The Optimal Currency Basket under Vertical Trade

Juanyi Xu *
Hong Kong University of Science and Technology, Kowloon, Hong Kong

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Abstract

This paper explores the theory of optimal currency basket in a small open economy general equilibrium model with sticky prices. In contrast to existing literature, we focus on an economy with vertical trade, where the currencies in the basket may play different roles in invoicing trade flow. In a simple two-currency basket, one currency is used to invoice imported intermediate goods and is called "import currency", while the other currency is used to invoice exported finished goods and is called "export currency". We find that the optimal weights of the import currency and the export currency depends critically on the structure of vertical trade. Moreover, if a country decides to choose a single-currency peg, the choice of pegging currency also depends on how other competing economies respond to external exchange rate fluctuations.

JEL classification: F3, F4

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*Department of Economics, Hong Kong University of Science and Technology, Clear Water Bay, Kowloon, Hong Kong. Email: jennyxu@ust.hk. Tel: +852 23587604; fax: +852 23582084.

1 Introduction

The purpose of this study was to re-examine the theory of the optimal currency basket for small open economies in a *vertical trade* context. The literature on optimal currency baskets proliferated in the early 1980s. For example, see Behandari (1985), Flanders and Helpman (1979), Flanders and Tishler (1981), and Turnovsky (1982). The optimality of a currency basket in those studies was defined mainly in terms of trade balance stabilization or real income stabilization. Recently, some studies considered various alternative objectives for the exchange rate policy and showed that, depending on the objective, the optimal currency basket weights can be different. For example, see the work of Yoshino et al. (2004).

These papers, however, are based on horizontal trade models, and ignore the changes in trade patterns that have occurred in the last thirty years. As has been well documented by Feenstra (1998), Hummels et al. (1998), and Yi (2003), the vertical structure wherein intermediate goods are imported to produce finished products that are re-exported has been a more and more important feature of today's global production and trade. Hummels (2001) found that vertical trade accounted for 21% of the exports of ten OECD and four emerging market countries in 1990 and grew almost 30% between 1970 and 1990. Other studies have also documented an increase in vertical trade activity for specific regions or countries. [1]

Vertical trade is especially important for East Asian small open economies. A fairly large fraction of trade in these economies is characterized by vertical trade. Amador and Cabral (2008) have shown that the share of Asia in total world vertical specialization has increased sharply over the last twenty years, representing 60% of the total in the 2001-2005 period (from 16% in the 1981-1985 period). Also, Uchida (2008) show that in East Asian countries the total vertical specialization (VS)[2] shares range from 0.16 (China) to 0.59 (Singapore). Also, vertical

[1]Some examples are Amador and Cabral (2008) for Portugal, Breda et al. (2007) for Italy and six other EU countries, and Cadarso et al. (2007) for nine EU countries. Kaminski and Ng (2001) analyzed the evolution of the trade in parts and components of ten Central and Eastern European countries and concluded that all of them engaged in vertical trade, especially Estonia, Hungary and Slovakia.

[2]In Uchida (2008), VS=(imported intermediates/gross output)*exports, is defined as share of the import content of the exports.

trade has played an important role in the rapid trade growth in East Asia over the last thirty years. Uchida (2008) found that from 1985 to 2000 in six Asian economies (Korea, Thailand, Malaysia, Philippine, Indonesia, and Taiwan), the total VS growth can explain most export growth, ranging from 55% (Thailand) to 98% (Korea). Hong Kong and Singapore, in particular, focus on re-export incivilities and are considered entrepot economies. From 2000-2008, the share of re-exports in the total merchandise exports of Hong Kong increased from 88% to 96%. In 2008, 48% of Singapore's exports were in terms of re-export activities.

The increase of vertical trade in East Asia is closely related to the division of production processes in the region. Hiratsuka (2008) shows that Japan exports much of parts and components to ASEAN countries and China while importing final goods from them. Meanwhile East Asia's production networks have become deeply linked with the NAFTA and the EU. Fung (2007) also finds that ASEAN countries have large share of intermediate goods in both imports and exports, while China is an exporter of capital goods and consumption goods. One example of the international production process segmentation in Asia is that ASEAN countries import part and components from Japan or import capital goods from China, produce final consumption goods and then sell them to the US or the EU. Another example is Hong Kong, an important entrepot for trade between China and the rest of the world. [3] According to the analysis of the evolution of trade patterns in East Asia by Lemoine and Ünal Kesenci (2002, 2004) and Gaulier et al. (2005, 2006), China plays a very important role. Their studies shows that the emergence of the Chinese economy has intensified the international segmentation of production processes among Asian countries.

With vertical trade, naturally, different currencies have different roles in trade invoicing. A currency can be either an import currency or an export currency. The former is the invoicing currency for imported intermediate goods, while the latter is the invoicing currency for exported finished goods. Using Hong Kong as an example, who intermediate trade between China and the

[3]As documented by Feenstra and Hansen (2004), over the 1988-1998 period, 53% of Chinese exports were shipped through Hong Kong in this manner.

rest of the world, the US dollar can be considered as the most important export currency, while Chinese Renminbi (hereafter,"RMB") can be considered as the main import currency. Another example is a small ASEAN country such as Thailand, which imports parts and components from Japan and exports finished goods to the US. Then Japanese yen can then be considered as the import currency and the US dollar the export currency. Obviously, for small open economies characterized by vertical trade, if a currency basket peg is chosen, both import currency and export currency should play important roles in the determination of optimal currency basket. This is extremely relevant for East Asian small open economies who usually choose to a pegged exchange rate regime explicitly or implicitly.[4] For these economies, what are the optimal weights of different currencies in the basket? If a single currency peg is preferable due to the operational complexity of a currency basket, which currency to peg to, the import currency or the export currency?

Clearly, the optimal currency basket under vertical trade will be different from that under horizontal trade, so the traditional reduced-form model with horizontal trade is probably not an appropriate framework to analyze this issue. To answer these questions, this paper developed a small open economy general equilibrium sticky price model to study the optimal currency basket and the choice of the pegging currency. It features vertical trade, where intermediate goods are imported for re-export. For simplicity, we consider a two-currency basket.[5] One currency is used in invoicing imported intermediate goods and the other for invoicing exports. The major uncertainty faced by the economy is the exchange rate fluctuation between the import currency and the export currency. The monetary authority chooses an optimal currency basket peg composed of the import currency and the export currency to maximize the expected utility of a representative household.

[4]Exchange rate regimes vary from a currency board hard peg to the US dollar in Hong Kong to a sliding or crawling peg to the dollar in Indonesia. Although these pegs are often not openly admitted or disguised as currency baskets, the common adherence to the dollar is easy to recognize. For example, Singapore follows an exchange-rate-centered monetary policy, targeting a trade-weighted exchange rate index. Thailand has followed a managed floating system since the financial crisis.

[5]It is easy to include more currencies into the basket, but this will not change the qualitative findings about the choice between the import currency and the export currency.

Our model shows that the optimal currency basket depends critically on the structure of vertical trade, such as the elasticity of substitution between local labor and imported intermediate goods, and the share of intermediate goods in the traded firm's production. In addition, we apply the model to East Asian Economies and derive the condition under which East Asian small open economies should abandon a US dollar peg and switch to an RMB peg.[6]

The intuition behind these results are simple. For a small open economy, exchange rate volatility between the import currency and the export currency will be divided into exchange rate changes of domestic currency against the import currency and the export currency according to their weights in the currency basket. For export goods producers, the exchange rate fluctuation between domestic currency and the export currency causes instability of export revenue and also leads to more volatile demand for export goods. Meanwhile, an exchange rate fluctuation between domestic currency and the import currency will cause substitution between imported intermediates and local labor, hence leads to instability of firms' import costs and also volatile demand for labor. On the one hand, the choice of optimal currency basket must balance the trade-off between revenue instability and cost instability so as to reduce the consumption volatility. On the other hand, an optimal currency basket is also expected to reduce the volatility of labor by stabilizing export demand and input substitution. So the structural parameters that affect traded goods firms' cost and revenue structures and the demand for traded labor will be key factors in determining the optimal currency basket.

Although these factors can affect the optimal composition of currency basket, the export currency peg is always superior to the import currency peg if the economy chooses a single-currency peg. This is because, in general, instability of export demand and export revenue will leads to more volatile consumption and labor. Nevertheless, if we take the response of other economies to the external exchange rate changes between import and export currency into consideration, then the relative welfare ranking could be be revised. This finding implies that there could be a role for the RMB in future monetary policy designs in East Asia, but the

[6] Of course, this condition is based on the assumption that the yuan will be fully convertible in the future.

emergence of a RMB peg relies on regional policy coordination.

There have been two strands of literature related to this topic. In the respect of optimal currency basket theory, Slavov (2005), Teo (2005), and Shioji (2006) examined this issue in general equilibrium model with micro-foundations. They emphasized the importance of the currency of foreign debt denomination and the export invoicing currency in determining optimal currency basket. In this paper, we focus on the implication of vertical trade and different roles of currencies for trade-invoicing for choosing the optimal currency basket and the pegging currency.

In looking at monetary policy under vertical trade, our paper is related to the paper by Huang and Liu (2006). They argued that vertical trade reconciles the welfare consequences of unilateral monetary expansion under different export pricing behaviors. Also, in a related paper (Shi and Xu, 2007), we explored the optimal monetary policy response to domestic and foreign technology shocks in an open economy with vertical trade. However, both papers focus on a two-country framework, while this paper explores the implication of vertical trade on fixed exchange rate regime choices in a *small open economy.* In a sense, we investigate a constrained optimal policy for a small open economy in this paper.

This paper is organized as follows. Section 2 presents the benchmark model. Section 3 solves the optimal currency basket for a calibrated small open economy using second-order approximation. Section 4 examines factors that affect the choice of optimal currency basket. Section 5 concludes.

2 Basic Model

In our model, there are three countries in the world: two large countries, A and B, and a small open economy. For convenience, we call the two large countries as the 'US' and 'mainland China' and the small open economy as 'Hong Kong' or 'home'.[7,8] The home households consume

[7]One can also think of A as the "US dollar area" and B as the " RMB area", where the respective currency is the invoicing currency for trade flow in the specific area.

[8]Hong Kong is only an example. The same analysis can be applied to other small open economies characterized by vertical trade. For example, the two large economies can be Japan and US, and the small open economy can

domestically produced non-traded goods and foreign goods which are imported from the US and China. Households supply labor for both non-traded goods firms and traded goods firms. This small open economy is characterized by vertical trade. Traded goods firms in this small economy import intermediate goods from country B (China) to produce finished goods which are exported to country A (the US). The imported intermediates goods are assumed to be priced in RMB, while the export goods are priced in dollars, so the US dollar is an export currency and the RMB is an import currency.[9,10] Figure 1 presents a flow chart of the structure of the goods and assets markets in the model.

The nominal exchange rates of the US dollar and the RMB in terms of domestic currency in period t are denoted as S_t^A and S_t^B, respectively. Under triangular arbitrage conditions, we have $S_t^A = S_t^B S_t^{BA}$, where S_t^{BA} is the exchange rate of the dollar in terms of the RMB in period t. In this model, S^{BA} is the major source of uncertainty for the economy. We also consider the foreign demand shocks from the US market and the intermediate goods price shocks from China.

2.1 Households

The preference of the representative household is given by [11]

$$EU = E_t \sum_{s=t}^{\infty} \beta^{s-t} \{ \frac{[C_s^v (1 - L_s)^{1-v}]^{1-\rho}}{1-\rho} - 1 \}, \tag{1}$$

be Malaysia or Thailand.

[9]To focus on the optimal currency basket, we take the invoicing choice as exogenous to our model. The assumption of exports being priced in dollars is consistent with the empirical evidence in Cook and Devereux (2006). They show that most export goods in East Asian economies are priced in foreign currencies, especially in US dollars. Given the fact that traded goods firms are located in a small open economy, the assumption that invoicing currency of imported inputs is exogenous to traded goods firms' decision is also justifiable.

[10]Although dollar's volatility against the yuan is relatively lower than against other major currencies, the flexibility of RMB exchange rate has been increasing over the last few years. The Chinese government is taking steps to facilitate the use of the RMB as a settlement currency for current account transactions in the region and elsewhere in the world. With a more flexible yuan exchange rate, RMB has the potential for increased international use as an invoicing-currency. The fluctuation of the dollar/yuan exchange rate will then increasingly be one of the major concerns for East Asian economies.

[11]We thank an anonymous referee for suggesting that we use the King-Plosser-Rebelo (1988) preference so that the utility function is consistent with balanced growth.

where C is an aggregate consumption index defined across domestic non-traded goods and imported consumption goods; L_s is the labor supply of households. β is the discount factor; ρ is the inverse of the elasticity of intertemproal substitution; v is the share of consumption in utility. The consumption index, C, is given by $C_t = (C_{Nt}/(1-\alpha))^{1-\alpha}(C_{Ft}/\alpha)^{\alpha}$, where C_{Nt} is the aggregate of domestically produced non-traded goods, C_{Ft} is the aggregated imported consumption, and α is the share of imported foreign goods in domestic households' consumption basket.[12] It is assumed that the aggregate imported consumption good is defined as $C_{Ft} = (C^A_{Ft}/\gamma)^{\gamma}(C^B_{Ft}/(1-\gamma))^{1-\gamma}$, where C^A_F and C^B_F are imported consumption goods from countries A and B, respectively. The consumer price index for domestic households can be then derived as

$$P_t = P_{Nt}^{1-\alpha} P_{Ft}^{\alpha}, \tag{2}$$

where P_{Nt} and P_{Ft} are the price indices of domestic non-traded goods and imported foreign consumption goods. For simplicity, the foreign-currency prices of imported consumption goods from both Country A and Country B are normalized to unity. Hence, the import goods price index, P_F, is given by $P_{Ft} = (S^A_t)^{\gamma}(S^B_t)^{1-\gamma}$, where γ and $1-\gamma$ are the weight of imported US goods and Chinese goods in the basket of imported consumption goods.

Assume also that households do not have access to international financial markets and they can only hold one-period domestic bonds, B_t, to smooth consumption across periods.[13] Their period t budget constraints are:

$$P_t C_t + B_{t+1} = W_t L_t + (1+i_t)B_t + \Pi_t, \tag{3}$$

where Π_t is the profit that households receive from the non-traded goods firms and the traded goods firms.

[12] It is assumed that the domestic household does not consume domestically produced traded goods, so all the home produced traded goods are exported to the US market.

[13] The focus of this paper is vertical trade, so the assumption about the financial market will be kept as simple as possible. Assuming that households do not have access to foreign financial markets eliminates the impact of financial issues on the choices of the pegging currency.

The households choose non-traded and imported goods to minimize their expenditure conditional on total composite demand. Therefore, the demand for non-traded and imported goods is

$$C_{Nt} = (1-\alpha)\frac{P_t C_t}{P_{Nt}}, \qquad C_{Ft} = \alpha\frac{P_t C_t}{P_{Ft}}. \tag{4}$$

From the household's optimization problem, we derive the standard Euler equation and the optimal condition for the labor-leisure choice:

$$\frac{1}{1+i_{t+1}} = \beta E_t[(\frac{C_{t+1}}{C_t})^{v(1-\rho)-1}(\frac{1-L_{t+1}}{1-L_t})^{(1-v)(1-\rho)}(\frac{P_t}{P_{t+1}})], \tag{5}$$

$$\frac{1-v}{v}\frac{C_t}{1-L_t} = \frac{W_t}{P_t}. \tag{6}$$

2.2 Firms

There are two production sectors in this small open economy: the non-traded good sector and the traded good sector. Firms in these two sectors are assumed to produce differentiated goods and to have monopolistic power. Both non-traded goods and traded goods prices are set in a Calvo pricing mechanism (Calvo 1983). The two sectors differ in their production technologies. Non-traded firms produce output using only labor, while export goods are produced by combining labor and imported intermediate goods.

2.2.1 The Non-traded Goods Sector

There is a continuum of firms indexed by $j \in$ [0,1] in the non-traded goods sector. Each firm is monopolistically competitive in the market for non-traded good j, which is imperfect substitute in the production of composite good Y_N. Aggregate non-traded output is defined as $Y_{Nt} = (\int_0^1 Y_{Nt}(j)^{\frac{\lambda-1}{\lambda}} dj)^{\frac{\lambda}{\lambda-1}}$, where λ is the elasticity of substitution across differentiated non-traded goods. Given the aggregation, the demand for individual non-traded goods j can be derived as

$$Y_{Nt}(j) = (\frac{P_{Nt}(j)}{P_{Nt}})^{-\lambda} Y_{Nt}, \tag{7}$$

where $P_{Nt} = (\int_0^1 P_{Nt}(j)^{1-\lambda} dj)^{\frac{1}{1-\lambda}}$ is the price index for the composite non-traded goods.

Each firm has a linear production technology, $Y_{Nt}(j) = L_{Nt}(j)$. As in Calvo (1983), a given firm may reset its price with probability $1 - \kappa_N$ each period. Therefore, when resetting price, a firm j will choose $P^o_{Nt}(j)$ to maximize the following weighted expected profit:

$$E_t \sum_{l=0}^{\infty} [(\beta\kappa_N)^l \frac{\Lambda_{t+l}}{\Lambda_t} \frac{\Pi_{t+l}(j)}{P_{t+l}}], \tag{8}$$

where $\Pi_{t+l}(j) = [P^o_{Nt}(j) - MC_{Nt+l}(j))]Y_{Nt+l}(j)$ is the non-traded firm j's profit in period $t+l$, and $\Lambda_t = U'_c(C_t, 1 - L_t)$ is the marginal utility of consumption for a representative household, and $MC_{Nt}(j) = W_t$ represents the marginal cost for non-traded firms. the optimal price for the non-traded good firm is then given by

$$P^o_{Nt}(j) = \frac{\lambda}{\lambda - 1} \frac{E_t \sum_{l=0}^{\infty} (\beta\kappa_N)^l \frac{\Lambda_{t+l}}{P_{t+l}} MC_{Nt+l} P^{\lambda}_{Nt+l} Y_{Nt+l}}{E_t \sum_{l=0}^{\infty} (\beta\kappa_N)^l \frac{\Lambda_{t+l}}{P_{t+l}} P^{\lambda}_{Nt+l} Y_{Nt+l}}. \tag{9}$$

Given the Calvo pricing, a fraction κ_N of prices remain unchanged from the previous period, and the aggregate price for non-traded goods can be rewritten as $P_{Nt} = [\kappa_N (P_{Nt-1})^{1-\lambda} + (1 - \kappa_N)(P^o_{Nt})^{1-\lambda}]^{\frac{1}{1-\lambda}}$.

2.2.2 The Traded Goods Sector

There is also a unit interval [0,1] of monopolistically competitive firms indexed by i in the traded good sector that produce differentiated export goods and sell them to the US market. The aggregate export goods is given by $Y_{Tt} = (\int_0^1 Y_{Tt}(i)^{\frac{\lambda-1}{\lambda}} di)^{\frac{\lambda}{\lambda-1}}$. Export firms face a similar problem to that in the non-traded good sector, setting export prices to maximize their expected profit stream. However, export prices are priced in US dollars, which implies that the US dollar is an *export currency.*

Export firms use imported intermediate goods from Country B and local labor to produce differentiated goods which are re-exported to Country A. The traded goods firms' production function is given as

$$Y_{Tt}(i) = [\alpha_T^{\frac{1}{\theta}} L_{Tt}(i)^{\frac{\theta-1}{\theta}} + (1-\alpha_T)^{\frac{1}{\theta}} IM_t(i)^{\frac{\theta-1}{\theta}}]^{\frac{\theta}{\theta-1}} \tag{10}$$

where α_T is the share of labor in the traded goods firms' production, and $\theta > 0$ is the elasticity of substitution between local labor and imported intermediate inputs. The marginal cost, MC_T, is then given by

$$MC_{Tt} = [\alpha_T W_t^{1-\theta} + (1-\alpha_T)(S_t^B P_{mt}^*)^{1-\theta}]^{\frac{1}{1-\theta}} \tag{11}$$

where P_{mt}^* is the RMB price of intermediate goods, which is assumed to be an exogenous shock.

Each firm i faces a downward-sloping demand function,

$$X_t(P_{Tt}^*(i)) = (\frac{P_{Tt}^*(i)}{P_{Tt}^*})^{-\lambda}(\frac{P_{Tt}^*}{P_{asia,t}^*})^{-\mu} X_t, \tag{12}$$

where $P_{Tt}^*(i)$ is the price of export good i from home; P_{Tt}^* is the price index of home produced export goods; and $P_{aisa,t}^*$ is the aggregate price of export goods sold in the world market from Asian countries. Without loss of generality, let $P_{Tt}^*(i)$, P_{Tt}^*, and $P_{aisa,t}^*$ be denominated in dollars. Also, in Eq. 12, $\mu > 0$ is the elasticity of substitution between home export goods and foreign export goods and $\lambda > 1$ is the elasticity of substitution across domestically produced individual traded goods. X_t is a foreign demand shock, which is assumed to follows a stochastic process.

Intuitively, $P_{asia,t}^*$ should be a function of S_t^{BA} or its lags. That is, when the dollar/RMB exchange rate fluctuates, exchange rates between the US dollar and other Asian currencies may also change, which in turn affect the dollar price of aggregate exported goods from Asian countries. In a sense, this can be considered as an indirect exchange rate pass-through of changes in dollar/RMB rate to export prices from other Asian countries. Also, it reveals the competition effect between export goods from the home economy and those from other Asian economies. Obviously, the impact of S^{BA} on P_{asia}^* also depends on the exchange rate policies of other Asian countries. If they adopt flexible exchange rate regimes or an RMB peg, then an appreciation of the dollar against the RMB (increase of S_t^{BA}) usually implies appreciation of the

US dollar against other Asian currencies and decreases in the dollar prices of their exports.[14] If other Asian countries peg their currencies to the US dollar, then exchange rate changes between the dollar and RMB will not affect the US dollar prices of their exports. In a later section, we will specify the functional form of $P^*_{asia,t}$ based on estimation.

Traded goods firms set prices in a manner similar to that of the non-traded good firms, but in terms of US dollars. Each firm may reset its price with probability $1-\kappa_T$ every period. When resetting prices, firm j will choose $P^{o,*}_{Tt}(j)$ to maximize its weighted expected profit:

$$E_t \sum_{l=0}^{\infty}[(\beta\kappa_T)^l \frac{\Lambda_{t+l}}{\Lambda_t}\frac{\Pi_{t+l}(j)}{P_{t+l}}], \tag{13}$$

where $\Pi_{t+l}(j) = [S^A_{t+l}P^{o,*}_{Tt}(j) - MC_{Tt+l}(j))]Y_{Tt+l}(j)$ is the traded goods firm j's profit in period $t+l$. The optimal price for the traded goods firm is given by

$$P^{o,*}_{Tt}(j) = \frac{\lambda}{\lambda-1}\frac{E_t\sum_{l=0}^{\infty}(\beta\kappa_T)^l\frac{\Lambda_{t+l}}{P_{t+l}}MC_{Tt+l}P^{\lambda}_{Tt+l}Y_{Tt+l}}{E_t\sum_{l=0}^{\infty}(\beta\kappa_T)^l\frac{\Lambda_{t+l}}{P_{t+l}}S^A_{t+l}P^{\lambda}_{Tt+l}Y_{Tt+l}} \tag{14}$$

The aggregate price for domestically produced traded goods is then $P^*_{Tt} = [\kappa_T(P^*_{Tt-1})^{1-\lambda} + (1-\kappa_T)(P^{o,*}_{Tt})^{1-\lambda}]^{\frac{1}{1-\lambda}}$.

2.3 Exchange Rate Policy

The monetary authority's role in this model is to set the weights of import and export currencies in a currency basket, which satisfies.

$$(S^A_t)^{\omega}(S^B_t)^{1-\omega} = 1, \qquad\qquad 0 \leq \omega \leq 1 \tag{15}$$

[14]In fact, the export pricing behavior of firms in other Asian economies should also be considered. If the export prices of most Asian economies are preset in US dollars, then in the short run, $P^*_{asia,t}$ will be less sensitive to changes in S^{BA}_t. Nevertheless, as Shi and Xu (2010) have shown, for a small open economy, exchange rate policies can affect export firms' pricing currency choices. A fixed exchange rate regime will lead to foreign currency pricing, while a flexible exchange rate regime will lead firms to set export prices in the domestic currency, which increases the sensitivity of export prices to S^{BA}_t.

We allow for a continuum of exchange rate regimes that can be generalized as a basket peg with weights ω and $1-\omega$ on the dollar and the RMB, respectively. This policy rule is also equivalent to setting two exchange rates, S_t^A and S_t^B, as functions of S_t^{BA}. Under triangular arbitrage condition, we have: $S_t^A = (S_t^{BA})^{1-\omega}$ and $S_t^B = (S_t^{BA})^{-\omega}$. There are two special cases, when the monetary authority chooses either $\omega = 0$ or $\omega = 1$. That is,

- An RMB peg ($\omega = 0$): $S_t^B = 1$ and $S_t^A = S_t^{BA}$. In this case, all the fluctuations of S_t^{BA} are absorbed by S_t^A.
- A US dollar peg ($\omega = 1$): $S_t^A = 1$ and $S_t^B = \frac{1}{S_t^{BA}}$. In this case, all the fluctuations of S_t^{BA} are absorbed by S_t^B.

2.4 Equilibrium

In equilibrium, besides the optimality conditions for firms and households, we have the market clearing conditions for the labor market, the export goods market, and the non-traded goods market as follows,

$$L_{Nt} + L_{Tt} = L_t. \tag{16}$$

$$Y_{Tt} = (\frac{P_{Tt}^*}{P_{asia,t}^*})^{-\mu} X_t. \tag{17}$$

$$Y_{Nt} = (1-\alpha)\frac{P_t C_t}{P_{Nt}}. \tag{18}$$

In equilibrium, $B_t = 0$, so the household's budget constraint can be rewritten as

$$S_t^A P_{Tt}^* Y_{T_t} - \alpha P_t C_t - S_t^B P_{mt}^* IM_t = 0. \tag{19}$$

This is a balance of payment condition, where the export revenue covers both imports for consumption, $\alpha P_t C_t$, and imports for production, $S_t^B P_{mt}^* IM_t$. This condition also implies that domestic consumption expenditure depends on net export revenue.

Table 1: Calibration Parameters

Parameter	value	Parameter	value	Parameter	value
ρ	2	β	0.99	α	0.4
λ	5	α_T	0.4	γ	0.5
v	0.36	ϕ	0.59	σ_s	0.98%
μ	1	θ	0.5	σ_m	1.3%
κ_N	0.85	κ_T	0.75	σ_x	0.7%
ρ_s	0.92	ρ_x	0.85	ρ_m	0.77

3 Model Results

In this section we present some welfare results under two extreme cases, $\omega = 0$ (RMB peg) and $\omega = 1$ (US dollar peg) when the economy is disturbed by external shocks. We also report the optimal weight of currency basket and investigate factors that affect the composition of the optimal currency basket.

3.1 Calibration

Table 1 lists the structural parameters of the model that need to be calibrated. The coefficient of risk aversion, ρ, is set to 2 as is commonly assumed in the literature. The discount factor, β is calibrated at 0.99, so that the steady state annual real interest rate is 4%. The share of consumption in utility v is set to 0.36. The elasticity of substitution across individual export goods, λ, is chosen to be 5, which gives a price mark-up of about 25 percent. This is higher than the markup in industrial economies, however, it is close to the margin of Hong Kong's reexport activities reported by Feenstra and Hansen (2004). The elasticity of substitution between home-produced trade goods and other Asian goods, μ, is set to unity. α is set equal to 0.4, which implies that the share of non-traded goods in the consumer basket is 0.6. This is close to the evidence cited by Cook and Devereux (2006) for East Asian economies. The proportion of US goods in the total imported consumption goods, γ, is set to 0.5 so that we can focus on exploring the impact of trade invoicing currencies on the composition of the optimal currency basket.

Vertical trade is the major feature of our model, so we elucidate how different values of parameters governing vertical trade features (α_T and θ) affect the optimal composition of currency basket. For the benchmark case, we set $\alpha_T = 0.4$, so that the share of labor in the traded goods sector is approximately equal to that estimated by Cook and Devereux (2006). For θ, we consider a low value for the elasticity of input substitution in the traded goods sector, setting $\theta = 0.5$. This is consistent with the fact that re-exporting usually involves processing trade,[15] which implies a low elasticity of input substitution.

We set the parameters governing the price rigidities in the non-traded good sector and traded good sector, $\kappa_N = 0.85$ and $\kappa_T = 0.75$. This means that all prices in the two sectors will adjust on average after 6 and 4 quarters, respectively. This follows the standard estimation used in the literature and it is also consistent with the findings of Ortega and Rebei (2006) that nominal rigidity in the non-traded goods sector is higher than that in the traded goods sector. To get a reasonable value for ϕ, the elasticity of other countries' export prices on changes of S^{BA}, we use the dollar denominated US import index from four Asian newly industrialized countries (NICs, including Korea, Hong Kong, Singapore and Taiwan) and the dollar/RMB exchange rate changes from 2005 Q2 to 2009 Q4 to estimate ϕ.[16] Details of the data and the estimation procedure are given in the Technical Appendix. The estimation reveals that the exchange rate changes between US dollar and RMB has a significant effect (at the 10% level) on Asian economies' export prices ($\phi = 0.59$), but with a one quarter lag. Therefore, we simply assume that $P_{asia,t} = (S^{BA}_{t-1})^{-\phi}$ and set $\phi = 0.59$ in the benchmark model. The value of ϕ will be varied to see how changes in ϕ affect the choice of the optimal currency basket.[17]

[15]Processing trade refers to importing all or part of the raw and auxiliary materials, parts and components, accessories, and packaging materials from abroad in bond, and re-exporting the finished products after processing or assembly by enterprises within the domestic economy.

[16]Starting from July 21, 2005, The People's Bank of China announced the adoption of a managed floating exchange rate regime, based on market supply and demand, under which the exchange rate of the RMB would be managed in relation to a basket of currencies. For this reason only exchange rate fluctuations after 2005 Q2 are considered.

[17]If the dollar denominated US import index from ASEAN countries and the dollar/RMB exchange rates are used to estimate ϕ, the result is $\phi = 0.83$ with a significance level $> 10\%$, and $< 15\%$, with no lag. So the estimated ϕ from the Asian NICs was used in the benchmark case. We also estimate the response of dollar denominated US import index from Asia to exchange rate changes between yen and dollar, but the results were

The main uncertainty in the model is the exchange rate volatility between the US dollar and the RMB, which is assumed to follow an AR(1) process,

$$\log(S_t^{BA}) = \rho_s \log(S_{t-1}^{BA}) + \epsilon_{st}, \tag{1}$$

where $0 < \rho_s < 1$ and the serially uncorrelated shock ϵ_{st} is normally distributed with zero mean and standard deviation σ_s. We estimate the process of S_t^{BA} by using the HP filtered quarterly (log) exchange rate between the RMB and the dollar from 2005 Q3 to 2010 Q3. From the estimation, we set $\rho_s = 0.92$ and $\sigma_s = 0.009843$.[18]

In addition, we consider two other types of external disturbances: shocks to the intermediate goods price, P_{mt}^*, and foreign demand shocks from the US market, X_t.

$$P_{mt}^* = (1 - \rho_m)\bar{P_m^*} + \rho_m P_{mt-1}^* + \epsilon_{mt}, \tag{2}$$

$$log(X_t) = (1 - \rho_x) log(\bar{X}) + \rho_x log(X_{t-1}) + \epsilon_{xt}, \tag{3}$$

where $0 < \rho_m < 1$ and $0 < \rho_x < 1$, the serially uncorrelated shocks, ϵ_{mt} and ϵ_{xt} are normally independently distributed with zero mean and standard deviation σ_m and σ_x, respectively. We set $\rho_X = 0.85$ and $\sigma_x = 0.007$, which are close to the estimates from Gali and Monacelli (2005) and Ortega and Nooman (2005). Since intermediate goods price shocks can be approximately interpreted as terms of trade shocks for a small open economy, we set $\rho_m = 0.77$ and $\sigma_m = 0.013$ as in Devereux, Lane, and Xu (2006).

not significant. This is perhaps because the competition of exports from Japan with those from Asian countries is much weaker than that between export goods from China and Asian countries.

[18] The model is stationary. Also, the mean of the log exchange rate is zero. So in calibrating the exchange rate shock, we need to detrend the data. This persistence is slightly higher than that of the major currencies against the US dollar. If the trend of S^{BA} is introduced into the model, the model has to be detrended before being solved. This will not, however, affect the results.

Table 2: Welfare Comparison
(Benchmark Case)

ξ_k	$S^{BA}shock$	+X shock	$+P_m^*$ shock	Three shocks
$\omega = 0$	-0.0036%	-0.0061%	-0.0044%	-0.0069%
$\omega = 1$	0.0038 %	0.0012 %	0.003 %	0.0004%
ω^*	0.8	0.8	0.8	0.8

3.2 Welfare Results

In this subsection, we study welfare properties of alternative policy regimes in this economy. The welfare measurement we use here is the conditional expected lifetime utility of the representative household at time zero. Following Schmitt-Grohe and Uribe (2004), the expected lifetime utility is computed conditional on the initial state being the deterministic steady state, which is the same for all policy regimes. To compare welfare across different regimes, define ζ_k as the percentage change of deterministic steady-state consumption that will give the same conditional expected utility, EU, under policy regime k. That is, ζ_k is given implicitly by:

$$\frac{\frac{1}{1-\rho}[((1+\zeta_k)\bar{C})^v(1-\bar{L})^{1-v}]^{1-\rho}-1}{1-\beta} = EU_k, \tag{4}$$

where a bar over a variable denotes the deterministic steady state of that variable. If $\zeta_k > 0(< 0)$, the welfare under regime k is higher (lower) than that under the steady-state case.

The welfare results of two extreme cases (import currency peg and export currency peg) and the optimal currency basket are presented in Table 2. The optimal weight, ω^*, of a currency basket, can be derived through a grid search by considering 100 values of ω, which range from 0 to 1 with an increment of 0.01. The optimal currency basket weight is the value of ω that delivers the largest ξ_k.

Table 2 presents welfare results for four different cases. The first column represents the case with an exchange rate shock only. In the second and third columns the economy is subject to one more external shock, namely, a foreign demand shock or an intermediate goods price shock, respectively. The last column reports the welfare result when the economy is subjected to all three shocks. Table 2 shows that, in the benchmark case: (1) In terms of welfare, the export currency peg ($\omega = 1$) is superior to the import currency peg ($\omega = 0$); (2) the optimal weight in a currency basket is mainly determined by the exchange rate shock, not the others; (3) the foreign demand shock and the intermediate goods price shock have no impact on the optimal weight, ω^*, nor on the welfare ranking of the policy regimes. Their presence just changes the magnitude of the welfare gain or loss. This is because these two shocks are real shocks from which a small open economy cannot be insulated under any fixed exchange rate regimes. The following analysis will therefore focus on the case with exchange rate shocks only.

It should be noted that this welfare result[19] is related to the small open economy setting. This modeling framework helps us to focus on the home economy but closes endogenous feedback loops between the countries involved in the production and trade chain. Also, to simplify the analysis, multiple stages of production and trade were not considered, which eliminated efficiency gain role of vertical trade when upstream goods cross borders downstream many times and create efficiency gain at each stage.

If we consider a full-fledged three country model and allow for those endogenous feedback loops, the welfare results might be different. Using a US monetary expansion as an example, obviously the US demand shock will leads to increases in demand for intermediate goods produced by China through vertical trade. This will lead to an increase of P_m^* and thus to changes in the terms of trade, and it may also affect the exchange rate between export currency and import currency. These changes will in turn alter the relative benefits from export revenue stabilization and import cost stabilization, and thus consumption and labor volatility. So the optimal currency basket and the welfare difference between the export currency peg and the

[19]Huang and Liu (2006) showed that vertical vertical production and trade can have significant welfare implications in a two country model by magnifying the efficiency-improvement effect of trade and dampening the term of trade effect caused by domestic monetary expansions. Nevertheless, in this paper even with vertical trade, the foreign demand shock and terms of trade shock were found to change only the magnitude of the welfare gain /loss, but have no impact on the composition of optimal currency basket. The difference in welfare results is due to the difference in model setting.

import currency peg may change once the endogenous feedback loops caused by foreign demand shocks are taken into consideration in a full fledged three-country model. However, whether this will lead to an increase or decrease in the optimal ω^*, depends on the relative goods flow through vertical trade, the trade structure, and number of stages of production and trade. More stages of production and trade, for example, will increase the efficiency-improvement role of trade due to the foreign demand shocks and reduce the terms of trade effect, thus leads to more stabilization of export currency in the optimal currency basket. Following the same logic, trade structure such as the share of intermediate goods exports in total export from Country B(China) also matters.

Nonetheless, the size of the home economy in our model was assumed to be very small relative to those of Country A and B. So the impact of these endogenous feedback loops on the domestic economy through vertical trade will not be big because of the relative size of this small open economy. Introducing a three-country model may affect the findings of this paper quantitatively, but not qualitatively.

3.3 Impulse Response Functions

To explain the welfare results, the impulse response functions of aggregate variables to a positive S^{BA} shock under an export currency peg and an import currency peg are reported in Figure 2. The illustrations are divided into categories of real variables (namely, consumption, employment, sectoral employment, and traded sector output) and those of nominal variables (namely, CPI, wage, S_A, S_B, non-traded goods prices, traded goods prices, and traded sector marginal cost).

Under an export currency peg, an increase in S^{BA} implies a decrease in S^B. So the price of imported goods faced by domestic households decreases, which reduces the domestic CPI and increases consumption. This will lead to expenditure switching from non-traded goods to imported consumption goods. So the non-traded goods sector may shrink in this case. But if domestic consumption increases, then a stronger demand for non-traded goods could offset partially the substitution effect. In the benchmark model, as shown in Figure 2, the consumption first increases, so does the non-traded goods sector's output and the nominal wage.

The appreciation of domestic currency against the RMB also implies decreases in intermediate goods prices and then decreases in the marginal costs and prices of traded goods. This will increase the demand for export goods in the first period. In the second period, increases of S^{BA} leads to a decrease in export goods prices from other Asian economies. The competition between exports goods from the home country and other economies will then lead to a decreases in the demand for domestically produced export goods. As a result, the traded goods sector's output will fall in the second period and recovery gradually. In this case, both the fall in export demand and the substitution effect between labor and imported intermediate goods lead to decrease in traded goods sector employment and then total employment. The decrease in traded goods demand also leads to decrease of total consumption and non-traded goods consumption in the second period. Note that due to price stickiness, changes in P_N and P_T are smooth.

Under an import currency peg, an increase in S^{BA} implies a rise in S^A (the domestic currency depreciates against the dollar). So the price of imported foreign consumption goods and the domestic CPI increase. This will also generate an expenditure switching effect between imported foreign consumption goods and non-traded goods, which may cause the expansion of the non-traded goods sector and the movement of labor from the traded sector to the non-traded sector. As the non-traded goods sector is labor intensive, total employment will increase. Also, nominal wages will increase as well, which pushes up the marginal costs and prices of non-traded goods.

Figure 2 shows that in the second period the demand for domestically produced export goods will fall due to the increase of S^{BA}. Finally, since export goods are priced in dollars, an increase in S^A will have a wealth effect, which helps to increase the export revenue and partially offsets the negative (lagged) competition effect on domestic export demand. Meanwhile, the import currency peg also reduces fluctuation in the costs of imported intermediates. So an import currency peg may increase expected export revenue. As a result, although faced with a higher CPI, the households could consume more.

What drives the difference in welfare results between an export currency peg and an import currency peg? In our model, the mean of consumption and labor are almost unaffected by the choice of currency basket. Therefore, the welfare difference between the export currency peg and the import currency peg mainly comes from difference in the volatility of consumption and labor under the two exchange rate regimes. For a small open economy, exchange rate volatility between an import currency and an export currency can be divided into changes in the exchange rate of domestic currency against the import currency and those against the export currency according to their weights in the currency basket. For export goods producers, the exchange rate fluctuation between domestic currency and the export currency causes instability of export revenue and also leads to more volatile demand for export goods. Meanwhile, an exchange rate fluctuation between domestic currency and the import currency will cause substitution between imported intermediates and local labor, leading to instability of the firms' import costs and also volatile demand for labor.

On the one hand, from the balance of payment condition (19), the consumption expenditure is proportional to the net export revenue (export revenue minus import cost), so any instability of net export revenue will imply volatile consumption. Hence, an optimal currency basket must balance the trade-off between revenue instability and cost instability so as to reduce the consumption volatility. On the other hand, exchange rate fluctuations of export currency lead to volatile demand for export goods and labor in traded sector, while exchange rate changes of import currency also cause unstable demand for labor. Therefore an optimal currency basket is also expected to reduce the volatility of labor by stabilizing export demand and input substitution. This makes the structural parameters that affect traded goods firms' cost and revenue structure and the demand for traded sector labor key factors in determining the optimal currency basket.

4 What Affects Optimal Currency Basket?

In this subsection, we investigate how the structure parameters governing vertical trade affect ω^*, the composition of the optimal currency basket. The welfare results are report in Tables 3-5. Note that in each table, unless specified otherwise, the values of the other structural parameters

Table 3: Welfare Change with Trade Structure
(with S^{BA} shock only)

	Labor share				Input substitution elasticity			
ξ_k	$\alpha_T = 0.3$	$\alpha_T = 0.35$	$\alpha_T = 0.4$	$\alpha_T = 0.5$	$\theta = 0.2$	$\theta = 0.5$	$\theta = 0.8$	$\theta = 1.1$
$\omega = 0$	-0.0041 %	-0.0038%	-0.0036%	-0.0032%	-0.0052 %	-0.0036%	-0.0007%	0.0027%
$\omega = 1$	0.0066 %	0.005 %	0.0038%	0.0022%	0.0013 %	0.0038%	0.0071%	0.0107%
ω^*	0.94	0.86	0.8	0.72	0.76	0.8	0.84	0.86

are those of the benchmark case.

The first parameter is α_T, the share of labor in the traded goods firms' production. Table 3 shows that more weight should be put on the import currency when α_T is larger. When α_T increases, more labors is needed in the traded sector, so households need to work more, which leads to more wage income and consumption. Hence, the mean of consumption and labor are higher given a higher α_T, as shown in Table 4. However, for a given value of α_T, changes in ω have little impact on EC and EL. Therefore, any impact of the currency basket's composition on welfare mainly works through the changes in variance of consumption and labor. From Table 4 we can see that, when α_T increases, the volatility of labor increases under an export currency peg, while the volatility of consumption and labor decrease under an import currency peg. This implies that the welfare delivered by an import currency peg increases with α_T. Intuitively, when more labor is needed in the traded goods sector, a given fluctuation in the cost of imported intermediate goods will lead to a more volatile labor demand. So when α_T increases, in the optimal currency basket the import currency should be weighted more so as to reduce the substitution between imported intermediates and labor caused by fluctuations of the import currency. This will in turn reduce labor volatility.

θ is the elasticity of input substitution in the traded goods sector. Table 4 shows that, increases of θ leads to lower mean of the consumption and employment, due to lower labor demand. Nevertheless, given θ, EC and EL does not change with ω. So as was the case for α_T, only the second moments of consumption and employment will be affected by the choice of currency weighting. On one hand, if the elasticity of input substitution is large, then a

Table 4: Volatility of Consumption and Labor
(with S^{BA} shock only)

	Labor share		Input substitution elasticity	
ξ_k	$\alpha_T = 0.3$	$\alpha_T = 0.5$	$\theta = 0.2$	$\theta = 1.1$
$\omega = 0$	$\sigma_C = 0.0076$	$\sigma_C = 0.0061$	$\sigma_C = 0.0067$	$\sigma_C = 0.0065$
	$\sigma_L = 0.0022$	$\sigma_L = 0.0018$	$\sigma_L = 0.0021$	$\sigma_L = 0.0014$
$\omega = 1$	$\sigma_C = 0.0037$	$\sigma_C = 0.0032$	$\sigma_C = 0.0034$	$\sigma_C = 0.0031$
	$\sigma_L = 0.0014$	$\sigma_L = 0.0017$	$\sigma_L = 0.0017$	$\sigma_L = 0.0016$
$\omega = 0$	$EC = 0.5738$	$EC = 0.6408$	$EC = 0.6451$	$EC = 0.5516$
	$EL = 0.2928$	$EL = 0.3031$	$EL = 0.3036$	$EL = 0.2881$
$\omega = 1$	$EC = 0.5739$	$EC = 0.6409$	$EC = 0.6451$	$EC = 0.5516$
	$EL = 0.2928$	$EL = 0.3031$	$EL = 0.3036$	$EL = 0.2881$

fluctuation in the exchange rate of the domestic currency against the import currency will lead to a volatile demand for traded sector labor. So when θ increases, the exchange rate fluctuation of the import currency should be reduced to decrease labor volatility. On the other hand, increased elasticity of input substitution helps to stabilize the cost of imported intermediate goods, $S_t^B P_{m,t}^* IM_t$, given exchange rate changes between the domestic and import currencies. This is because, with a more elastic substitution between labor and imported intermediates, changes in intermediate goods prices due to fluctuations in S_t^B can be offset by changes in the quantity of imported intermediate goods. So import costs will be less volatile for given changes in imported intermediates prices. More weight can thus be put on the export currency so as to stabilize the export revenue and reduce consumption volatility. When θ increases, these two opposite effects will be at work. As shown in Table 4, as θ increases, the volatility of labor decreases more under an import currency peg, while the volatility of consumption decreases more under an export currency peg. In terms of welfare, the effect on consumption volatility dominates. As a result, the optimal ω increases with θ.

The third relevant parameter is κ_T, which measures price rigidity in the traded goods sector and affects the dynamics of export prices. The effect of κ_T on welfare and the optimal currency basket is reported in Table 5. Four cases are investigated; $\kappa_T = 0.85$, $\kappa_T = 0.75$, $\kappa_T = 0.55$, and $\kappa_T = 0.25$. These values represented prices in the traded goods sector adjusting on average in 20,

Table 5: Welfare Change with Price Rigidities in the Traded Sector
(with S^{BA} shock only)

ξ_k	$\kappa_T = 0.85$	$\kappa_T = 0.75$	$\kappa_T = 0.55$	$\kappa_T = 0.25$
$\omega = 0$	-0.0035 %	-0.0036%	-0.0047 %	-0.0061%
$\omega = 1$	0.0049 %	0.0038 %	0.0009 %	-0.0021 %
ω^*	0.85	0.8	0.73	0.66

12, 6.7, 4 months, respectively. Table 5 shows that when κ_T decreases (prices are more flexible in the traded goods sector), a lower weight will be put on the export currency in a currency basket. This is because when price rigidities are low, the export price is mainly determined by firms' marginal costs, as is the aggregate export price. Hence, the benefit of export revenue stabilization under an export currency peg will be reduced. This implies that with more flexible prices an import currency peg may stabilize not only export firms marginal cost's but also their export revenues, and thus may stabilize consumption more. More weight should therefore be put on the import currency when price rigidity in the export sector decreases.

Tables 2-5 indicates that although the parameters governing the vertical trade structure and price rigidities in the traded goods sector can affect the optimal currency basket, given reasonable parameter values an export currency peg always dominates an import currency peg in terms of welfare. In practice, when countries choose a fixed exchange rate regime, they often choose a single currency peg instead of a currency basket. Do the results in Tables 2-5 imply that Asian economies should always peg their currencies to the US dollar if they choose a single currency peg? Table 6 shows that the answer to this question depends on ϕ, the parameter characterizing the response of Asian economies' average export prices to exchange rate fluctuations of the dollar against the RMB.

If $\phi = 0$, this implies that the exchange rate between other Asian currencies and the US dollar will not change when S_t^{BA} changes. This refers to the case where other Asian countries follow the US dollar peg. If $\phi > 0$, then a decrease in S_t^{BA} (the US dollar depreciates against the RMB) will lead to depreciation of the US dollar against other Asian currencies and an increase

Table 6: Welfare Change with ϕ
(S^{BA} shock)

ξ_k	$\phi = 0.3$	$\phi = 0.59$	$\phi = 0.8$	$\phi = 0.9$	$\phi = 1$	$\phi = 1.1$
$\omega = 0$	-0.011 %	-0.0036%	0.0010%	0.0030%	0.0049 %	0.0065%
$\omega = 1$	0.0020%	0.0038 %	0.0044%	0.0044%	0.0043%	0.0041%
ω^*	1	0.8	0.64	0.56	0.48	0.4

of $P^*_{asia,t}$ due to delayed indirect exchange rate pass-through or export competition effects. This corresponds to the case where other Asian countries follow flexible exchange rate regimes or peg their currencies to other currencies instead of the US dollar.

Table 6 shows that when ϕ increases, the welfare ranking between an import currency peg and an export currency peg may be reversed. That is, in terms of welfare, an import currency peg becomes superior to an export currency peg when ϕ is large enough. Meanwhile, ω^* decreases when ϕ increases, implying more weight should be put on the import currency in the optimal currency basket. This finding suggests that the home country should take the responses of other Asian economies to the dollar/RMB exchange rate fluctuations into consideration when deciding which currency to peg to.

The intuition is as follows. If other Asian economies choose not to fix their currencies to the US dollar, $\phi > 0$, then a fluctuation in the exchange rate of the dollar/RMB rate usually implies fluctuations of the US dollar against other Asian currencies as well and in the same direction. Such exchange rate changes will be passed through to export goods prices from these countries, with a lag. Since home country's export goods prices are set in dollars, the US dollar depreciation will make goods from other Asian economies relatively more expensive and lead to a higher demand for export goods from the home country (again, with a lag). Therefore, when ϕ is larger, any exchange rate fluctuation between the dollar and RMB will lead to a more volatile demand for Hong Kong goods, which will in turn reduce the export revenue and consumption stabilization benefits under a US dollar peg. Meanwhile, since a US dollar peg will imply more volatile import costs in face of S^{BA} shock, it leads to volatile domestic labor demand. Figure 3 depicts the value of EC, σ_C, EL, and σ_L for different values of ω, given $\phi = 0$ and $\phi = 1$. [20] Clearly, when $\phi = 1$, both consumption and labor volatility increase with ω. Therefore, when ϕ is large enough, an RMB peg may dominate a dollar peg in terms of welfare.

If other Asian economies choose to peg their currencies to the US dollar instead ($\phi = 0$), then fluctuations in the dollar/RMB rate will not cause substitution between home goods and other Asian goods. Thus the demand for Hong Kong goods is relatively stable. In this case the welfare benefits of a US dollar peg are larger. In Figure 3, given that $\phi = 0$, both consumption and labor volatility decrease when ω increases. This means that when ϕ is small, it is better for the home economy to peg to the export currency.

The key intuition, therefore, is that the value of ϕ affects the benefits from export revenue stabilization and thus consumption and labor volatility, which changes the welfare ranking between an export currency peg and an import currency peg. This finding has an important implication for the emergence of an RMB peg in Asia. If other Asian economies choose flexible exchange rate regimes or choose to peg their currencies to currencies other than the US dollar, externalities may lead Hong Kong to abandon its US dollar (export currency) peg. This finding implies that there could be a role for the RMB in the monetary policies of East Asia small open economies, but the emergence of an RMB peg relies on regional policy coordination.[21]

5 Conclusion

This paper develops a small open economy general equilibrium model with sticky prices to study the determinants of the optimal currency basket. The model emphasizes vertical trade and the different roles of currencies in invoicing trade flow. A second-order approximation method is used to solve for the optimal weighting between import and export currencies in a currency basket peg. We find that the optimal weight is affected significantly by the structure of vertical

[20] Note that as before, different values of ϕ only lead to very small difference in EC and EL. So the main welfare difference comes from changes in σ_C and σ_L.

[21] This issue of regional policy coordination is so important that, in our view, it deserves full attention in a separate study.

trade. In most cases, in terms of welfare, an export currency peg is superior to an import currency peg. However, when the responses of other economies are taken into consideration, an import currency peg may dominate an export currency peg in terms of welfare. This result also suggests that the emergence of any RMB peg in East Asia will depend on regional policy coordination.

This study did not address the debate about "fixed or flexible". Instead, we explore the optimal policy when the economy has to choose a fixed exchange rate regime and asks "fix to what?". In a sense, we investigate a constrained optimal policy for a small open economy. Our model provides a framework based on vertical trade to study the optimal currency basket for small open economies. It should be noted that other rules for monetary policy, such as targeting producer price inflation, may yield better welfare results than the optimal exchange rate peg discussed here. A natural extension in future research would be to relax the assumptions about the structure of the financial market and compare the importance of trade structure and financial structure in determining the optimal currency basket for a small open economy.

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Figure 1: **Flow Chart for the Small Open Economy**

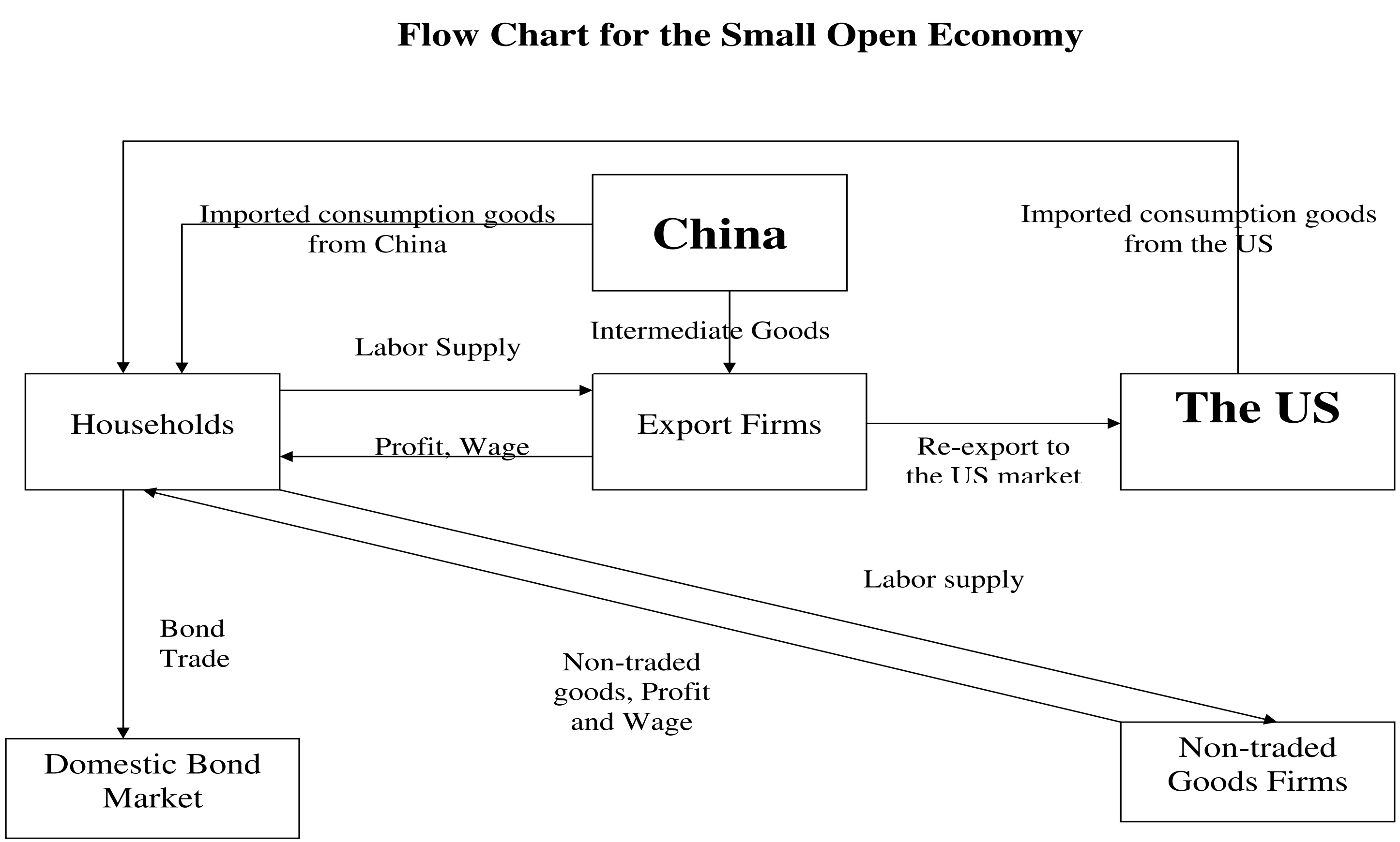


Figure 2: **Impulse Response to $+S^{BA}$ shock: Dollar Peg and RMB Peg**

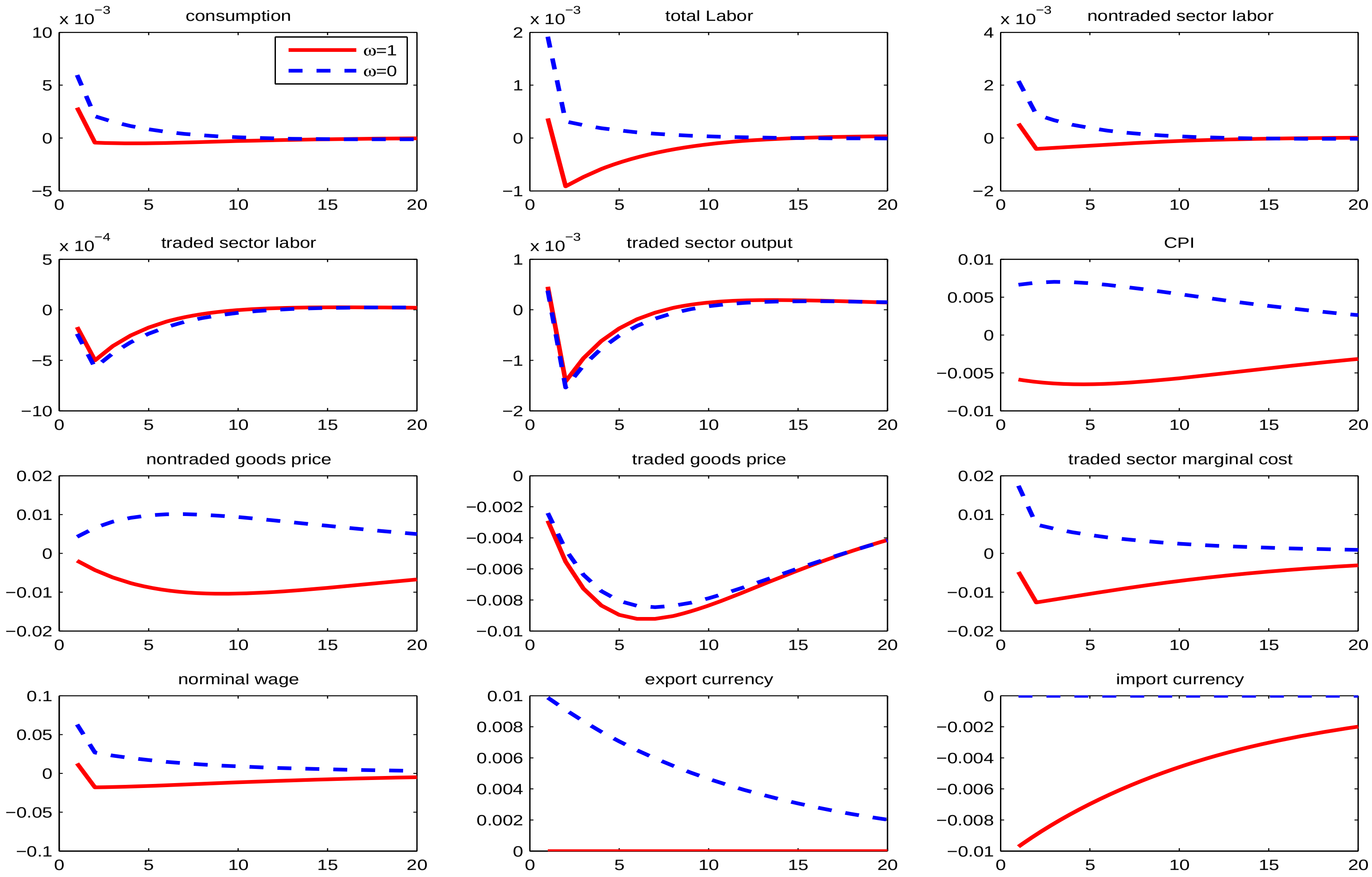
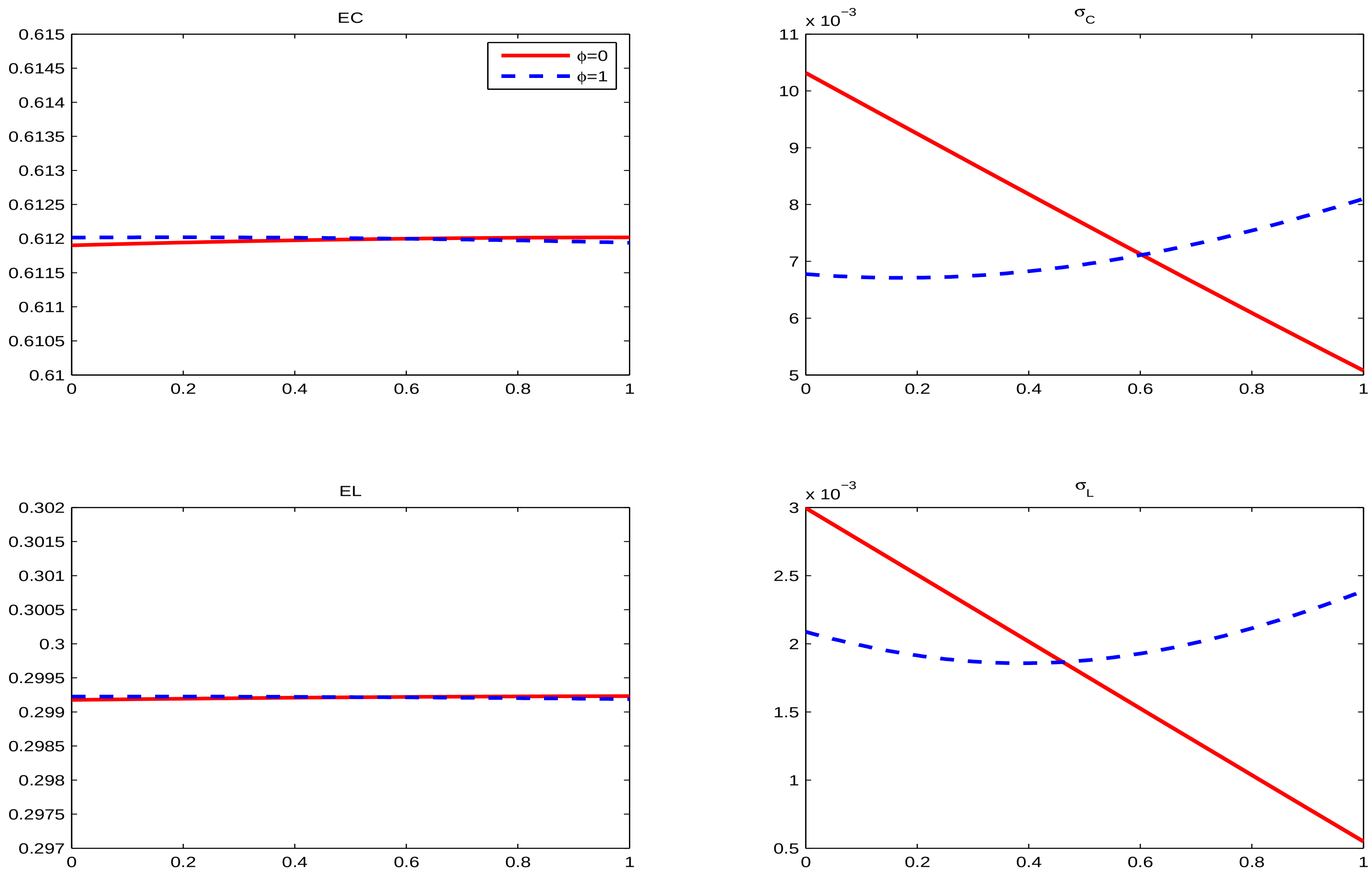


Figure 3: EC, EL, σ_C, σ_L **for different** ω **when** $\phi = 0, 1$



Technical Appendix

(Not to be Published

A Equilibrium

In our model, we have 11 price variables, P_t, W_t, P_{Ft}, P_{Nt}, S_t^A, S_t^B, i_t, P_{Tt}^*, MC_{Tt}, and 8 quantity variables, C_t, L_t, Y_{Nt}, Y_{Tt}, L_{Nt}, L_{Tt} and IM_t, and 3 exogenous variables, S_t^{BA}, X_t, and P_{mt}^*.

$$P_t = P_{Nt}^{1-\alpha} P_{Ft}^{\alpha} \tag{1}$$

$$P_{Ft} = (S_t^A)^{\gamma}(S_t^B)^{1-\gamma} \tag{2}$$

$$S_t^A P_{Tt}^* Y_{T_t} - \alpha P_t C_t - S_t^B P_{mt}^* IM_t = 0. \tag{3}$$

$$Y_{Nt} = (1-\alpha)\frac{P_t C_t}{P_{Nt}} \tag{4}$$

$$\frac{1}{1+i_{t+1}} = \beta E_t[(\frac{C_{t+1}}{C_t})^{v(1-\rho)-1}(\frac{1-L_{t+1}}{1-L_t})^{(1-v)(1-\rho)}(\frac{P_t}{P_{t+1}})], \tag{5}$$

$$\frac{1-v}{v}\frac{C_t}{1-L_t} = \frac{W_t}{P_t} \tag{6}$$

$$Y_{Nt} = L_{Nt} \tag{7}$$

$$P_{Nt}^o(j) = \frac{\lambda}{\lambda-1}\frac{E_t\sum_{l=0}^{\infty}(\beta\kappa_N)^l \frac{\Lambda_{t+l}}{P_{t+l}} W_{t+l} P_{Nt+l}^{\lambda} Y_{Nt+l}}{E_t\sum_{l=0}^{\infty}(\beta\kappa_N)^l \frac{\Lambda_{t+l}}{P_{t+l}} P_{Nt+l}^{\lambda} Y_{Nt+l}} \tag{8}$$

$$P_{Nt} = [\kappa_N(P_{Nt-1})^{1-\lambda} + (1-\kappa_N)(p_{Nt}^o)^{1-\lambda}]^{\frac{1}{1-\lambda}} \tag{9}$$

$$L_t = L_{Nt} + L_{Tt} \tag{10}$$

$$L_{Tt} = \alpha_T(\frac{W_t}{MC_{Tt}})^{-\theta} Y_{Tt} \tag{11}$$

$$IM_t = (1-\alpha_T)(\frac{S_t^B P_{mt}^*}{MC_{Tt}})^{-\theta} Y_{Tt} \tag{12}$$

$$MC_{Tt} = [\alpha_T W_t^{1-\theta} + (1-\alpha_T)(S_t^B P_{mt}^*)^{1-\theta}]^{\frac{1}{1-\theta}} \tag{13}$$

$$Y_{Tt} = (\frac{P^*_{T_t}}{P^*_{asia,t}})^{-\mu} X_t \tag{14}$$

$$P^{o,*}_{Tt}(j) = \frac{\lambda}{\lambda - 1} \frac{E_t \sum_{l=0}^{\infty} (\beta \kappa_T)^l \frac{\Lambda_{t+l}}{P_{t+l}} MC_{Tt+l} P^{\lambda}_{Tt+l} Y_{Tt+l}}{E_t \sum_{l=0}^{\infty} (\beta \kappa_T)^l \frac{\Lambda_{t+l}}{P_{t+l}} S^A_{t+l} P^{\lambda}_{Tt+l} Y_{Tt+l}} \tag{15}$$

$$P^*_{Tt} = [\kappa_T (P^*_{Tt-1})^{1-\lambda} + (1 - \kappa_T)(P^{o,*}_{Tt})^{1-\lambda}]^{\frac{1}{1-\lambda}} \tag{16}$$

$$(S^A_t)^{\omega} (S^B_t)^{1-\omega} = 1 \tag{17}$$

$$(S^{BA}_t) S^B_t = S^A_t \tag{18}$$

$$log(X_t) = (1 - \rho_x) log(\bar{X}) + \rho_x log(X_{t-1}) + \epsilon_{xt} \tag{19}$$

$$P^*_{mt} = (1 - \rho_m) \bar{P}^*_m + \rho_m P^*_{mt-1} + \epsilon_{mt} \tag{20}$$

$$log(S^{BA}_t) = \rho_s log(S^{BA}_{t-1}) + \epsilon_{st} \tag{21}$$

B Steady state system

In steady state, we impose $X = 1$, $S^{BA} = 1$[22], and $P^*_m = P^* = 1$.

$$P = P_N^{1-\alpha} {P_F}^{\alpha} \tag{1}$$

$$P_F = (S^A)^{\gamma} (S^B)^{1-\gamma} \tag{2}$$

$$S^A P^* Y_T - \alpha PC - S^B P^*_m IM = 0. \tag{3}$$

$$Y_N = (1 - \alpha) \frac{PC}{P_N} \tag{4}$$

$$\frac{1}{1+r} = \beta \tag{5}$$

[22]We assume $S^{BA} = 1$, so that the steady state is independent of the choice of exchange rate regime ω.

$$\frac{1-v}{v}\frac{C}{1-L}=\frac{W}{P} \tag{6}$$

$$Y_N = L_N \tag{7}$$

$$P_N = \frac{\lambda}{\lambda-1}W \tag{8}$$

$$L = L_N + L_T \tag{9}$$

$$L_T = \alpha_T(\frac{W}{MC_T})^{-\theta}Y_T \tag{10}$$

$$IM = (1-\alpha_T)(\frac{S^B P_m^*}{MC_T})^{-\theta}Y_T \tag{11}$$

$$MC_T = [\alpha_T W^{1-\theta} + (1-\alpha_T)(S^B P_m^*)^{1-\theta}]^{\frac{1}{1-\theta}} \tag{12}$$

$$Y_T = P_T^{*-\mu}X \tag{13}$$

$$P_T^* = \frac{\lambda}{\lambda-1}\frac{MC_T}{S^A} \tag{14}$$

$$S^A = 1 \tag{15}$$

$$S^B = 1 \tag{16}$$

C Estimation of ϕ

C.1 Data

The data for the US dollar denominated US import index from four Asian newly industrialized countries (NICs, including Korea, Hong Kong, Singapore and Taiwan) monthly data from 1993m02 to 2009m12; provided by U.S. Bureau of Labor Statistics (here after, BLS). Exchange rate of Dollar/yuan are defined as the price of the US dollar in term of RMB from 2005 Q2 to 2009 Q4. It is monthly data provided by Board of Governors of the Federal Reserve system (here after, FED). The data on GDP of Hong Kong, Singapore and Korea are denominated in US dollar; quarterly data; calculated by dividing GDP in national currency provided by Interna-

Table 7: Estimation of ϕ

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Dependent Variable: $DLOG(EXPI_{nic}))^a$				
Sample: 2005Q2 2009Q4 (19 observations)				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.018035	0.003589	-5.024494	0.0002
$DLOG(S^{RMB,US})$	0.166640	0.313243	0.531983	0.6031
$DLOG(S^{RMB,US})(-1)$	-0.590411	0.319416	-1.848405	0.0858
$DLOG(CPI_{NIC})^b$	1.452183	0.547460	2.652583	0.0189
$DLOG(GDP_{US})$	0.947206	0.329772	2.872301	0.0123
R-squared	0.732367	Adjusted R-squared		0.655900
Akaike info criterion	-6.189183	Schwarz criterion		-5.940647
F-statistic	9.577610	Durbin-Watson stat		1.956284

[a] $DLOG(variable)$ is the first difference of log variables.
[b] $DLOG(CPI_{NIC})$ is the GDP weighted inflation of Asian Newly Industrialized Countries; defined as $DLOG(CPI_{NIC}) = DLOG(CPI_{HK}) * GDP_{HK}/GDP_{NIC} + DLOG(CPI_{TWN}) * GDP_{TWN}/GDP_{NIC} + DLOG(CPI_{SGP}) * GDP_{SGP}GDP_{NIC} + DLOG(CPI_{KOR}) * GDP_{KOR}/GDP_{NIC}$.

tional Financial Statistics Online (here after, IFS) by exchange rate provided by FED. The data for GDP of Taiwan is denominated in US dollar; quarterly data; calculated by dividing GDP in national currency provided by Taiwan government statistics website by exchange rate provided by FED. CPI of Hong Kong, Singapore, and Korea are monthly data, provided by IFS. CPI of Taiwan is from Taiwan government statistics website. The US GDP is denominated in US dollar; quarterly data; provided by IFS. The monthly data are then transferred into quarterly data by Eviews 6.0.

C.2 Estimation

Table 7 gives the details of the estimation. All data are quarterly data. Our estimation shows that the exchange rate between the dollar and the yuan is significant in explaining the export price of Asian Newly Industrialized Countries to the US, but with a quarter lag. The Durbin-Watson stat 1.956284, which is very close to 2. This implies that the autocorrelation of residual is very small, so it is not necessary to add more lags in the regression. Therefore, we simply assume that $P_{asia,t} = (S_{t-1}^{BA})^{-\phi}$ and set $\phi = 0.59$ in the benchmark model.