

The Optimal Currency Basket with Input Currency and Output Currency

Kang Shi*

The Chinese University of Hong Kong

Juanyi Xu

Hong Kong University of Science and Technology

August 2007

Abstract

This paper explores the determination of the optimal currency basket in a small open economy general equilibrium model with sticky prices. In contrast to traditional literature, we focus on an economy with vertical trade, where one currency is used as the invoicing currency of imported intermediate goods and is called the “input currency”, while the other currency is used for the invoicing of exported finished goods and is called the “output currency”. We find that in the optimal currency basket the weight between the input currency and the output currency depends critically on the structure of vertical trade. Moreover, we show that if a country decides to choose a single-currency peg, then the choice of pegging currency depends mainly on how other economies respond to external exchange rate fluctuations. In a sense, our paper provides a case for the Chinese RMB peg in some East Asian economies, given the importance of the RMB as an input currency.

JEL classification: F3, F4

Keywords: Input currency, Output currency, Currency basket peg; Welfare

*Shi: Department of Economics, Chinese University of Hong Kong, Shatin, New Territories, Hong Kong; Tel (852)26098194; Email: kangshi@cuhk.edu.hk. Xu: Department of Economics, Hong Kong University of Science and Technology. Email: jennyxu@ust.hk. Tel: (852)2358-7604. We thank Michael B. Devereux, David Cook, and the seminar participants at Chinese University of Hong Kong, Xiamen University, and the 2006 Biennial Conference of the Hong Kong Economics Association for comments and helpful discussions. Part of this research was conducted while Juanyi Xu and Kang Shi were visiting the Hong Kong Institute for Monetary Research as Research Fellows. The views expressed in this paper are those of the authors, and do not necessarily reflect those of the Hong Kong Institute for Monetary Research, its Council of Advisors, or the Board of Directors.

1 Introduction

The US dollar has played an important role for East Asian economies for decades. Even the strong performance of Japanese yen in the mid 80's did not challenge the dominance of US dollar in East Asia. Many East Asian economies pegged their currencies to the dollar explicitly or implicitly. The exchange rate regimes ranged from a currency board hard peg in Hong Kong to a sliding or crawling peg in Indonesia. After the Asian financial crisis, some of them claim that they would follow more flexible exchange rates system. But they still place more or less value on their exchange rate stability against the US dollar and intervene to stabilize their exchange rates.¹ Nevertheless, with the fast development of China, recently media and policy makers in East Asian economies have started to discuss the possibility of adopting a RMB peg.

This discussion is basically initiated by two important changes in the global economy. On the one hand, the persistent depreciation of the US dollar has lasted for almost three years, and this trend has not reversed yet. On the other hand, the Chinese economy has been more and more important, and gradually integrated in the global economy. Beginning from July 21, 2005, China has implemented a regulated, managed floating exchange rate system based on market supply and demand and in reference to a basket of currencies.² Although currently the fluctuation of the dollar/RMB exchange rate is not very large,³ the recent surge in China's foreign reserves and international political pressure have both conspired to reevaluate the dollar/RMB exchange rate and increase the flexibility of RMB exchange rate in the future. Thus, the fluctuation of the dollar/RMB exchange rate will increasingly be one of the major concerns of East Asian economies, especially for entrepot economies like Hong Kong and Singapore, who intermediate trade between China and the

¹This has become known as the "fear of floating", see Calvo and Reinhart (2000) for details. For example, Singapore follows an exchange-rate-centered monetary policy, targeting a trade-weighted exchange rate index. Thailand follows a managed floating system since the financial crisis. Park et al. (2001) shows that Korea is still fearful of floating although it claims a flexible exchange rate regime.

²Before that, the Chinese RMB is fixed to the US dollar.

³See Figure 1 for the fluctuation of dollar/RMB exchange rate from July 27th, 2005 to Jan. 24th, 2007.

rest of the world.

Why does the dollar/RMB exchange rate volatility matter so much for these economies? This is because re-exporting goods from China to the rest of the world is very important for them. For example, as documented by Feenstra and Hansen (2004), over the period 1988-1998, 53% of Chinese exports were shipped through Hong Kong in this manner. Net of customs, insurance, and freight charges, Chinese goods are much more expensive when they leave Hong Kong than they enter. The average markup on Hong Kong re-exports of Chinese goods was 24%. The income flow from these entrepot activities is large. In 1998, re-export Chinese goods equaled 47% of Hong Kong's GDP. In 2005, out of the 2,329.5 billion HK dollar imported goods to Hong Kong (45% is from China), 2,114.1 billion HK dollar goods are re-exported. Thus, for these economies, a fairly large fraction of trade is in the form of vertical trade. As documented by Cook and Devereux (2004), most export goods in East Asian economies are priced in foreign currencies, especially in the US dollar. So in this manner, RMB is an "input currency", which is the invoicing currency for most imported intermediate goods, while the dollar is an "output currency", which is the invoicing currency for most re-exported finished goods. For economies like Hong Kong and Singapore, both the US dollar and the Chinese RMB are important and should play important roles in their monetary policies.⁴

Different roles of input currency and output currency are also important for other open economies around the world. As well documented by Feenstra (1998), Hummels et al. (2001), and Yi (2003), the vertical structure has been a more and more important feature of today's global production and trade. Hummels et al. (1998) show that the increase in the vertical trade can account for more than 25 percent of the increase in the total trade in most OECD countries. Therefore, some small open economies may also face a situation

⁴For these entrepot economies, goods are also imported from the rest of the world and re-exported to China. That is, the vertical trade pattern can be the other way around. However, considering both ways of vertical trade will only change the quantitative result, but not the qualitative prediction of the model. Furthermore, given the high percentage of imported goods from China in these entrepot economies and the fact that most export goods are priced in dollars in East Asia, it is reasonable to focus only on the case where the input currency is RMB and the output currency is dollar.

similar to the entrepot economies, where different currencies play different roles in invoicing trade flows. If these economies decide to choose a fixed exchange rate regime for political or policy credibility reasons, a natural policy is a currency basket peg. The question is, what are the optimal weights of different currencies in the currency basket? Furthermore, if a single currency is preferable due to the operational complexity of a currency basket, which currency to fix to; the input currency or the output currency?

According to the theory of optimal currency baskets, the choice of pegging currency for a small open economy depends critically on the trade weight of its trade partner in total trade balance.⁵ This literature, however, is based on the horizontal trade model, and ignores changes of trade pattern in the last thirty years. What determines the choice of pegging currency under vertical trade, especially when currencies play different roles in invoicing trade flow? How do different roles of different currencies affect their weights in the optimal currency basket?

To answer these questions, this paper develops a small open economy general equilibrium sticky price model to study the optimal currency basket and the choice of pegging currency. Our model features vertical trade, where intermediate goods are imported for re-export. In addition, we assumed intermediate goods are invoiced in the RMB (input currency) while finished goods are invoiced in US dollars (output currency).⁶ The monetary authority chooses a currency basket peg composed of the RMB and the dollar to maximize the expected utility of the representative household.

Our model shows that the optimal weights between the dollar and the RMB in a currency basket depend critically on the structure of vertical trade, such as the elasticity of substitution between local labor and imported intermediate goods, and the share of inter-

⁵This issue has also been addressed in the theory of optimum currency areas, where criteria have been developed that countries on a common currency (or with fixed rates) should fulfill. For example, see Eichengreen and Bayoumi (1999).

⁶For notational convenience, we use the RMB and the dollar to denote the input currency and the output currency, respectively. But this model setting and its implication will work as long as the input and output currency are different. Also, our analysis in this paper is based on an important assumption that the RMB will be fully convertible in the future.

mediate goods in the traded firm's production. In addition, we find that price rigidities in traded sector can also affect the optimal composition of different currencies in the currency basket.

Intuitively, for a small open economy, exchange rate volatility between input currency and output currency will be divided into exchange rate changes against input currency and output currency according to their weights in the currency basket. For traded firms, the fluctuation of output currency cause the instability of export revenue, while the fluctuation of input currency will lead to the instability of firms' import cost. Both revenue instability and cost instability will imply instability of real variables, such as consumption and employment. So the choice of optimal currency basket implies a clear trade-off between revenue instability and cost instability, and in turn the real instability. Therefore, any structural parameters which can affect traded firms' import cost and export revenue structure will be key factors in the determination of an optimal currency basket. For example, if the elasticity of input substitution is big, the gain of import cost stabilization will increase. Therefore, the economy will has an incentive to stabilize the exchange rate against the input currency. That is, more weight should put on the input currency in the optimal currency basket.

However, although these factors can affect the optimal weight between input currency and output currency in a currency basket, given reasonable parameter values, they can not alter the relative ranking of input currency peg and output currency peg. In other word, if the economy chooses a single-currency peg, the output currency peg is always superior to the input currency peg. This is because in general, the instability of export revenue will hurt the economy more than the instability of import cost. Nevertheless, if we consider the response of other Asian currencies to the dollar/RMB exchange rate fluctuation, then an input currency (RMB) peg may welfare dominate the output currency (dollar) peg.

The intuition is as follows. If other Asian economies choose not to fix their currencies to the US dollar, then the fluctuation of the dollar/RMB exchange rate also implies fluctuations of the US dollar vs. other Asian currencies.⁷ Since Hong Kong export goods are priced

⁷This is quite possible. For example, in the 1980s, the US dollar first appreciates, then depreciates relative to all major currencies. So is the recent US dollar depreciation during the last three years.

in dollars, fluctuations of dollar against other Asian currencies will generate a substitution between Hong Kong goods and other Asian export goods, which causes instability of Hong Kong's export demand. As a result, this will reduce the gain of stabilizing the export revenue under a dollar peg. Therefore, if this demand substitution effect is large enough, then the economy should increase the weight of input currency in the basket, or peg to the input currency directly. That is to say, if other Asian economies choose flexible exchange rate regimes or choose to peg their currencies to other currencies than the US dollar, then the export competition may lead entrepot economies to abandon the dollar (output currency) peg. This finding implies that there could be a role for the RMB in the future monetary policy design of East Asian small open economies, but the emergence of a RMB peg relies on regional policy coordination.

The literature of optimal currency basket proliferated in the early 1980, but most work is based on reduced-form model, so rigorous welfare analysis is not possible.⁸ Recently, Slavov (2005) and Teo (2005) examine this issue in general equilibrium model with micro-foundations. Slavov (2005) builds a small economy model where trade is invoiced in dollar and yen to study the optimal currency basket. He argues that dollar-denominated foreign debts and the financial market friction will pull the optimal policy away from the trade-weighted basket, and toward putting a greater weight on the currency in which foreign debts are denominated. Teo (2005) also investigates whether East Asian economies should peg to the dollar in a three-country center-periphery general equilibrium model. He focuses on the export invoicing currency and finds that the predominance of dollar-invoicing in trade implies that the dollar should receive a smaller weight than suggested by bilateral trade shares. Nevertheless, the trade structure in their models is horizontal, so their results do not capture the impact of vertical trade and different roles of trade-invoicing currencies on the choice of optimal currency basket and pegging currency, which is the focus of our project.⁹ Also, they focus on the choice between the dollar and the Japanese yen since their

⁸See Turnovsky (1982) for a survey.

⁹To highlight the importance of vertical structure, we will not consider the financial market, capital flow, and FDI issues in this paper.

models are built on horizontal trade, while we emphasize the potential role of the Chinese RMB in East Asia in the future.¹⁰

As to the emphasis on vertical trade, our paper is related to Huang and Liu (2006). They argue that vertical trade reconciles the welfare consequence of unilateral monetary expansion under different export pricing behavior. Also, in a related paper (Shi and Xu, 2006a), we explore 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 for exchange rate regime choices in a small open economy.

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 concludes.

2 Basic Model

In the model, there are three countries in the world: two large countries A and B (can be considered as the US and the mainland China) and a small open economy in East Asia ('home' or 'Hong Kong'). One can also think of A as the "US dollar area" and B as the "RMB area", in the sense that the dollar or the RMB is the invoicing currency of trade flow in the specific area. The home households consume domestically produced non-traded goods and foreign goods, which are imported from the US and China, respectively. Households supply labor for non-traded goods firms and traded goods firms. The traded firms import intermediate goods from China and re-export finished goods to the US market. Figure 2 describes a flow chart of the structure of goods and assets markets in the economy.

The nominal exchange rate 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. By triangular arbitrage condition, we

¹⁰Compared to the Chinese RMB, the Japanese yen can be considered as another output currency, but not the input currency. According to the traditional literature, although the yen is also important in East Asia, it is still not as important as the US dollar since the share of Asian export to the US is much larger.

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. Other sources of uncertainty we considered in the model is the foreign demand shock from the US market and the intermediate goods price shock from China.

We will discuss the detailed structure of the model in the following subsections.

2.1 Households

The preferences of the representative household are given by

$$EU = E_t \sum_{s=t}^{\infty} \beta^{s-t} \left[\frac{C_s^{1-\rho}}{1-\rho} - \eta \frac{L_s^{1+\psi}}{1+\psi} \right] \quad (2.1)$$

where C is a consumption index defined across domestic non-traded goods and foreign goods; E_t is the expectation operator conditional on information at time t ; β is the discount factor; ρ is the inverse of the elasticity of intertemporal substitution; η is a scale parameter that measures the disutility of labor supply; and ψ is the inverse of the elasticity of labor supply. The consumption index C is given by

$$C_t = \left(\frac{C_{Nt}}{1-\alpha} \right)^{1-\alpha} \left(\frac{C_{Ft}}{\alpha} \right)^{\alpha} \quad (2.2)$$

where C_{Nt} is the aggregate domestically produced non-traded goods, C_{Ft} is the aggregate imported consumption, and α is the share of imported foreign goods in the total consumption expenditure of domestic households.¹¹ The Cobb-Douglas form of Eq. 2.2 implies a unit elasticity of substitution between domestic goods and foreign goods in consumption. The consumer price index for domestic households can be then derived as

$$P_t = P_{Nt}^{1-\alpha} P_{Ft}^{\alpha} \quad (2.3)$$

where P_{Nt} and P_{Ft} are the price indices of domestic non-traded goods and imported foreign goods, respectively.

¹¹The domestic household do not consume the domestically produced traded goods as all the home produced traded goods are exported to the US market.

It is assumed that households do not have access to international financial markets and they only can hold one-period domestic bond B_t to smooth consumption across periods.¹² Their period budget constraints are:

$$P_t C_t + B_{t+1} = W_t L_t + (1 + i_t) B_t + \Pi_t. \quad (2.4)$$

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

The household chooses non-traded and imported goods to minimise expenditure conditional on total composite demand. Therefore, the demand for non-traded and imported goods is then

$$C_{Nt} = (1 - \alpha) \frac{P_t C_t}{P_{Nt}}, \quad C_{Ft} = \alpha \frac{P_t C_t}{P_{Ft}} \quad (2.5)$$

We assume the aggregate imported consumption goods are defined as below

$$C_{Ft} = \left(\frac{C_{Ft}^A}{\gamma} \right)^\gamma \left(\frac{C_{Ft}^B}{1 - \gamma} \right)^{1 - \gamma} \quad (2.6)$$

where C_F^A and C_F^B are the imported consumption goods from countries A and B, respectively. Therefore, the import goods price index P_F can be derived as

$$P_{Ft} = (S_t^A)^\gamma (S_t^B)^{1 - \gamma} \quad (2.7)$$

where γ is the weight of US goods in the import consumption basket. For simplicity, the foreign-currency prices of imports from both the US and China are normalized to unity.

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

$$\frac{1}{1 + i_{t+1}} = \beta E_t \left(\frac{P_t C_t^\rho}{P_{t+1} C_{t+1}^\rho} \right) \quad (2.8)$$

$$W_t = \eta L_t^\psi P_t C_t^\rho. \quad (2.9)$$

¹²The focus of this paper is the vertical trade, so the assumption about the financial market will be as simple as possible. Thus, in this paper, we assume households do not have access to foreign financial markets to eliminate the impact of financial issues on the choices of pegging currency. This is also consistent with households' saving behavior in East Asian economies. In East Asia, households usually hold small amount of foreign assets for consumption-smoothing purpose.

2.2 Firms

There are two production sectors in this small open economy: the non-traded good sector and the export good sector. Firms in these two sectors produce differentiated goods and have monopolistic power. Also, all firms face costs of price adjustment. The two sectors differ in their production technologies. Non-traded firms produce output using only labor, while export goods are produced by combining labour and imported intermediate (capital) goods.

2.2.1 Non-traded Sector

There is a continuum of firms indexed by $j \in [0,1]$ in the non-traded goods sector. There is monopolistic competition in the market for non-traded goods, which are imperfect substitute in the production of composite good Y_N , produced by a representative competitive firm. Aggregate non-traded output is defined according to a Dixit-Stiglitz type of function

$$Y_{Nt} = \left(\int_0^1 Y_{Nt}(j)^{\frac{\lambda-1}{\lambda}} dj \right)^{\frac{\lambda}{\lambda-1}} \quad (2.10)$$

where λ is the elasticity of substitution across differentiated non-traded goods. Given the above aggregation, the demand for individual non-traded goods j can be derived

$$Y_{Nt}(j) = \left(\frac{P_{Nt}(j)}{P_{Nt}} \right)^{-\lambda} Y_{Nt} \quad (2.11)$$

where the price index for the composite non-traded goods P_{Nt} is given by

$$P_{Nt} = \left(\int_0^1 P_{Nt}(j)^{1-\lambda} dj \right)^{\frac{1}{1-\lambda}} \quad (2.12)$$

Each monopolistically competitive firm has a linear production technology:

$$Y_{Nt}(j) = L_{Nt}(j) \quad (2.13)$$

Firms in the non-traded sector set their prices as monopolistic competitors. We follow Rotemberg (1982) in assuming that each firm bears a small direct cost of price adjustment. As a result, firms will only adjust prices gradually in response to changes in demand or

marginal cost. Non-traded firms are owned by domestic households. Thus, a firm maximizes its expected profit stream, using the household's marginal utility as the discount factor. We may define the objective function of the non-tradable firm j as:

$$E_t \sum_{l=0}^{\infty} \beta^l \Gamma_{t+l} \left[P_{Nt+l}(j) Y_{Nt+l}(j) - MC_{Nt+l} Y_{Nt+l}(j) - \frac{\psi_{P_N}}{2} P_{t+l} \left(\frac{P_{Nt+l}(j) - P_{Nt+l-1}(j)}{P_{Nt+l-1}(j)} \right)^2 \right], \quad (2.14)$$

where $\Gamma_{t+l} = \frac{1}{P_{t+l} C_{t+l}^{\rho}}$ is the discount factor. $MC_{Nt} = W_t$ represents marginal cost for firm j , and the third expression inside parentheses describes the price adjustment incurred by firm j at time t .

Firm j chooses a sequence of prices $P_{Nt+l}(j)|_{l=0, \dots, \infty}$ to maximize (2.14). Since all non-traded goods firms face the same optimization problem, after imposing symmetry, we may write the optimal price setting equation as:

$$P_{Nt} = \frac{\lambda}{\lambda - 1} MC_{Nt} - \frac{\psi_{P_N}}{\lambda - 1} \frac{P_t}{Y_{Nt}} \frac{P_{Nt}}{P_{Nt-1}} \left(\frac{P_{Nt}}{P_{Nt-1}} - 1 \right) + \frac{\psi_{P_N}}{\lambda - 1} E_t \left[\beta \frac{\Gamma_{t+1}}{\Gamma_t} \frac{P_{t+1}}{Y_{Nt}} \frac{P_{Nt+1}}{P_{Nt}} \left(\frac{P_{Nt+1}}{P_{Nt}} - 1 \right) \right]. \quad (2.15)$$

When the parameter ψ_{P_N} is zero, firms simply set price as a markup over marginal cost. In general, however, the non-traded goods price follows a dynamic adjustment process.

2.2.2 Traded Sector Firms

It is assumed that there is a unit interval $[0,1]$ of firms indexed by i in the export sector, who produce differentiated export goods to sell in the US market. They face a similar problem to those in the non-traded sector, setting export prices to maximize their expected profit stream. The major difference is that given our assumption that the US dollar is the output currency, export prices are set in the US dollar.

Each firm i in this sector sells a differentiated export good and the aggregate traded goods is given by

$$Y_{Tt} = \left(\int_0^1 Y_{Tt}(i)^{\frac{\lambda-1}{\lambda}} di \right)^{\frac{\lambda}{\lambda-1}} \quad (2.16)$$

Export firms, however, use a different production technology. We assume that there exists vertical trade in this small open economy in the sense that each monopolistically competitive firm i imports intermediate goods from China to produce differentiated good and re-exports their output to the US market. The traded firms' production function is given as follows

$$Y_{Tt}(i) = [\alpha_T^{\frac{1}{\theta}} L_{Tt}^{\frac{\theta-1}{\theta}} + (1 - \alpha_T)^{\frac{1}{\theta}} IM_t^{\frac{\theta-1}{\theta}}]^{\frac{\theta}{\theta-1}} \quad (2.17)$$

where α_T is the share of labor in the traded firm's production, $\theta \geq 0$ is the elasticity of substitution between local labor and imported intermediate inputs.

In a general case where $\theta > 0$, the marginal cost MC_T is given by

$$MC_{Tt} = [\alpha_T W_t^{1-\theta} + (1 - \alpha_T)(S_t^B P_{mt}^*)^{1-\theta}]^{\frac{1}{1-\theta}} \quad (2.18)$$

Note that P_{mt}^* is the RMB price of intermediate goods. Assume that it follows an AR(1) stochastic process,

$$P_{mt}^* = (1 - \rho_m) \bar{P}_m + \rho_m P_{mt-1}^* + \epsilon_{mt} \quad (2.19)$$

where $0 < \rho_m < 1$, and the serially uncorrelated shock ϵ_{mt} is normally distributed with zero mean and standard deviation σ_m .

Each firm i in this sector sells a differentiated good to the US market, and faces a downward-sloping demand function

$$X_t(P_{Tt}^*(i)) = \left(\frac{P_{Tt}^*(i)}{P_{Tt}^*}\right)^{-\lambda} \left(\frac{P_{Tt}^*}{P_{asia,t}^*}\right)^{-\mu} X_t \quad (2.20)$$

where $P_{Tt}^*(i)$ is the price of export good i from this small open economy to the US; P_{Tt}^* is the price index of export goods from this economy to the US market; and $P_{asia,t}^*$ is the aggregate price level of other Asian export goods sold in the US market. Without loss of generality, let $P_{Tt}^*(i)$, P_{Tt}^* , and $P_{asia,t}^*$ be denominated in dollars. Also, in Eq. 2.20, $\mu > 0$ is the elasticity of substitution between traded goods produced in Hong Kong and other Asian economies, and λ is the elasticity of substitution across domestically produced individual traded goods, where $\lambda > 1$. X_t is assumed to be a foreign demand shock, following a stochastic process

$$\log(X_t) = (1 - \rho_x) \log(\bar{X}) + \rho_x \log(X_{t-1}) + \epsilon_{xt} \quad (2.21)$$

where $0 < \rho_x < 1$ and the serially uncorrelated shock ϵ_t is normally distributed with zero mean and standard deviation σ_x .

In addition, we assume that $P_{asia,t}^*$ is a function of S_t^{BA} . The intuition is that when the dollar/RMB exchange rate changes, the US dollar price of export goods from other Asian countries to the US may also change because exchange rates between these Asian currencies and the US dollar change. The size of the impact of S_t^{BA} on $P_{asia,t}^*$ depends on the exchange rate policies of other Asian countries. For example, in case of a dollar/RMB appreciation (S_t^{BA} increases), if other Asian countries adopt flexible exchange rate regimes or a RMB peg, then their currencies will also depreciate against the dollar. Since export goods from Hong Kong are priced in US dollars, the depreciation will in turn increase the competitiveness of other Asian goods in the US market. Therefore, *ceteris paribus*, the substitution between Hong Kong goods and other Asian goods might reduce the demand for Hong Kong's export goods.¹³ If other Asian countries pegged their currencies to the US dollar, then the dollar/RMB exchange rate changes will not affect the US dollar price of export goods from these economies. So the demand for Hong Kong goods will not be affected.

For simplicity, we let $P_{asia,t}^* = (S_t^{BA})^{-\phi}$, where ϕ represents the sensitivity of other (dollar-denominated) Asian export prices to the dollar/RMB exchange rate fluctuation. If $\phi = 0$, this implies the exchange rate between other Asian currencies and the US dollar will not change when S_t^{BA} changes. So this refers to a case where other Asian countries follow a dollar peg. If $\phi > 0$, then the decrease of S_t^{BA} (US dollar depreciates against the RMB) will lead to depreciation of the US dollar against other Asian currencies and the increase of $P_{asia,t}^*$. 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

¹³In fact, the export pricing behavior of firms in other Asian economies should also be considered. For instance, if export price of most Asian economies are preset in US dollars, then in short run, $P_{asian,t}^*$ will be less sensitive to S_t^{BA} . Nevertheless, as shown by Shi and Xu (2006b), for a small open economy, exchange rate policies can affect the export firm's pricing currency choice. Fixed exchange rate regimes will lead to foreign currency pricing, while flexible exchange rate regime leads firms to set export price in domestic currency, which increases the sensitivity of aggregate export price to S_t^{BA} .

(for instance, peg to the RMB).

Each traded firm sets price in the same manner as the non-traded firms, but the price in terms of US dollars. Thus, the objective function of the traded firm i is given by:

$$E_t \sum_{l=0}^{\infty} \beta^l \Gamma_{t+l} \left[S_t^A P_{Tt+l}^*(i) Y_{Tt+l}(i) - MC_{Tt+l} Y_{Tt+l}(i) - \frac{\psi_{P_T}}{2} P_{t+l} \left(\frac{P_{Tt+l}^*(i) - P_{Tt+l-1}^*(i)}{P_{Tt+l-1}^*(i)} \right)^2 \right], \quad (2.22)$$

where $Y_{Tt+l}(i) = X_{t+l}(P_{Tt+l}^*(i))$.

Firm i chooses its price to maximize (2.22). Imposing symmetry, we may write the optimal price setting equation as:

$$P_{Tt}^* = \frac{\lambda}{\lambda-1} \frac{MC_{Tt}}{S_t^A} - \frac{\psi_{P_T}}{\lambda-1} \frac{1}{S_t^A} \frac{P_t}{Y_{Tt}} \frac{P_{Tt}}{P_{Tt-1}} \left(\frac{P_{Tt}}{P_{Tt-1}} - 1 \right) + \frac{\psi_{P_T}}{\lambda-1} E_t \left[\beta \frac{1}{S_t^A} \frac{\Gamma_{t+1}}{\Gamma_t} \frac{P_{t+1}}{Y_{Tt}} \frac{P_{Tt+1}}{P_{Tt}} \left(\frac{P_{Tt+1}}{P_{Tt}} - 1 \right) \right]. \quad (2.23)$$

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

2.3 Exchange Rate Policy

The central bank's role in this model is to set the weight of input and output currency in a currency basket, which satisfies.

$$(S_t^A)^\omega (S_t^B)^{1-\omega} = 1, \quad 0 \leq \omega \leq 1 \quad (2.24)$$

In general, we can allow for a continuum of exchange rate regimes which 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} . By triangular currency arbitrage, we can have: $S_t^A = (S_t^{BA})^{1-\omega}$ and $S_t^B = (S_t^{BA})^{-\omega}$. There are two special cases, where the central bank chooses either $\omega = 0$ or $\omega = 1$. That is,

- A 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 , the exchange rate of dollar vs. Hong Kong dollar.
- A 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 , the exchange rate of RMB vs. Hong Kong dollar.

2.4 Equilibrium

In equilibrium, besides the optimality conditions for firms and households, we have the following market clearing conditions. The labor market clearing condition is given by

$$L_{Nt} + L_{Tt} = L_t \quad (2.25)$$

The non-traded goods market clearing condition is given by

$$Y_{Nt} = (1 - \alpha) \frac{P_t Z_t}{P_{Nt}} \quad (2.26)$$

where Z_t is the aggregate absorption, including consumption and the goods used for price adjustment cost in traded and non-traded sectors.

$$Z_t = C_t + \frac{1}{2} \psi_{p_N} \left(\frac{P_{Nt}}{P_{Nt-1}} - 1 \right)^2 + \frac{1}{2} \psi_{p_T} \left(\frac{P_{Tt}^*}{P_{Tt-1}^*} - 1 \right)^2 \quad (2.27)$$

The traded goods market clearing condition is given by

$$Y_{Tt} = \left(\frac{P_{Tt}^*}{P_{asia,t}^*} \right)^{-\mu} X_t \quad (2.28)$$

This implies that the output in the trade sector is determined by the foreign demand X_t , export firms' pricing decision, and other Asian countries' export price.

In a symmetric equilibrium, $B_t = 0$, so we can rewrite the household's budget constraint as

$$S_t^A P_{Tt}^* Y_{Tt} - \alpha P_t Z_t - S_t^B P_{mt}^* IM_t = 0. \quad (2.29)$$

This is a balance of payment condition, where the export revenue covers both imports for consumption $\alpha P_t Z_t$ and imports for production $S_t^B P_{mt}^* IM_t$.

3 Welfare Results

In this section we present some welfare results under different policy regimes (different weights of currency basket) when the economy is disturbed by external shocks. We focus

on two extreme cases $\omega = 0$ (RMB peg) and $\omega = 1$ (dollar peg). Besides, we also report the optimal weight and investigate the factors that affect the optimal currency basket.

The main uncertainty in this model is dollar/RMB exchange rate volatility, which is assumed to follow an AR(1) process.

$$\log(S_t^{BA}) = \rho_s \log(S_{t-1}^{BA}) + \epsilon_{st} \quad (3.1)$$

where $0 < \rho_s < 1$ and the serially uncorrelated shock ϵ_{st} is normally distributed with zero mean and standard deviation σ_s .

In addition, we consider two other types of external disturbances as discussed above: a) shocks to the intermediate goods price, P_{mt}^* ; and b) the foreign demand shock from the US market, which is represented by shocks to X_t .

3.1 Calibration

Table 1 lists the structural parameters in our 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 elasticity of labor supply $\frac{1}{\psi}$ is set to unit, following Christiano et. al (1997). The elasticity of substitution across individual export goods λ is chosen to be 11, following Betts and Devereux (2000). This gives a price mark-up of about 1.1, which is consistent with the finding of Basu and Fernald (1994). The elasticity of substitution between home-produced trade goods and other Asian goods μ is set to unity. α is set to equal 0.4, which implies that the share of non-traded goods in the consumer price index is set to 0.6. This is close to the evidence cited in Schmitt-Grohe and Uribe (2001) for Mexico, and in Cook and Devereux (2004) for Malaysia and Thailand. The size 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 different trade-invoicing roles of dollar and RMB on the choice of optimal currency basket. We set $\eta = 1$ for simplicity as it is just a scale parameter and will not affect welfare results.

Vertical trade is the most important feature of our model. So we will investigate the impact of parameters governing vertical trade features (α_T and θ) on the optimal weight

Table 1: Calibration Parameters

Parameters	value	Parameters	value	Parameters	value
ρ	2	β	0.99	α	0.4
λ	11	α_T	0.4	γ	0.5
ψ	1	ϕ	0.7	σ_ϵ	1%
μ	1	θ	0.5	σ_s	1.3%
ϕ_{P_N}	120	ϕ_{P_T}	105	σ_x	0.7%
ρ_s	0.95	ρ_x	0.85	ρ_m	0.77

between input and output currency in the currency basket. For the benchmark case, we set $\alpha_T = 0.4$, so that the share of labor in trade goods sector is approximately equal to the estimates in Cook and Devereux (2004) for Malaysia and Thailand. As to θ , we consider a low value for the elasticity of input substitution in the traded goods sector, setting $\theta = 0.5$. In other words, the elasticity of substitution between local labor and imported intermediate goods is small. This is consistent with the fact that usually re-exporting involves processing trade,¹⁴ which implies a low elasticity of input substitution.

We will then consider different values of α_T and θ to see how this affect the welfare results. First, we let α_T range from 0.3 to 0.4. With this range for α_T and the calibration for α ($\alpha = 0.4$), the total expenditure on imported goods (including the imported intermediate goods and consumption goods) is approximately half of the GDP, which is consistent with empirical evidence. Regarding θ , intuitively, it affects the cost structure of export firms, the demand for labor, and thus the choice of different currency basket. So we also explore the implication of different values of θ (ranging from 0.25 to 1.05) on the optimal currency basket weight.

We set the parameters governing the cost of adjustment in non-traded sector and traded

¹⁴Processing trade refers to the business activity of 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.

sector, $\phi_{P_N} = 120$ and $\phi_{P_T} = 105$. This implies that, if the model were interpreted as being governed by the dynamics of the standard Calvo price adjustment process, all prices in non-traded goods sector and traded-goods sector will adjust on average after 5 and 4 quarters, respectively.¹⁵ This follows the standard estimation used in the literature and it is also consistent with Ortega and Nooman (2005)'s finding that nominal rigidity in non-traded goods sector is higher than that in traded goods sector. Since ϕ_{P_T} is an important parameter in determining the traded firms' pricing behavior, which may in turn affect the optimal currency basket weight, in later discussion we will also consider other values of ϕ_{P_T} .

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 the intermediate goods shock can be approximately interpreted as a terms of trade shock for a small open economy, we set $\rho_m = 0.77$ and $\sigma_m = 0.013$ as those in Devereux, Lane, and Xu (2006). We assume that the dollar/RMB exchange rate has a similar stochastic process to those of the major currencies, therefore, we set $\rho_s = 0.95$ and $\sigma_s = 0.01$.

Finally, we find that the elasticity of other Asian countries' export price on the dollar/RMB exchange rate fluctuation, ϕ , is a key parameter that affects the choice of optimal currency basket. As discussed before, $\phi = 0$ represents an extreme case where all Asian countries choose to peg their currencies to the US dollar, so in the benchmark case we will set ϕ to an intermediate level, 0.7. Different values of ϕ (ranging from 0.5 to 1.0) will be considered when we discuss the optimal exchange rate policy in later discussion.

3.2 Welfare Comparison

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 measure the magnitude of welfare differential across regimes, we define ζ_k as the percentage change of deterministic steady

¹⁵That is, the probability of firms which do not adjust price are 80% and 75% respectively.

Table 2: Welfare Comparison

(Benchmark Case)				
ξ_k	S^{BA}	+X shock	$+P_m^*$ shock	Three shocks
$\omega = 0$	-0.07%	-0.13 %	-0.10%	-0.16%
$\omega = 1$	-0.04%	-0.10 %	-0.07%	-0.13%
ω^*	0.68	0.68	0.68	0.68

state consumption that will give the same conditional expected utility EU under policy regime k . That is, ζ_k is given implicitly by:

$$\frac{\frac{1}{1-\rho}[(1 + \zeta_k)\bar{C}]^{1-\rho} - \frac{\eta}{1+\psi}\bar{L}^{1+\psi}}{1 - \beta} = EU_k \quad (3.2)$$

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 implied to be higher (lower) than that of the steady state case. Higher values of ζ_k correspond to higher welfare.

The welfare EU_k is computed by taking second-order Taylor approximations of the structural equations around the deterministic steady state. The system of equations is solved using a perturbation method described in Schmitt-Grohe and Uribe (2004). In Tables 2-6, we will discuss the welfare results of two extreme cases (RMB peg and dollar peg) and the optimal currency basket. We will also investigate how changes in external shocks and values of α_T , θ , ϕ_{P_T} , and ϕ , affect the choice of optimal weights of input and output currency in a currency basket peg. To derive the optimal weight ω^* of a currency basket, we do 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 highest ξ_k . Note that in each table, unless specified, the values of other structural parameters are those for the benchmark case as listed in Table 1.

In Table 2, we present welfare results for four different cases. The first is the case where the model is only buffeted by the dollar-RMB exchange rate volatility. The second and the third one are the cases where the economy is subject to one extra external shock, foreign demand shock or intermediate goods price shock, respectively. The last column reports the

welfare result for the case where the economy is subject to all three shocks. We also report the optimal weight ω^* which delivers the highest welfare in each case. Table 2 show that in the benchmark case, (1) In terms of welfare, the output currency peg ($\omega = 1$) is superior to the input currency peg ($\omega = 0$); (2) The optimal weight in a currency basket is mainly determined by the dollar/RMB exchange rate volatility, not by other shocks. (3) Foreign demand shock and intermediate goods price shock have no impact on the optimal weight ω^* and the welfare ranking of policy regimes. Their presence just amplifies the welfare loss. This is because these shocks are real shocks which an economy cannot insulate from under fixed exchange rate regimes. So in the following analysis, we will focus on the case with dollar/RMB exchange rate shocks only.

3.2.1 Impulse Response Function

To explain the welfare comparison results, we first explore the impact of a positive S^{BA} shock under the dollar peg and the RMB peg. As explained above, the S^{BA} shock is calibrated to follow an AR(1) process. Figure 3 gives impulse response functions. The illustrations are divided into categories of real variables (namely, consumption; employment; traded employment; imported intermediates; and sectoral output) and those of nominal variables (namely, CPI price; wage; S_A , S_B ; non-traded goods price; price for export goods in dollars; export revenue $S_t^A P_{T,t}^* Y_{T,t}$; import cost $S_t^B P_{IM,t}^* IM_t$; and traded sector net income $S_t^A P_{T,t}^* Y_{T,t} - S_t^B P_{IM,t}^* IM_t$).

If the economy chooses to peg its currency to the RMB, when there is an increase in S^{BA} , the exchange rate of dollar against the domestic currency S^A will appreciate. This will increase the price of imported foreign consumption goods and then cause the increase of domestic CPI. Meanwhile, it also generates an expenditure switching effect between imported foreign goods and domestically produced non-traded goods, which may cause the expansion of the non-traded sector and the transfer of labor from traded sector to non-traded sector. As the non-traded sector is labor intensive, this implies that the total employment will increase and nominal wage will be pushed up as well.

In this economy, however, the major effects of a dollar appreciation are on the traded

sector. Firstly, as export goods are priced in dollars, the increase of S^A will have a wealth effect on the export revenue side. Secondly, due to the RMB peg, the price of imported intermediate goods is not affected by the dollar appreciation. So the input substitution between labor and imported intermediate goods will reduce the use of labor and increase the use of imported intermediate goods for producing a given amount of traded output. Note that due to price rigidities, the traded output are mainly determined by the demand from the rest of the world. Nevertheless, it is worthwhile mentioning that the demand for traded goods will be affected by ϕ , the response of other Asian currencies to the S^{BA} shock. Given our calibration of ϕ ($\phi = 0.7$), the increase in S^{BA} will cause an appreciation of the dollar against other East Asian currencies. Since Hong Kong export goods are priced in dollars, this will lead to a decrease of demand for Hong Kong export goods. From Figure 3 we can see the traded output decreases in response to a positive S^{BA} shock. Given our calibration, the overall effect of an increase on S^{BA} is that it increases the net export revenue. As a result, there will be more domestic consumption expenditure in equilibrium. Therefore, even in the presence of higher CPI, the consumption will increase in our model.

If the domestic currency is pegged to dollar, then an increase in S^{BA} implies that the exchange rate of RMB against the domestic currency depreciates. Now the price of imported goods faced by domestic households becomes cheaper, and this may decrease the domestic CPI. Compared to the case of a RMB peg, this will lead to a negative substitution effect on the non-traded sector. Therefore, the non-traded sector may shrink in this case. But if the domestic consumption increases, then the demand for non-traded goods will offset some of the substitution effect. As shown by Figure 3, the non-traded sector output still increases, but the magnitude is smaller than that in the case with the RMB peg. This also implies that the total employment and nominal wage will not increase as much as those in the case of a RMB peg.

For the traded sector, since S^A is constant, there will be no wealth effect of exchange rate changes on the export revenue. So the export revenue is mainly determined by the traded output and decreases. However, in this case, the exporters gain from the RMB depreciation since imported intermediated are priced in RMB. So there is an wealth effect from import

cost reduction. It is clear from Figure 3 that that this effect is smaller than the wealth effect (from S^A increases) under the RMB peg, but it still increases domestic consumption. Finally, in this case, since nominal wage only increases slightly, the substitution effect between labor and imported intermediate goods is also smaller compared to the RMB peg case.

From Figure 3, we can find that the responses of consumption and employment under the dollar peg are smaller than those under the RMB peg. This may explain why the dollar peg welfare-dominates the RMB peg. Intuitively, what drives the difference in welfare results under different exchange rate regimes? For a small open economy, exchange rate volatility between input currency and output currency can be divided into changes of exchange rates against input currency and those against output currency according to the exchange rate arrangement. For traded firms, the fluctuation of output currency cause the instability of export revenue while the fluctuation of input currency will lead to the instability of firms' import cost. This implies that there is a clear trade-off between revenue instability and cost instability. Since the economy is characterized by re-export activities, different impacts of S^{BA} shock on traded sector under the dollar peg and the RMB peg imply different instability of real variables, such as consumption, employment, and the welfare level.

Therefore, any structural parameters which can affect traded firms' cost and revenue structure will be key factors for the determination of an optimal currency basket. This is what we will explore in the following welfare analysis based on second-order approximation.

3.2.2 Welfare Comparison

As the major feature of this economy is vertical trade, we first investigate how the structural parameters governing vertical trade affect the composition of optimal currency basket. The first parameter is θ , the elasticity of input substitution in the traded firm's production. Given the dollar/RMB exchange rate volatility, if the elasticity of input substitution is big, then the fluctuation of the domestic currency against the input currency will lead to a volatile demand for input, especially for local labor. So when θ is big, the benefits of cost stability is bigger. In other words, the benefits of the RMB peg is bigger. This can

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

ξ_k	Labor share			Input substitution elasticity				
	$\alpha_T = 0.3$	$\alpha_T = 0.35$	$\alpha_T = 0.4$	$\theta = 0.25$	$\theta = 0.5$	$\theta = 0.8$	$\theta = 1.05$	$\theta = 2$
$\omega = 0$	-0.136%	-0.098 %	-0.073%	-0.106%	-0.072 %	-0.053%	-0.0448%	-0.0334%
$\omega = 1$	-0.044%	-0.0378 %	-0.0376%	-0.0353%	-0.0376 %	-0.041%	-0.0443%	-0.0519%
ω^*	0.97	079	0.68	0.81	0.68	0.57	0.5	0.35

be illustrated by the first row of Figure 4, when θ increases, the RMB peg implies more stable labor demand and consumption than the dollar peg. Therefore, the economy has an incentive to stabilize the exchange rate against input currency when θ increases. That is, more weight should be put on the input currency in the optimal currency basket. From Table 3 we can see that the welfare results confirms our finding from Figure 4.

When $\theta = 2$, the input currency peg welfare-dominates the output currency peg. However, since the small open economy is an entrepot economy, the implied elasticity of substitution between local labor and imported intermediate goods might be small. So $\theta = 2$ is not a reasonable value if we want to calibrate our model to East Asian extrepot economies. But it shows that how important the vertical trade structure is in determining the optimal weights in a currency basket.

The second key parameter is α_T , the labor share in the traded firm's production. When the domestic labor share is low, the fluctuation of exchange rates against the input currency will not have a big impact on the domestic labor demand. Therefore, the benefits of import cost stabilization is lower, which reduces the welfare gain under the RMB peg. As shown by the second row of Figure 4, when α_T decreases, the consumption and labor volatility increase under a RMB peg. Thus, the RMB peg will lead to higher volatility of real variables when α_T decreases. Therefore, when α_T is lower, more weight will be put on the output currency in the optimal currency basket so as to stabilize the export revenue, which in turn improves welfare.

Finally, note that although the welfare under a dollar peg is always higher than that

Table 4: Welfare Change with Price Rigidities in Traded Sector

(with S^{BA} shock only)			
ξ_k	$\phi_{p_T} = 105$	$\phi_{p_T} = 55$	$\phi_{p_T} = 18$
$\omega = 0$	-0.072%	-0.058 %	-0.038 %
$\omega = 1$	-0.038%	-0.039 %	-0.041 %
ω^*	0.68	0.60	0.49

under the RMB peg given reasonable values of α_T and θ , from Table 3 we can see that the welfare difference becomes smaller as θ and α_T increase.

Also, as mentioned above, ϕ_{P_T} affects the dynamics of export prices, which may in turn affect the optimal currency basket weight.¹⁶ So we also report the welfare consequence of changes in price rigidities in the traded sector. In Table 4, we investigate three cases where $\phi_{P_T} = 105$, $\phi_{P_T} = 55$, and $\phi_{P_T} = 18$, respectively. These values imply that prices in the traded sector will adjust on average in 4, 3, and 2 quarters, respectively. Our result shows that when ϕ_{P_T} is lower (there are less price rigidities in the traded sector), lower weight will be put on the output currency in a currency basket. Intuitively, when price rigidities are low, the export price is mainly determined by the the firm's marginal cost. From Eq. 2.23, we can see that when ϕ_{P_T} is small, the export price approximately equals the markup times marginal cost divided by S_t^A , the exchange rate against the output currency. So for export firms, an input currency peg will stabilize not only the firm's marginal cost but also its export revenue ($P_{Tt}^* S_t^A Y_{Tt} \approx \frac{\lambda}{\lambda-1} MC_{T,t} Y_{T,t}$, when $\phi_T \rightarrow 0$). Therefore, more weight will be put on the input currency when the price rigidity in the export sector is lower.

From Tables 2-4, it can be seen that although the parameters governing vertical trade structure and price rigidities in the trade sector can affect the optimal weights between the input and output currency in an optimal currency basket, given reasonable parameter values for the East Asian economies, the output currency peg always welfare-dominates the input currency peg. In reality, when countries choose a fixed exchange rate regime, they

¹⁶We also examine the impact of firms' markup on the choice of optimal currency basket. Our result shows that changes of markup do not affect the optimal weight.

Table 5: Welfare Change with ϕ

	$(S^{BA} \text{ shock})$					
ξ_k	$\phi = 0.5$	$\phi = 0.6$	$\phi = 0.7$	$\phi = 0.8$	$\phi = 0.9$	$\phi = 1.0$
$\omega = 0$	-0.117%	-0.093 %	-0.072%	-0.056%	-0.044 %	-0.036%
$\omega = 1$	-0.031%	-0.032 %	-0.038%	-0.047%	-0.060 %	-0.078%
ω^*	0.96	0.82	0.68	0.55	0.41	0.28

often choose a single-currency peg instead of a currency basket. Thus, do our results in Tables 2-4 imply that the Asian entrepot economy should still peg their currency to the US dollar if they choose a single-currency peg? Table 5 shows that the answer to this question depends on ϕ , the parameter characterizing the response of other Asian currencies to the dollar/RMB exchange rate fluctuation.

From Table 5, we can see that when ϕ increases, the welfare ranking between input currency peg and output currency peg can be changed. That is, in terms of welfare, an input currency peg is superior to an output currency when ϕ is large enough. Meanwhile, ω^* decreases when ϕ increases, implying more weight will be put on the input currency in a currency basket. This finding suggests that monetary authority of East Asian entrepot economies should consider other Asian currencies' response to the dollar/RMB exchange rate volatility when deciding which currency to peg.

The intuition is as follows. If other Asian economies choose not to fix their currencies to the US dollar, then the fluctuation of the dollar/RMB exchange rate usually implies fluctuations of the US dollar against other Asian currencies. That is, when the US dollar appreciates relative to the RMB, the dollar will also appreciate against other Asian currencies. Since Hong Kong export goods prices are set in dollars, the dollar appreciation will make goods from other Asian economies relatively cheaper and lead to a lower demand for goods produced in Hong Kong. Therefore, when ϕ is larger, the dollar/RMB exchange rate fluctuation will lead to a more volatile demand for Hong Kong goods, which in turn significantly reduce the benefits of revenue stabilization under the dollar peg. Meanwhile,

since a dollar peg will imply a volatile import cost in face of S^{BA} shock, it leads to volatile domestic labor demand, as shown by the last row of Figure 4. So in this case, a RMB peg welfare dominates a dollar peg.

If other Asian economies choose to peg their currencies to the US dollar instead, then the dollar/RMB exchange rate fluctuation will not cause substitution between Hong Kong goods and other Asian goods. Thus, the demand for Hong Kong goods is stable. In this case, the welfare benefits of the dollar peg is large. From Figure 4, we can see that it implies lower real volatility. So it welfare dominates the RMB peg. In other words, when ϕ is small, it is better for Hong Kong to peg to the US dollar.

Therefore, the key intuition is that the value of ϕ affects the benefits from export revenue stabilization. So it can affect the welfare ranking between a dollar peg and a RMB peg. If other Asian economies choose flexible exchange rate regimes or choose to peg their currencies to other currencies than the US dollar, then the export competition may lead entrepot economies to abandon the dollar (output currency) peg. This finding implies that there could be a role of RMB in the future monetary policy design of East Asian small open economies, but the emergence of a RMB peg relies on regional policy coordination.

3.3 Discussion

The debate on optimal monetary policy for small open economies has been at the heart of international macroeconomics for many years. Traditional international macroeconomics literature and the utility-based new open economy macroeconomics literature both argue that for a small economy buffeted by external disturbances, it is better to allow the exchange rate to adjust. However, in reality, many East Asian economies, such as Hong Kong, Korea, and Thailand, pegged their currencies to the US dollar. For these economies, there are two kinds of benefits from the fixed exchange rates: making trade and investment less risky, thereby increasing welfare; and anchoring monetary policy. The costs of fixed exchange rates are to give up monetary autonomy and the danger of speculative attacks if the credibility of the peg is in doubt. In this paper, we do not focus on the debate on “fixed or flexible”, instead, we explore the optimal policy when the economy has decide to choose a fixed

exchange rate regime and ask “fix to what?”. In a sense, we investigate a constrained optimal policy for a small open economy.

Most East Asian countries have pegged their currencies to the US dollar for decades. According to the traditional optimal currency basket theory, this makes sense because the US is usually the most important trade partner for these economies. Since Japanese yen and Euro are both output currencies, the choice between the dollar and the yen or Euro can be explained by the traditional optimal currency basket theory based on horizontal trade. However, according to the vertical trade structure, the dollar and the RMB play different roles in invoicing trade flow. Thus, the choice between the dollar and the RMB are different from the choice between the dollar and the yen or Euro. China is gradually integrating into the world economy and the RMB exchange rate will also become more flexible. These changes will affect the optimal weight between the dollar and RMB in the currency basket and the relative welfare ranking between the dollar peg and the RMB peg.¹⁷

In this paper, another important finding is that the choice between the dollar peg and the RMB peg depends on other countries’ monetary policies. This implies that there exists strategic behavior for these small open economies when they choose monetary policy regimes, and the equilibrium of this regional monetary game depends on features of trade structure in this area.¹⁸

Note that in this paper we focus on the trade structure, so we ignore the role of capital flow and FDI on the choice of optimal currency basket and pegging currency. We emphasize the impact of vertical trade structure on the theory of optimal currency basket, which provides a different angle to study the monetary policy in small open economies.

¹⁷In our model, the currency basket is only composed of two currencies, but it is easy to include more currencies, such as the yen or Euro into the basket. Nevertheless, this will not change our findings on the choice between input currency and output currency.

¹⁸This issue is so important that it, in our view, deserves the full attention of a separate paper.

4 Conclusion

This paper develops a small open economy general equilibrium model with stick prices to study the theory of optimal currency basket. The model emphasizes vertical trade and different roles of currencies in invoicing trade flow, which are two empirically important features of some East Asian small open economies, such as Hong Kong. Using second-order approximation method, we can solve the optimal weight between input currency and output currency in a basket peg. We find that the optimal weight will be affected significantly by the structure of vertical trade, and price rigidities in trade sector.

In most cases, in terms of welfare, the output currency peg is superior to the input currency peg. However, when other Asian currencies (or prices of other Asian export goods in the US market) are sensitive to the dollar-RMB exchange rate fluctuation, the input currency peg can welfare-dominate the output currency peg. As RMB is an important input currency for Asian economies, this result implies that there could be a role of RMB in the design of future monetary policy for these small open economies. However, it also suggests that the emergence of a RMB peg relies on the regional policy coordination.

In short, our model provides a framework based on vertical trade to study the optimal currency basket for small open economies. For future research, a natural extension is to relax the assumption about the structure of financial market so that we can compare the importance of trade structure and financial structure in determining the optimal currency basket for small open economies.

References

- [1] Basu, Susanto and John G. Fernald, 1997, "Returns to Scale in U.S. Manufacturing: Estimates and Implications", *Journal of Political Economy*, 105(2), 249-83.
- [2] Betts, Caroline and Michael B. Devereux, 2000, "Exchange Rate Dynamics in a Model of Pricing-to-Market", *Journal of International Economics*, 50, 215-244.
- [3] Calvo, Guillermo and Carmen Reinhart, 2002, "Fear of Floating", *Quarterly Journal of Economics*, 117, 379-408.
- [4] Christiano, Lawrence J., Martin Eichenbaum and Charles L. Evans, 1997, "Monetary Policy Shocks: What Have We Learned and to What End?", *Handbook of Macroeconomics*, North-Holland Pub. Co.
- [5] Cook, David and Michael B. Devereux, 2001, "The Macroeconomics of International Financial Panics", Mimeo, Hong Kong University of Science and Technology.
- [6] Cook, David and Michael B. Devereux, 2004, "External Currency Pricing and the East Asian Crisis", forthcoming, *Journal of International Economics*.
- [7] Devereux, Michael, Philip Lane, and Juanyi Xu, 2006, "Exchange Rates and Monetary Policy in Emerging Market Economies", *Economic Journal*, Vol. 116, page 478-506.
- [8] Ortega, Eva and Rebei Nooman, 2005, "The Welfare Implications of Inflation versus Price-Level Targeting in a Two-Sector, Small Open Economy," Working Papers, Bank of Canada.
- [9] Eichengreen, B. and T. Bayoumi, 1999, "Is Asia an Optimum Currency Area? Can It Become One? Regional, Global and Historical Perspectives on Asian Monetary Relations", in Stefan Collignon, Jean Pisani-Ferry, and Yung Chul Park (eds.), *Exchange Rate Policies in Emerging Asian Countries*.
- [10] Feenstra, Robert C., 1998, "Integration of Trade and Disintegration of Production in the Global Economy", *Journal of Economics Perspectives* 12: 31-50.

- [11] Feenstra, Robert and Gordon H. Hansen, 2004, "Intermediates in Entrepot Trade: Hong Kong Re-export Chinese Goods", *Journal of Economics and Management Strategy*, Vol. 13, 3-35.
- [12] Gali, J. and T. Monacelli, 2004, "Monetary Policy and Exchange Rate Volatility in a Small Open Economy", *Review of Economic Studies*, 72(3), 707-734.
- [13] Hummels, David, Jun Ishii, and Kei-mu Yi, 1998, "Vertical Specialization and the Changing Nature of world Trade", *Economic Policy Review*, June 1998.
- [14] Hummels, David, Jun Ishii, and Kei-mu Yi, 2001, "The Nature and Growth in Vertical Specialization in a World Trade", *Journal of International Economics* 54, 75-96.
- [15] Huang, Kelvin and Zheng Liu, 2006, "Sellers Local Currency Pricing or Buyers Local Currency Pricing: Does It Matter for International Welfare Analysis?", *Journal of Economic Dynamics and Control*, Vol. 30(7), pp. 1183-1213.
- [16] Park, Yung Chul, Chae-Shick Chung and Yunjong Wang, 2001, "Fear of Floating: Korea's Exchange Rate Policy after the Crisis", *Journal of the Japanese and International Economies* 15, 225-51.
- [17] Rotemberg, Julio J, 1982, "Monopolistic Price Adjustment and Aggregate Output," *Review of Economic Studies* 49(4), 517-31,
- [18] Rotemberg, Julio J. and Michael Woodford, 1998, "An Optimization-Based Econometric Framework for the Evaluation of Monetary Policy: Expanded Version", NBER Working Paper 6990.
- [19] Schmitt-Grohe, Stephanie and Martin Uribe, 2001, "Stabilization Policy and the Costs of Dollarization", *Journal of Money, Credit, and Banking* 33, 482-509.
- [20] Schmitt-Grohe, Stephanie and Martin Uribe, 2004, "Solving Dynamic General Equilibrium Models Using a Second-Order Approximation to the Policy Function", *Journal of Economic Dynamics and Control*, 28, 755-775.

- [21] Shi, Kang and Juanyi Xu, 2006a, “Optimal Monetary Policy with Vertical Production and Trade”, forthcoming, *Review of International Economics*.
- [22] Shi, Kang and Juanyi Xu, 2006b, “Twin dollarization and Exchange Rate Policy”, Mimeo, Chinese University of Hong Kong.
- [23] Slavov, Slavi, 2005, “ Should Small Open Economies East Asia Keep All Their Eggs in One Basket: The Role of Balance Sheet Effects”. Mimeo, Pomona College.
- [24] Turnovsky, Stephen J., 1982, “A Determination of the Optimal Currency Basket: a Macroeconomic Analysis”, *Journal of International Economics*, 12, 333-354.
- [25] Teo, Wing Leong, 2005, “ Should East Asia’s Currencies be Pegged to the Yen? The Role of Invoice Currency”, Mimeo, National University of Taiwan.
- [26] Woodford, Michael, 2003, *Interest and Prices: Foundations of a Theory of Monetary Policy*, Princeton University Press, 2003.
- [27] Yi, Kei-mu, 2003, “Can Vertical Specialization Explain the Growth of World Trade?”, *Journal of Political Economy* 111, 52-102.

Figure 1: Exchange Rate fluctuation

Dollar-RMB Exchange Rate from July 2006 – Jan. 2007

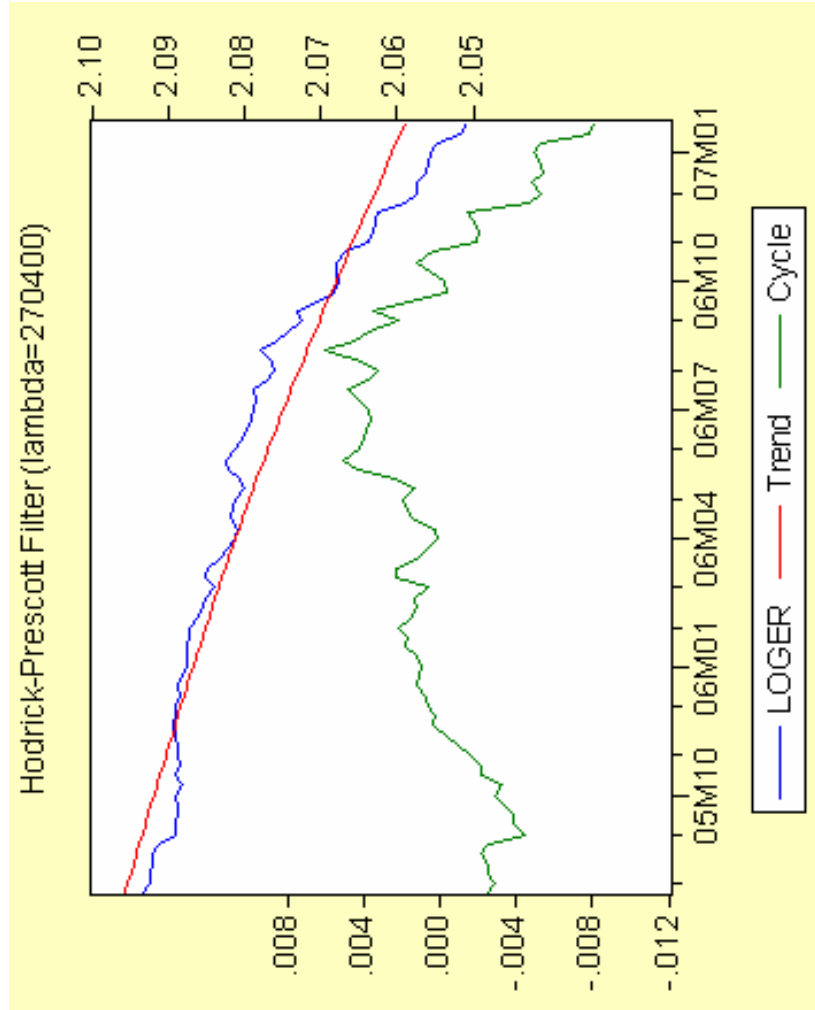


Figure 2: Flow Chart for the Small Open Economy

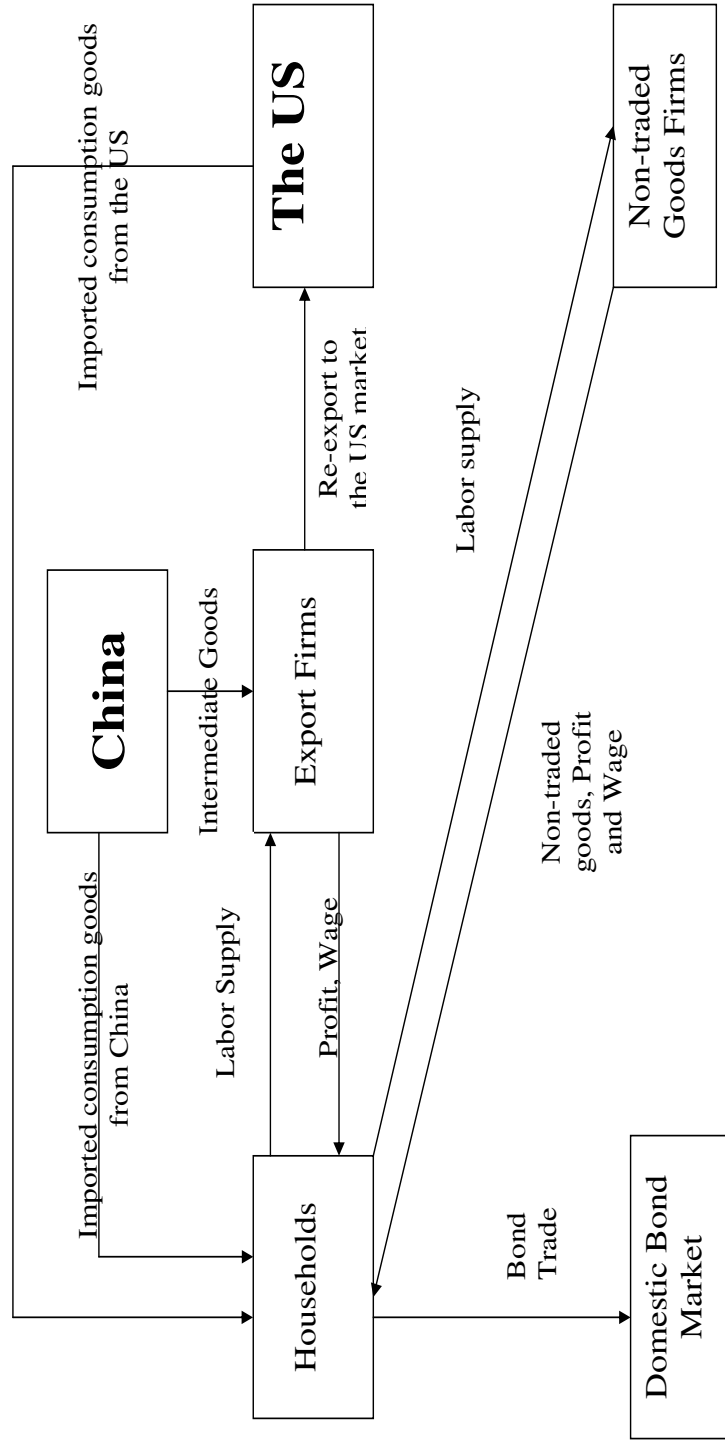


Figure 3: Impulse Response to S^{BA} shock: Dollar Peg and RMB Peg

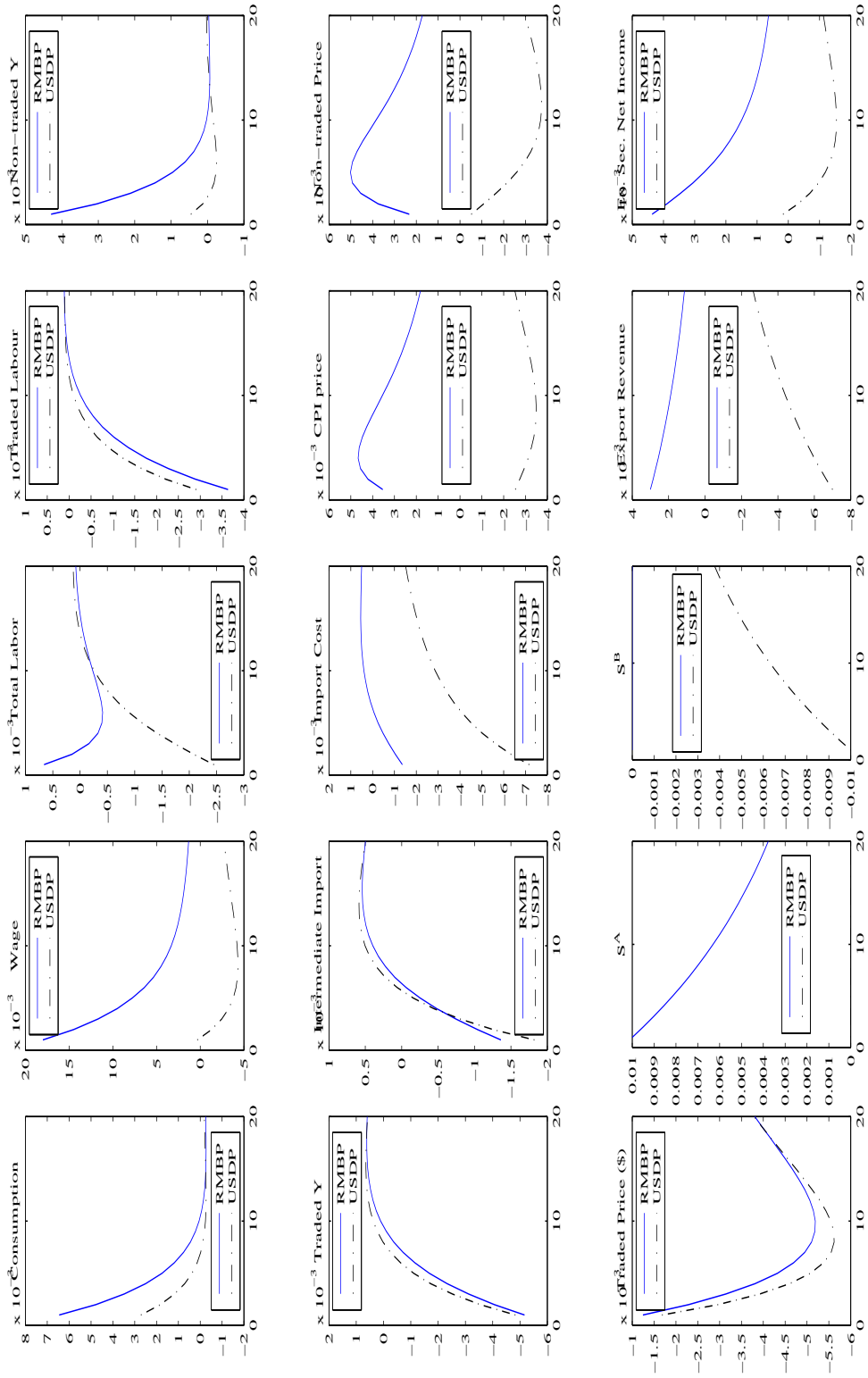
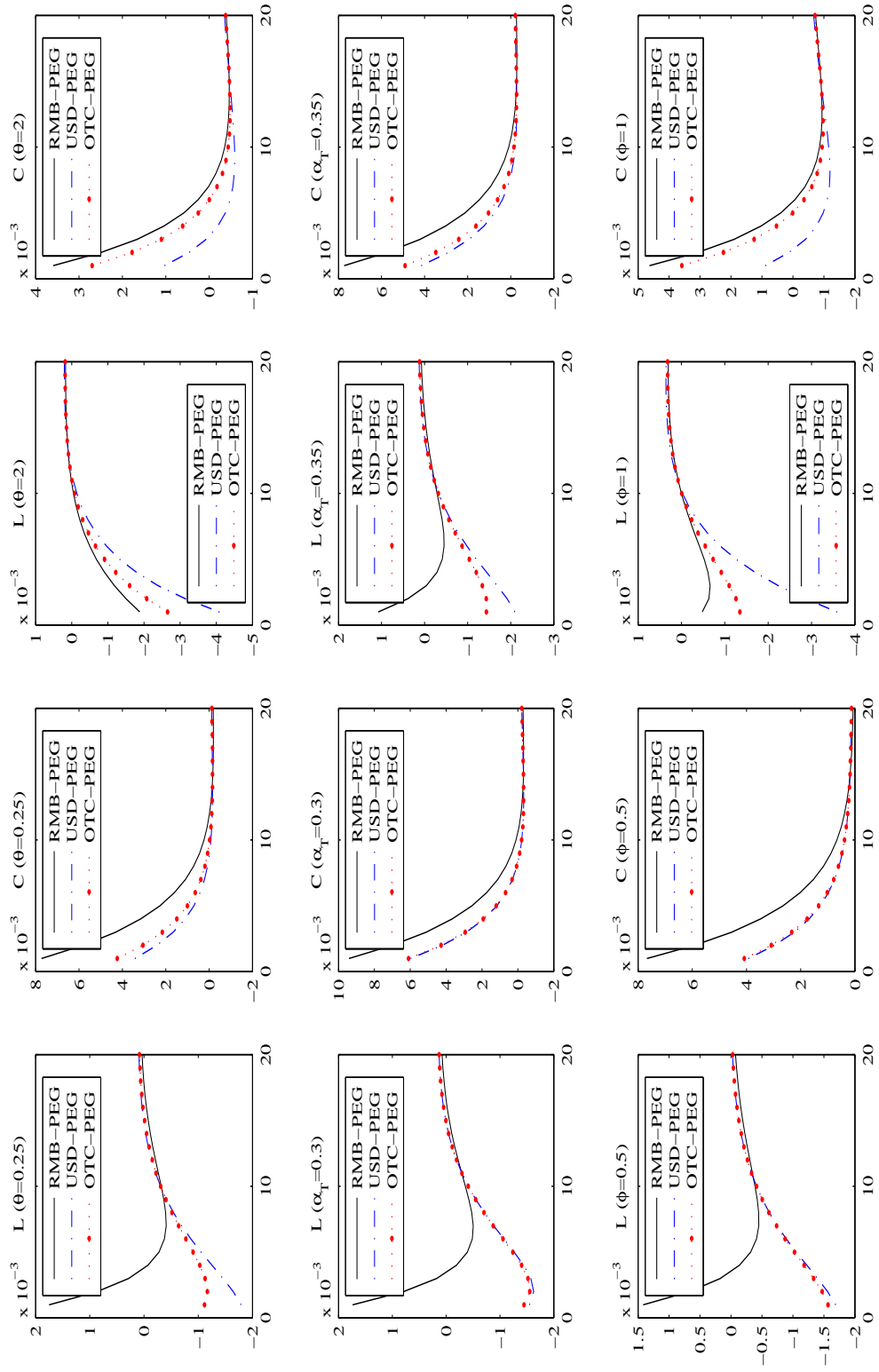


Figure 4: IRS of Labor/Consumption to $+S^{BA}$ shock (Different θ , α_T , and ϕ).



Technical Appendix

(Not to be Published)

A Equilibrium

In our model, we have 9 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} , IM_t and AC_t , and 3 exogenous variables, S_t^{BA} , X_t , and P_{mt}^* .

$$P_t = P_{Nt}^{1-\alpha} P_{Ft}^\alpha \quad (\text{A.1})$$

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

$$S_t^A P_{Tt}^* Y_{Tt} - \alpha P_t (C_t + AC_t) - S_t^B P_{mt}^* IM_t = 0. \quad (\text{A.3})$$

$$Y_{Nt} = (1 - \alpha) \frac{P_t (C_t + AC_t)}{P_{Nt}} \quad (\text{A.4})$$

$$AC_t = \frac{1}{2} \psi_{p_N} \left(\frac{P_{Nt}}{P_{Nt-1}} - 1 \right)^2 + \frac{1}{2} \psi_{p_T} \left(\frac{P_{Tt}^*}{P_{Nt-1}^*} - 1 \right)^2 \quad (\text{A.5})$$

$$\frac{1}{1 + i_{t+1}} = \beta E_t \left(\frac{C_t^\rho P_t}{C_{t+1}^\rho P_{t+1}} \right) \quad (\text{A.6})$$

$$W_t = \eta L_t^\psi P_t C_t^\rho. \quad (\text{A.7})$$

$$Y_{Nt} = L_{Nt} \quad (\text{A.8})$$

$$P_{Nt} = \frac{\lambda}{\lambda - 1} W_t - \frac{\psi_{P_N}}{\lambda - 1} \frac{P_t}{Y_{Nt}} \frac{P_{Nt}}{P_{Nt-1}} \left(\frac{P_{Nt}}{P_{Nt-1}} - 1 \right) + \frac{\psi_{P_N}}{\lambda - 1} E_t \left[\beta \frac{P_t C_t^\rho}{P_{t+1} C_{t+1}^\rho} \frac{P_{t+1}}{Y_{Nt}} \frac{P_{Nt+1}}{P_{Nt}} \left(\frac{P_{Nt+1}}{P_{Nt}} - 1 \right) \right]. \quad (\text{A.9})$$

$$L_t = L_{Nt} + L_{Tt} \quad (\text{A.10})$$

$$L_{Tt} = \alpha_T \left(\frac{W_t}{MC_{Tt}} \right)^{-\theta} Y_{Tt} \quad (\text{A.11})$$

$$IM_t = (1 - \alpha_T) \left(\frac{S_t^B P_{mt}^*}{MC_{Tt}} \right)^{-\theta} Y_{Tt} \quad (\text{A.12})$$

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

$$Y_{Tt} = \left(\frac{P_{Tt}^*}{S_t^{BA-\phi}} \right)^{-\mu} X_t \quad (\text{A.14})$$

$$P_{Tt}^* = \frac{\lambda}{\lambda-1} \frac{MC_{Tt}}{S_t^A} - \frac{\psi_{P_T}}{\lambda-1} \frac{1}{S_t^A} \frac{P_t}{Y_{Tt}} \frac{P_{Tt}^*}{P_{Tt-1}^*} \left(\frac{P_{Tt}^*}{P_{Tt-1}^*} - 1 \right) + \frac{\psi_{P_T^*}}{\lambda-1} E_t \left[\beta \frac{1}{S_t^A} \frac{P_t C_t^\rho}{P_{t+1} C_{t+1}^\rho} \frac{P_{t+1}}{Y_{Tt}} \frac{P_{Tt+1}^*}{P_{Tt}^*} \left(\frac{P_{Tt+1}^*}{P_{Tt}^*} - 1 \right) \right]. \quad (\text{A.15})$$

$$(S_t^A)^\omega (S_t^B)^{1-\omega} = 1 \quad (\text{A.16})$$

$$(S_t^{BA}) S_t^B = S_t^A \quad (\text{A.17})$$

$$\log(X_t) = (1 - \rho_x) \log(\bar{X}) + \rho_x \log(X_{t-1}) + \epsilon_{xt} \quad (\text{A.18})$$

$$P_{mt}^* = (1 - \rho_m) \bar{P}_m^* + \rho_m P_{mt-1}^* + \epsilon_{mt} \quad (\text{A.19})$$

$$\log(S_t^{BA}) = \rho_s \log(S_{t-1}^{BA}) + \epsilon_{st} \quad (\text{A.20})$$

B Steady state system

In steady state, we impose $X = 1$, $S^{BA} = 1$ ¹⁹, and $P_m^* = P^* = 1$.

$$P = P_N^{1-\alpha} P_F^\alpha \quad (\text{B.1})$$

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

$$S^A P^* Y_T - \alpha PC - S^B P_m^* IM = 0. \quad (\text{B.3})$$

$$Y_N = (1 - \alpha) \frac{PC}{P_N} \quad (\text{B.4})$$

$$\frac{1}{1+r} = \beta \quad (\text{B.5})$$

$$W = \eta L_t^\psi PC^\rho. \quad (\text{B.6})$$

¹⁹We assume $S^{BA} = 1$, so that the steady state is independent of the choice of exchange rate regime ω .

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

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

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

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

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

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

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

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

$$S^A = (S^{BA})^{1-\omega} = 1 \tag{B.15}$$

$$S^A = (S^{BA})^\omega = 1 \tag{B.16}$$