (square root of $1/\kappa$)	2.90, 0.38, 1.00	12.06, 7.59, 9.69	11.41, 9.37, 8.82

Table 2: Parameter values for the calibration exercise (B)

Preference parameters

Preference parameters:	
Discount factor (β)	0.9
Utility weight on money (χ)	1
Elasticities:	
Between tradables and non-tradables (ρ)	2
Between high-tech and low-tech (ψ)	2
Within high-tech (θ_H)	3
Within low-tech (θ_L)	10
Within non-tradables (θ_N)	10
Share parameters (ω 's):	They equal the actual expenditure shares that appear in the upper panel of Table 5.

Table 3: Parameter values for the calibration exercise (C)

Value shares of currencies used for invoicing.

In the order of Asian, Japanese, and US currencies.

	To Asia	**To Japan**	**To US**
From Asia	-	2%, 27%, 71%	2%, 0%, 98%
From Japan	3%, 48%, 49%	-	0%, 16, 84%
From US	0%, 0%, 100%	0%, 17%, 83%	-

Table 4: Output shares, by type of goods produced and by country of destination

Data

ASIA		to ASIA	to JPN	to USA	total
	H	0.5%	2.7%	7.0%	10.2%
	L	16.7%	3.8%	5.4%	25.8%
	N	63.9%			63.9%
	sum	81.1%	6.5%	12.4%	100.0%
JPN		to ASIA	to JPN	to USA	total
	H	1.5%	4.8%	2.2%	8.4%
	L	0.9%	13.4%	0.7%	14.9%
	N		76.6%		76.6%
	sum	2.4%	94.8%	2.9%	100.0%
USA		to ASIA	to JPN	to USA	total
	H	0.8%	0.4%	4.1%	5.3%
	L	0.5%	0.5%	11.8%	12.9%
	N			81.8%	81.8%
	sum	1.3%	0.9%	97.7%	100.0%

Model Steady State

ASIA		to ASIA	to JPN	to USA	total
	H	0.4%	3.1%	6.2%	9.6%
	L	16.4%	5.4%	4.0%	25.8%
	N	64.6%			64.6%
	sum	81.4%	8.5%	10.2%	100.0%
JPN		to ASIA	to JPN	to USA	total
	H	1.4%	4.6%	1.6%	7.6%
	L	0.7%	13.5%	0.3%	14.5%
	N		77.8%		77.8%
	sum	2.1%	96.0%	2.0%	100.0%
USA		to ASIA	to JPN	to USA	total
	H	0.6%	0.4%	3.9%	4.9%
	L	0.5%	0.8%	11.9%	13.2%
	N			81.8%	81.8%
	sum	1.2%	1.1%	97.7%	100.0%

Table 5: Expenditure shares, by type of goods purchased and by country of origin

Data

ASIA		from Asia	from JPN	from USA	total
	H	0.5%	6.7%	4.9%	12.1%
	L	16.7%	3.9%	3.1%	23.7%
	N	63.9%			63.9%
	sum	81.1%	10.6%	8.0%	99.7%
JPN		from Asia	from JPN	from USA	total
	H	0.7%	4.8%	0.6%	6.0%
	L	1.0%	13.4%	0.8%	15.1%
	N		76.6%		76.6%
	sum	1.7%	94.8%	1.3%	97.8%
USA		from Asia	from JPN	from USA	total
	H	0.9%	1.1%	4.1%	6.1%
	L	0.7%	0.4%	11.8%	12.9%
	N			81.8%	81.8%
	sum	1.6%	1.5%	97.7%	100.8%

Model Steady State

ASIA		from Asia	from JPN	from USA	total
	H	0.4%	6.0%	5.2%	11.5%
	L	16.4%	3.1%	4.4%	24.0%
	N	64.6%			64.6%
	sum	81.4%	9.1%	9.6%	100.0%
JPN		from Asia	from JPN	from USA	total
	H	0.7%	4.6%	0.7%	6.0%
	L	1.2%	13.5%	1.4%	16.2%
	N		77.8%		77.8%
	sum	1.9%	96.0%	2.1%	100.0%
USA		from Asia	from JPN	from USA	total
	H	0.8%	0.9%	3.9%	5.6%
	L	0.5%	0.2%	11.9%	12.6%
	N			81.8%	81.8%
	sum	1.2%	1.1%	97.7%	100.0%

5 Main findings

5-1 Monetary shocks

In this section I report the simulation results. I first report the responses of Asia's current account to foreign monetary shocks. It is assumed that there was a once-and-for-all 10% increase in Japan's (or the US's) money supply. The world economy deviates from the previous long run equilibrium with zero bond holdings, and, after one period, jumps to a new long run equilibrium. I study, under different pricing regimes and different weights of the Japanese yen and the US dollars in invoicing, how the Asian current account responds to the shock in the short run. I do not explicitly report long run consequences, but they can be inferred from the short run results. If Asia experiences a short run current account deficit, in the long run equilibrium, it has to produce a surplus whose amount is equal to the short run deficit times the long run interest rate (which is equal to the subjective discount rate) every period. The opposite is true when Asia enjoys a short run surplus.

Figures 1-3 summarizes the results. The horizontal axis corresponds to different exchange rate regimes for Asia. "Flex" at the very left of the axis denotes the case of the flexible exchange rate regime. To the right of that, it is assumed that Asia adopts a basket peg, and the number on the axis denotes the weight of the US Dollar in Asia's currency basket. That is, "1" corresponds to the case of a complete Dollar peg, while "0" corresponds to the case of a yen peg. The vertical axis measures the short run response of Asia's current account, as a ratio to its own GDP in the original steady state, under different weights attached to the US dollar. Different lines depict responses to a Japanese monetary expansion and the US one.

Figure 1 describes the response of Asia's current account under the assumption of "Producer Currency Pricing" (PCP). Note that, under a complete Dollar peg, Asian current account turns deficit by about 6% of its steady state GDP when there is a Japanese monetary expansion. It produces a surplus of an almost equal amount when there is a US monetary expansion. These effects, however, are lessened as Asia increases the yen's weight in its currency basket, and its current account becomes almost independent of foreign monetary shocks when the weight is around 50 percent. Hence, Asia's current account is almost insulated from fluctuations in the yen-dollar rate when the basket weights between the Japanese yen and the US dollars are fifty-fifty.

I next considered the case of "Local Currency Pricing (LCP)". However, in this case, Asia's current account remained virtually unchanged in response to a monetary expansion in either country. As the sales prices for any type of tradable goods in any economy become independent of a current period shock under this regime, either Japan's or the US's monetary policy cannot yield a sizable quantitative effect, irrespective of Asia's currency system.

Figure 2 shows the results for the case of the "US Currency Pricing" (UCP), while Figure 3 depicts the case of the "Invoicing Currency Pricing" (ICP). Note that they are very similar to each other, reflecting the fact that the US dollar is the major invoicing currency in almost any international transaction. Hence, I will discuss the two cases together. In those cases, when the basket weight of the Japanese yen is very small, Asia's current account turns deficit in response to a Japanese monetary expansion while it turns surplus in the case of a US monetary easing, just as in the Producer Currency Pricing case. However, the effect is quantitatively weaker. As the basket weight of the yen is increased, the effect on Asia's current account is weakened, but only gradually. It is only when the basket weight of the yen is increased to about 80 percent that Asia's current account is stabilized. Hence, we conclude that, under the Invoice (or the US) Currency Pricing regime, Asia has to adopt a basket weight for Japan that far exceeds its trade share, if it wants to insulate its trade balance from external monetary shocks. Most importantly, this result shows that the pricing regime does matter for the choice of the optimal basket weights, and can potentially be an important factor for the consideration of the exchange rate systems.

Figure 1: Response of Asian Current Account (relative to steady state GDP)
Producer Currency Pricing

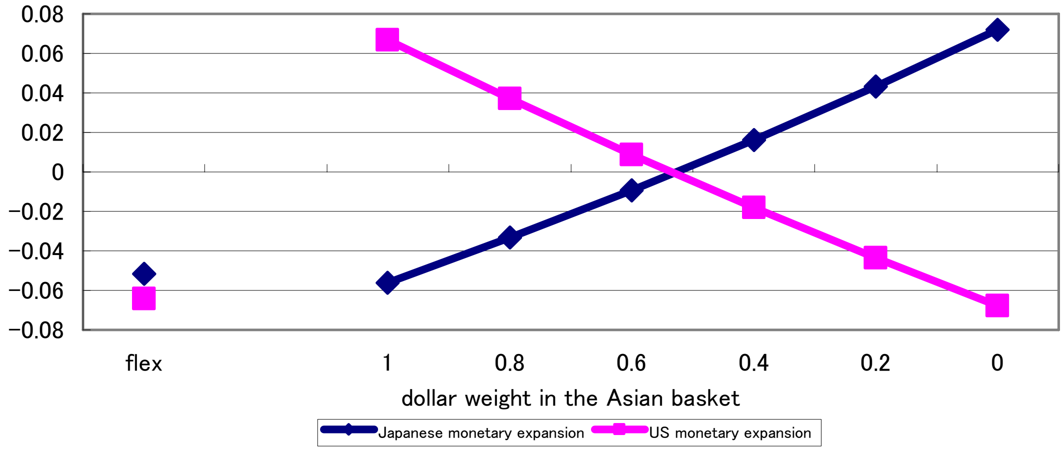


Figure 2: Response of Asian Current Account (relative to steady state GDP)
US Currency Pricing

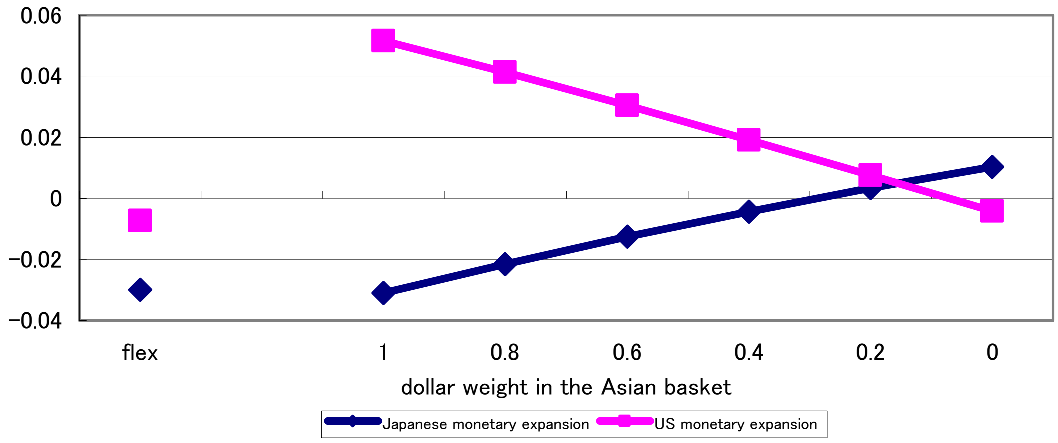
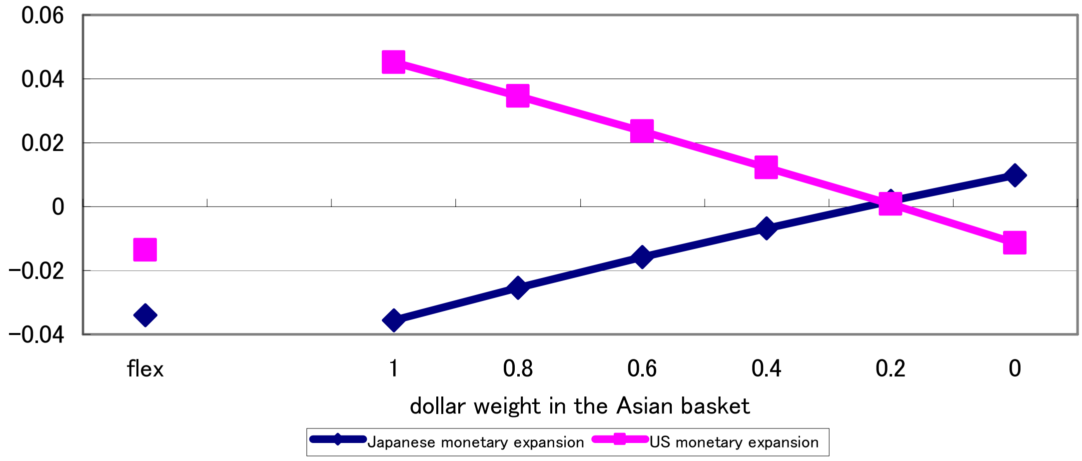


Figure 3: Response of Asian Current Account (relative to steady state GDP)
Invoicing Currency Pricing



5-2 Productivity shocks

I also studied the case of a negative productivity shock to Japan and the US. Here, a "negative productivity shock" means an across-the-board decline in the parameter κ for an entire country. Specifically, this parameter is lowered by $1/(1.1^2)$ times, which corresponds to a 10% decline in labor productivity. Results were very close to those in Figures 1-3, both qualitatively and quantitatively (hence the figures for this case are omitted to save space). Most notably, it is still true that, in the Invoicing Currency Pricing (ICP) case, Asia's trade balance is insulated from foreign shocks when the basket weight of the yen is about 80%.

5-3 Other considerations: GDP and welfare

Trade balance may not be the only concern when choosing an exchange rate regime. Some central banks may wish to stabilize short run fluctuations in GDP. Others may intend to choose a regime that minimizes fluctuations in the overall welfare.

Figure 4 shows the response of short run GDP in Asia to foreign monetary expansions, in the Invoicing Currency Pricing case. These are percentage (log) deviations from the original steady state. From the figure, it is less clear how to define GDP "stability" in this case, because it is not possible to find a value of a basket weight that produces near-zero responses of GDP to both types of shocks. If we define the variability of GDP by the sum of squares of the two responses in the figure, it turns out that GDP is most "stable" when the basket weight of the yen is around 0.6-0.8. Hence, a high weight for the Japanese yen is supported from the viewpoint of the GDP criterion. I found similar results in the productivity shock case.

Figure 5 depicts the response of welfare, defined as the population-weighted sum of life time utility of households that produce different types of goods. The numbers in the figure are its difference from the original steady state. Invoicing Currency Pricing is assumed. Again, measuring welfare variability by the sum of squares of the two responses in the figure, welfare is most stabilized when the basket weight of the yen is around 0.8. Hence, a high weight for the Japanese yen is supported from the welfare point of view. I found similar results in the productivity shock case.

Figure 4: response of Asian GDP (percentage change from the steady state)
Invoicing Currency Pricing

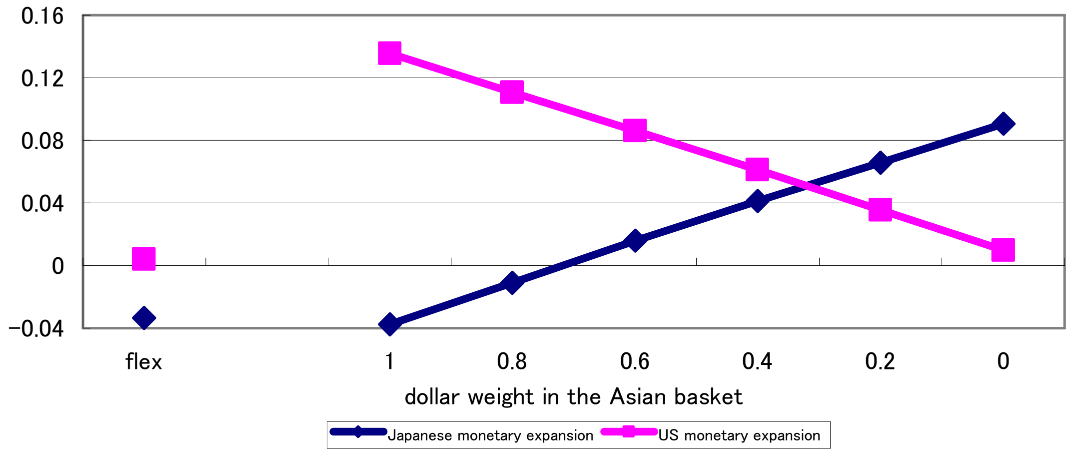
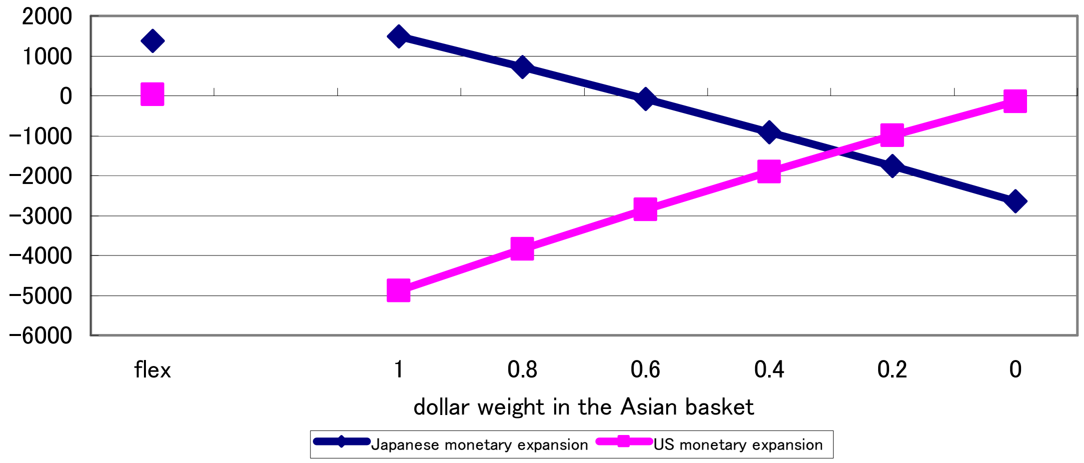


Figure 5: Response of Asian Welfare (difference from the steady state)
Invoicing Currency Pricing



6 Conclusions

This paper has utilized a new macroeconomic model to analyze the impact of different pricing regimes on the effects of the yen-dollar exchange rate fluctuations on Asian current account (as well as GDP and welfare), with a special emphasis on the case of invoicing currency pricing. The model is rich enough to incorporate various features of industrial (as well as trade) structure in East Asia, Japan, and the US. It has been shown that, if invoicing currency pricing holds, East Asia has to assign a much larger weight to the Japanese yen in its currency basket, compared to the case of producer currency pricing which is assumed in the basic new open economy macroeconomics model of Obstfeld and Rogoff (1995).

In a future version of the paper, I will explore the possibility of incorporating intermediate goods and FDI into this analytical framework.

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