Essays on the Optimal Choice of Exchange Rate Regimes

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Abstract[1]

Essays on the Optimal Choice of Exchange Rate Regimes

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The way a country manages its currency can affect its volume of trade, capital flows and income. A country, especially one with high degree of trade openness, needs to find the most suitable exchange rate arrangement to reduce the volatility of its currency value and output. This thesis examines the optimal choice of exchange rate arrangements from various aspects.

The first essay examines whether or not the Northeast Asian economies, that is, China, Japan, Korea, and Taiwan can form a currency union, where a single currency and a uniform monetary policy are adopted, or an exchange rate union, where all the currencies are pegged to an internal or external currency or currency basket. It also attempts to find the optimal currency or currency basket for the four Asian economies if an exchange rate union is feasible. Structural VAR models with identification assumptions are applied to analyze the correlations of supply, exchange rate, monetary, and demand shocks. The paper finds that the shocks of these four economies are not symmetric, implying that the Northeast Asian economies are not ready yet to form a common currency union. However, it is found that these economies can form an exchange rate union with a major currency basket including the U.S. dollar, the Japanese yen and the Euro as currency anchor. The paper also examines the option of pegging to a basket of regional currencies, similar to the Asian Currency Unit (ACU).

The second essay uses panel data on emerging and developing countries to study the interrelationships between balance-sheet currency mismatches and the choice of

[1] The first essay is joint work with Dr. Bang Jeon. The second essay is joint work with Dr. Alina Luca.

exchange rate regimes. The evidence shows that the lack of exchange rate flexibility reinforces currency mismatches and increases dollar liabilities, but the estimated economic effects are small.

The third essay uses a three-country model to analyze the choice of the optimal weights of a currency basket for emerging market economies. This model assumes imperfect capital mobility and allows the domestic country to impose a reserve requirement on capital inflows. The optimal weights are derived by minimizing the loss from the volatility of output and trade. The result shows that the optimal weights are affected by variance of the cross exchange rate between the two major currencies, the covariance between inflations in the two large countries and the cross exchange rate, the relative weights assigned to trade and output, and price and exchange rate elasticities of trade, demand and supplies.

CHAPTER 1: A CURRENCY UNION OR AN EXCHANG RATE UNION: EVIDENCE FROM NORTHEAST ASIA

1.1 Introduction

This paper examines whether the Northeast Asian economies, namely, China, Japan, Korea, and Taiwan, can form a currency union where a single currency and a uniform monetary policy are adopted or an exchange rate union where all the currencies are pegged to a single currency or a common currency basket. It also attempts to find a currency or a currency basket for the Northeast Asian economies if an exchange rate union is feasible.

The experience of the Euro rekindles an interest in the possibility of a common currency area[2] in other regions. One of the regions of interest is East Asia. The East Asian countries enjoy the highest growth rate in the world. Before the Asian financial crisis in 1997, most East Asian countries adopted a fixed exchange rate regime or a managed floating regime, virtually pegging to the U.S. dollar. This dollar peg makes the exports of countries, which compete with Japan for exports, fluctuate when the yen-dollar exchange rate changes. When the Japanese yen appreciates, the goods and services produced in Japan become less competitive. The exports of countries competing with Japan increase. When the Japanese yen depreciates, the products of Japan become more competitive. The exports of countries competing with Japan decline. The East Asian countries are export oriented countries. Fluctuations of trade can cause economic instability. So the volatility of the exchange rate between the Japanese yen and the U.S. dollar can lead to fluctuations in the income of the East

[2] The idea of a common currency area was developed by Robert A. Mundell in 1961. A common currency area is a region where a single currency is adopted by all the countries, and there is one central bank that conducts an independent monetary policy. Since the establishment of this theory, there have been a number of studies which investigate whether a common currency area is feasible for different areas of the world. The introduction of the euro in 1999 is considered to be a successful realization of this theory.

Asian countries which compete with Japan, like Korea, Hong Kong, and Singapore. The crisis made many East Asian countries suffer from a decline in growth and a free-falling currency value. Many countries are forced to float their exchange rates, which makes more fluctuations in exports and income. The crisis of 1997 makes more evident the importance of stability of the exchange rate among Asian countries. It also shows that the dollar peg seems to be risky for the East Asian countries. After learning this valuable lesson, the East Asian countries started to look for a more suitable exchange rate arrangement after the crisis.

During the 1997 Asian financial crisis, the East Asian countries claimed that they did not get enough help from the International Monetary Fund or the major lenders including the United States. This experience made these Asian countries realize that they should rely on themselves and that strengthening regional cooperation is an effective way to prevent crisis like one in 1997.

Accordingly, the finance ministers of the Association of Southeast Asian Nations (ASEAN) plus China, Japan, and Korea (ASEAN+3) agreed on the Chiang Mai Initiative (CMI) in May 2000. The CMI is a swap agreement that agrees to provide foreign reserves to member countries facing a speculative attack. Figure 1.1 shows the bilateral swap arrangements of the CMI. As of November 2005, the total amount of bilateral swap arrangements under the CMI is $58.5 billion, more than 80% of which is provided by China, Japan and Korea. In 1992, ASEAN countries formed the ASEAN Free Trade Area (AFTA). This agreement facilitates intra-regional trade and strengthens cooperation of the ASEAN countries. Japan established a partnership with the ASEAN in the AFTA and China agreed to form the ASEAN-China Free Trade Area (ACFTA) with the ASEAN in 2002. Besides the CMI and the AFTA, ASEAN+3 also aim to promote the development of domestic bond markets and the

creation of a regional bond market. The increasing financial and trade cooperation of the East Asian countries provides academia and policy-makers with a momentum to evaluate the feasibility and a timetable, if possible, of forming a common currency area in East Asia.

The Asian currency unit (ACU) is planned to be introduced by the Asian Development Bank (ADB) in 2006. The ACU is not legal tender. It is a statistical index based on a currency basket containing 10 ASEAN countries plus China, Japan and Korea. The weight of each currency is determined by GDP and the trade volume of the country that uses this currency. The weights of the Chinese yuan, the Japanese yen and the Korean won will be substantial. This index is expected to help to stabilize the fluctuation of the 13 currencies in the region. The ACU is the first step toward a single currency in the region. There is a long way to go from the ACU to a single currency. It needs the harmonious efforts and cooperation of governments.

Eichengreen and Bayoumi (1996) find that the East Asian countries satisfy the requirements of an optimum currency area. Larraín and Tavares (2005) find that the level of economic integration of the East Asian countries is approaching that of the European countries. Bénassy-Quéré (1999) finds that East Asia is still not ready for establishing an optimum currency area. Other authors find a few countries in the region are ready to form a currency area (Eichengreen and Bayoumi, 1994; Huang and Guo, 2005; Karras, 2005; Lim, 2005). There is not a consensus whether the East Asian countries can form a currency union or not.

However, political and culture factors play a very important role in conducting monetary cooperation like a currency union. Countries like Malaysia, Indonesia, Philippines and Thailand seem to be quite different from countries like China, Japan, and Korea in culture. It is less likely to form a common currency area in countries of

different economic environments and political structures. Hong Kong is a special administrative area of China. It is unlikely that Hong Kong would join a currency area without the co-ordination with the central government of China. It is also unlikely for Korea to form a common currency area with some Southeast Asian countries because of differences in culture, political and economic structures. It is less likely that all the East Asian countries form a common currency area in a reasonable short time period.

There is still a long way to go for all of the East Asian countries to adopt a single currency. Although the East Asian countries have increased financial and trade integration through swap agreements and free trade agreements, they have diverse economic structures, isolated labor and financial markets, and different levels of economic development. Economic divergence makes it difficult for the East Asian economies to adopt a uniform monetary policy. Some of the preconditions for establishing a common currency area include similar economic structures, common cultural backgrounds, and convergence of levels of economic development.

China, Japan, Korea and Taiwan are important economies in East Asia. They have relatively similar cultural backgrounds. They have become more integrated economically in recent years. They are major trading partners of each other. Taiwan's economic and trade relationships with China, Japan, and Korea are closer than those with the ASEAN countries. Taiwan's trade with these three countries is more than twice that with the ASEAN countries. Both China and Japan are the major trading partners of Taiwan. In addition, Taiwan is the third largest investor in China. As Taiwan increases its trade and investment in this area, it becomes more closely related with China, Japan and Korea, some lingering political agenda notwithstanding. Is it possible for them to form a currency union?

This paper is organized as follows. Section II describes the background and rationales for introducing a currency union in Northeast Asia. Section III provides related literature on the issue. Section IV describes our estimation methodology. Section V reports a summary of some statistical characteristics of data and results of preliminary tests. Section VI reports the empirical results on various options of a currency union and an exchange rate union in the region. Section VII provides the summary of the paper and conclusion.

1.2 Toward a Currency Union in Northeast Asia: Background and Rationale

At first glance, it does not seem easy for the Northeast Asian economies to form a currency area as they are different in the political structure and the current status of economic development. Japan is more developed than China, Korea and Taiwan. China is a socialistic country with a mixed economy while the others are not.

Since the 1980s, economic ties between China, Japan, Korea and Taiwan have kept increasing trade and capital flows among the four Northeast Asian countries. In 1991 the Northeast Asia Economic Forum (NEAEF) was created to promote the research, networking and dialogue relevant to the economic and social development of Northeast Asia. NEAEF conferences and seminars are held each year. The idea of the Northeast Asian Development Bank (NEADB) has been discussed since the establishment of NEAEF. A special committee for the establishment of the NEADB was created in 2000. This can be viewed as the first step toward the monetary unification of the Northeast Asian economies. Mutual benefits provide an incentive for the Northeast Asian countries to cooperate with each other.

There are many studies investigating what economic characteristics the members of a common currency area should share (Mundell, 1961; McKinnon, 1963; Kenen,

1969). Some criteria are created for potential candidates of a common currency area. The basic characteristic is that members of the common currency area should respond symmetrically to common shocks. Other criteria include factor mobility, trade openness, similar regional production pattern, high intra-regional trade, among others, as discussed below.

Trade Openness

China, Japan, Korea, and Taiwan have chosen the export-oriented economic growth strategy for their economic development. This development strategy increases the openness of their economies. Fluctuations of exchange rates cause instabilities in trade balance and income. The more open is the economy, the more its output is affected by changes in the currency value. A common currency helps to stabilize exchange rates, and then reduces fluctuations of trade balance and output. Table 1.1 gives the degree of trade openness of the four Northeast Asian economies.[3] It shows that Japan is the least open and Korea is the most open. China's total trade as a percentage of GDP increased significantly during the period from 1980 to 2003. In 1980, the total trade volume of China was only 15% of GDP and in 2003, it increased to 66%. China became the second most open country among the four economies after Korea (73%) in 2003. The trade openness of Korea and Taiwan fluctuates over time. But they are the most open among the four.

China, Japan, and Korea become more open in recent years through international cooperation. China joined the World Trade Organization (WTO) in 2001. Since then import barriers have dramatically been cut. China's market becomes more open. China, Japan and the ASEAN countries propose to establish the ASEAN-China FTA and the ASEAN-Japan FTA within 10 years. Korea and the U.S. started to discuss on

[3] Trade openness is defined as the total trade (imports plus exports) as a percentage of GDP.

a free trade agreement in early 2006. These efforts improve the openness of the Northeast Asian area, and it is expected to increase the benefits from a currency union in the region.

Intra-regional Trade

Countries can benefit from a common currency by keeping a stable exchange rate among its member countries when they have a significant amount of intra-regional trade. The East Asian countries experienced a dramatic growth in the intra-regional trade since 1980 (Sakakibara and Yamakawa, 2003). Table 1.2 lists the shares of trade with the major trading partners for China, Japan, Korea and Taiwan. The share of China in the trade of other economies has increased tremendously over time, especially for Taiwan. China is ranked as 27th in 1989 among all the trading partners of Taiwan, 12th in 1997. In 2003, China became the third largest trading partner of Taiwan after Japan and the U.S. In 2003, China was the 2nd largest trading partner of Japan and Korea after the U.S. The share of Japan in China' trade first increased and then decreased recently; and it kept declining in Korea and Taiwan. The shares of Korea in Chin's and Taiwan's trade have increased over time. The share of Korea in Japan's trade first declined and then increased. The shares of Taiwan in China's and Korea's trade have increased over time. The share of Taiwan in Japan's trade had increased from 1991 to 1997, until it declined in 2003. In 2003, the U.S. is the largest trading partner of Japan and Korea, and the second largest trading partner of China and Taiwan. The Northeast Asian economies still trade a lot with the U.S., but the relative share of the U.S. has decreased over time. Japan is the largest trading partner of China and Taiwan, and the third largest trading partner of Korea. The intra-regional trade has significantly increased over time. For example, the intra-regional trade of China has increased from 18 percent to 27 percent since the early 1990s. The intra-

regional trade of Korea and that of Taiwan have also increased from the 23-26 percent level to more than 33 percent during the period of 1991 through 2003. The intra-regional trade of Japan has increased from 15 percent to 27 percent during the same period.

Although the intra-regional trade has increased over time, the Northeast Asian economies still trade a lot with the U.S. and the euro area. Table 1.2 shows, however, that the shares of developed countries in the trade of the Northeast Asian economies tend to decline. The total trade of China, Korea and Taiwan with Japan has declined. But the share of the intra-regional trade in the total trade of Japan has increased significantly since early 1990s. The increase in the intra-regional trade among the Northeast Asian economies provides a more favorable environment to introduce a currency union in the region.

Factor Mobility

According to Mundell (1961), with free labor mobility, workers can move to other countries when a negative shock hits the domestic country, so that the increase in unemployment in the domestic country is relieved. Bayoumi and Eichengreen (1994) argue that the requirement of labor mobility is not that important because labor mobility even in many developed countries is not high. Labor still cannot move freely within the Northeast Asia. The role of the labor mobility on the labor market is different. China is a labor-exporting country, while Japan and Taiwan are labor-importing countries (Huang and Guo, 2005). The number of foreign workers has increased in the Northeast Asian region in recent years.

Another factor that moves among the economies is capital. Foreign Direct Investment (FDI) is an important channel of capital flows. FDI is essential for economic growth of the Northeast Asian economies, especially for China. Thanks to

its open-door policy in the late 1970s, China has attracted a large amount of inward FDI. China receives a significant portion of FDI inflows through Hong Kong, which accounts for more than 30% of FDI inflows into China each year. Another source is the U.S. (10%). But the share of inward FDI from the U.S. has been decreasing. Taiwan was the third largest source of FDI in the mainland China before 2003, after Hong Kong. Korea took the place of Taiwan in 2003. About one-fifth of all FDI inflows to China is intra-regional FDI. The inward FDI of Taiwan mainly comes from the U.S. and Japan, about 20% for each country. Intra-regional FDI is essential for Taiwan's economic growth.

Financial cooperation is active in this area, especially among China, Japan and Korea. In the implementation of the CMI swap agreement, China, Japan and Korea play very important roles. As of November 2005, more than 80% of the total amount of bilateral swap arrangements is provided by the three countries. Figure 1.1 shows that the swap arrangements among the three Northeast Asian economies account for over one-third of the total arrangements to cover 10 ASEAN nations plus China, Korea and Japan.

Increases in trade and FDI, which are driven by the increase in openness, contribute to economic growth in Northeast Asia. Increased intra-regional trade and FDI change trading and investment patterns in the region (Sakakibara and Yamakawa, 2003). Trade and capital shift to developing countries because of lower costs. The Northeast Asian economies depend less on the West, especially the U.S. Therefore, regional cooperation becomes more important. With the increased openness, intra-regional trade and capital flows, the Northeast Asian economies can benefit from introducing a common currency. By establishing a currency union and applying

uniform monetary policy, these economies can stabilize the exchange rate, and reduce the fluctuations in trade, capital flows and output.

Business Cycle Synchronization

Business cycle synchronization is one of the crucial requirements for member countries of a common currency area to introduce a common currency. The cost of adopting a single currency will be smaller if the business cycles of member countries are synchronized, because a uniform monetary policy can be applied when they encounter common shocks (Cheung and Yuen, 2004). Schnabl (2005) finds that the business cycle of Korea and that of Taiwan are synchronized because of increasing intra-regional trade and similar exchange rate, monetary, and fiscal policies. Cheung and Yuen (2004) find that China, Japan and Korea have synchronized business cycles in both short-run and long-run.

Business cycle synchronization is not a sufficient condition for adopting a uniform monetary policy. Shocks should also be symmetric across economies. Countries with synchronized business cycles should not introduce a uniform monetary policy if they experience shocks mainly as country-specific shocks instead of common shocks. Then they are not quite eligible to form a currency union. China, Japan, Korea, and Taiwan have become more open and more integrated in trade and finance since the early 1990s. Whether shocks are symmetric among the Northeast Asian economies determines whether or not they are ready to form a common currency area. If they are facing similar shocks, the cost of relinquishing an independent monetary policy will be trivial (Huang and Guo, 2005).

1.3 Literature Review

When a monetary union is formed, there is only one central bank that conducts monetary policy for the common currency area. The countries lose autonomous monetary policy. They also lose the seigniorage revenue from issuing money. The benefits include the reduction of transaction costs, and the stabilization of the exchange rate among countries participating in the union, which stimulates intra-regional trade and reduces trade fluctuations in trade with outsiders. The more open is the country, the more benefit it can get from monetary unification, because the unification reduces the transaction costs involved in international trade (McKinnon, 1963). Countries with a high degree of openness are more likely to be a member of a currency union.

According to Mundell (1961), two economies can benefit from monetary unification if they favor the same policy reaction when facing the same shock. Kenen (1969) suggests that countries with similar industries tend to experience similar shocks if shocks are industry-specific and the shocks are then positively correlated. One of the focuses of this paper is laid on investigating whether or not the macroeconomic shocks in the economies of China, Japan, Korea and Taiwan are symmetric. If shocks are symmetric across the regional nations, then they are qualified to form a monetary union.

There are a few studies on the optimum currency area for the Asian countries. Bénassy-Quéré (1999) examines the viability of a yen block in Asia by analyzing the relationship between the volatility of both nominal and real bilateral exchange rates, and output volatility, similarity in exports, and trade share. Eichengreen and Bayoumi (1996) use the similar methodology to investigate whether or not the East Asian countries satisfy the optimum currency basket criteria by checking the relationship

between the standard deviation of the bilateral exchange rate and output variability, export dissimilarity, share of exports, and the relative size of GDP. They estimate the volatility of the bilateral exchange rate as an index. Similar results of the index measurement across countries imply that they are eligible for an optimal currency area. The limitation of this method is that it tends to mix up the effects of different types of shocks.

Karras (2005) investigates whether or not there is an optimum currency area among 18 Asian and Pacific countries by examining the costs and benefits of forming a common currency area. He examines the correlation of the volatility of the nominal exchange rate against the U.S. dollar, inflation, and output between the Asian and Pacific countries and Japan, using different methods to de-trend the data.

Some other authors use the structural vector autoregression (SVAR) model with identification assumptions a la Blanchard and Quah (1989) to investigate whether shocks of different countries are correlated (Bayoumi and Eichengreen, 1994; Chow and Kim, 2003; Kwack, 2004; Zhang, Sato, and McAleer 2004; Huang and Guo, 2005). Bayoumi and Eichengreen (1994) take into account demand and supply shocks among 15 European countries, 11 Asian countries, and 13 American countries. Kwack (2004) also uses demand and supply shocks for 10 East Asian countries. In addition to the symmetry of shocks, he considers trade openness and FDI. Chow and Kim (2003) consider global, regional, and domestic supply shocks for 7 East Asian countries. However, these studies are quite limited because they examine only demand and supply shocks in their analyses. For example, monetary shocks can also make trade and output fluctuate. Huang and Guo (2006) choose a four-variable system including global supply shocks, domestic supply shocks, demand shocks and monetary shocks for 9 East Asia countries. Zhang, Sato, and McAleer (2004) examine the correlation

of supply, demand, and monetary shocks for the U.S. and 9 East Asian economies. For the East Asian countries, exports are very important. Most of these countries are export-dependent. So exchange rate shocks should be taken into account for the East Asian case. So in this paper, supply shocks, demand shocks, monetary shocks and exchange rate shocks are considered.

Several recent studies of the possibility of an optimum currency area in Asia focus on East Asia. The findings of the studies are mixed. Bayoumi and Eichengreen (1994) suggest two common currency areas for East Asia, a Northeast Asian bloc including Japan, Korea and Taiwan, and a Southeast Asian bloc including Hong Kong, Malaysia, Singapore, and possibly Thailand. Their study does not include China. Karras (2005) finds that Korea along with Indonesia is a promising candidate for the yen bloc based on analysis of costs and benefits. He does not examine the symmetry of shocks across counties. Huang and Guo (2006) propose a currency union including Hong Kong, Indonesia, Korea, Malaysia, Singapore, and Thailand. Taiwan is not included in the analysis. Lim (2005) finds that Hong Kong, Korea, Philippines, Singapore and Thailand can form a currency union. His study does not include China. Kwack (2004) and Chow and Kim (2003) find that there is not a common currency area in East Asia. Kwack (2004) only examines demand and supply shocks. Chow and Kim (2003) do not include China in their study.

It is still not clear whether shocks are symmetric among China, Japan, Korea and Taiwan, and whether or not they are eligible for a currency union. This paper attempts to investigate the possibility of establishing a currency union like the Euro area in Northeast Asia including China, Japan, Korea and Taiwan. The SVAR model is used to examine the correlation of domestic supply, demand, monetary and exchange rate shocks in the four Northeast Asian economies.

1.4 Methodology

Bayoumi and Eichengreen (1994) construct their structural vector autoregression (SVAR) model on the basis of an AD-AS framework. They assume that in the long-run, output is affected only by supply shocks. Demand shocks have no long-run effect on output. Huang and Guo (2006) extend this model by including external supply shocks and monetary shocks and they assume that monetary shocks do not affect the real exchange rate or output in the long-run. In this section, we extend the framework of Bayoumi and Eichengreen (1994) from a two-variable model to a four-variable model by incorporating exchange rate shocks and monetary shocks. For different choice of variables and shocks, see Table 1.12. The Northeast Asian economies are export-oriented economies. Changes in exchange rate provide significant impact on output in these economies by affecting imports and exports. It determines the competitiveness of their products. Monetary shocks are also important. If monetary shocks are symmetric across economies, they can adopt a uniform monetary policy with smaller costs. A common currency area will be a favorable option for them.

In this paper, the structural vector autoregression (SVAR) model is used. The Northeast Asian economies can be described using the following moving-average representation of the SVAR model.

(1)
$$\Delta x_t = A_0 u_t + A_1 u_{t-1} + A_2 u_{t-2} + \cdots$$
$$= A(L) u_t$$

where $\Delta x = [\Delta y, \Delta(e + p^* - p), \Delta(m - p), \Delta p]$. y_t is the logarithm of output; e_t is the logarithm of the nominal exchange rate; m_t is the logarithm of nominal money; p_t^* is the logarithm of foreign prices; and p_t is the logarithm of domestic prices.

$e_t + p_t^* - p_t$ is the real effective exchange rate. $m_t - p_t$ is the logarithm of real money balance. $u_t = [u_t^s, u_t^e, u_t^m, u_t^d]$ is a vector of unobserved shocks. u_t^s is a supply shock; u_t^e is an exchange rate shock; u_t^m is a monetary shock; and u_t^d is a demand shock. It is assumed that these shocks are uncorrelated.

Equation (1) can be rewritten in matrix form,

$$(2) \qquad \begin{pmatrix} \Delta y_t \\ \Delta(e_t + p_t^* - p_t) \\ \Delta(m_t - p_t) \\ \Delta p_t \end{pmatrix} = \begin{pmatrix} A_{11}(L) & A_{12}(L) & A_{13}(L) & A_{14}(L) \\ A_{21}(L) & A_{22}(L) & A_{23}(L) & A_{24}(L) \\ A_{31}(L) & A_{32}(L) & A_{33}(L) & A_{34}(L) \\ A_{41}(L) & A_{42}(L) & A_{43}(L) & A_{44}(L) \end{pmatrix} \begin{pmatrix} u_t^s \\ u_t^e \\ u_t^m \\ u_t^d \end{pmatrix}$$

$A(L)$ is a coefficient matrix representing the impulse response of output, the real effective exchange rate, real money balance, and inflation to various shocks. L is a lag operator.

Following Blabchard and Quah (1989), the following identifying restrictions are imposed to fully identify the model.

(1) The demand shock, monetary shock and exchange rate shock do not affect output in the long-run.

$$\sum_{i=0}^{\infty} A_{12i}(L) = 0\,;\ \sum_{i=0}^{\infty} A_{13i}(L) = 0\,;\ \text{and}\ \sum_{i=0}^{\infty} A_{14i}(L) = 0$$

(2) The real effective exchange rate is not affected by the monetary shock or demand shock in the long-run.

$$\sum_{i=0}^{\infty} A_{23i}(L) = 0\,,\ \text{and}\ \sum_{i=0}^{\infty} A_{24i}(L) = 0$$

(3) Real money balance is not affected by the demand shock in the long-run.

$$\sum_{i=0}^{\infty} A_{34i}(L) = 0$$

Therefore, Equation (2) becomes

$$(2') \qquad \begin{pmatrix} \Delta y_t \\ \Delta(e_t + p_t^* - p_t) \\ \Delta(m_t - p_t) \\ \Delta p_t \end{pmatrix} = \begin{pmatrix} A_{11}(L) & 0 & 0 & 0 \\ A_{21}(L) & A_{22}(L) & 0 & 0 \\ A_{31}(L) & A_{32}(L) & A_{33}(L) & 0 \\ A_{41}(L) & A_{42}(L) & A_{43}(L) & A_{44}(L) \end{pmatrix} \begin{pmatrix} u_t^s \\ u_t^e \\ u_t^m \\ u_t^d \end{pmatrix}$$

This model is estimated using the procedure proposed by Blanchard and Quah (1989). A reduced-form vector autoregression (VAR) for Δx is estimated to obtain

$$(3) \qquad \Delta x_t = v_t + B_1 v_{t-1} + B_2 v_{t-2} + \cdots$$

$$= B(L) v_t$$

where v_t are residuals of the reduced-form VAR equation; $B(L)$ is a coefficient matrix and $B(0) = 1$. To get equation (2'), residuals v_t must be transformed into shocks, u_t. The relationship between the unobserved shocks of the SVAR model and the residual of the reduced-form VAR model can be derived from equation (1) and (3), $v_t = A_0 u_t$, where $A_0 = B(L)^{-1} A(L)$. Then the unobserved disturbance is obtained as $u_t = A_0^{-1} v_t$.

Following Bayoumi and Eichengreen (1994), the correlation coefficients between shocks across economies are calculated. If the shocks are correlated across the economies, they are viewed as symmetric. If they are not correlated, the shocks are viewed as asymmetric.

1.5 Data

We use annual data for the four Northeast Asian economies during the period from 1970 to 2004 in this paper.[4] Data on China, Japan, Korea, the U.S. and countries of the Euro area[5] are obtained from different databases. Real GDP, CPI,[6] and M2 are taken from the Development Indicator of the World Bank. The exchange rate data are from the International Financial Statistics (IFS) of the International Monetary Fund (IMF). Trade data are collected from Direction of Trade Statistics of IMF. Data of Taiwan are obtained from various websites of local statistical authorities.[7] Variables of the Euro area before 1999 are estimated as the weighted average of all 12 countries. The weight is the average share of their GDP for the period from 1970-2004.

We calculate the real effective exchange in the following way. First, the nominal exchange rates of each country are transformed into real exchange rates using the CPI of both countries. The real effective exchange rate is the geometric average of the real exchange rate of domestic currency against the U.S. dollar, the Japanese yen and the euro. The weight is the average shares of trade for the period of 1990-2003.[8] The shares of each currency for the four economies are listed in Table 1.3. Table 1.3 shows that the U.S. dollar has the highest weight for Japan (70%), Korea (43%) and Taiwan (42%). The Japanese yen has the highest weight for China (40%). Figure 1.2 shows the real effective exchange rate (year 2000=100). In the long-run, the real effective exchange rates of China, Korea, and Taiwan tend to increase, while the real effective exchange rates of Japan are shown to have decreased.

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[4] Data of China covers the period from 1977 to 2004.
[5] The Euro area countries include Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, and Spain.
[6] For China and Germany, there are no data for CPI. GDP deflator is used instead.
[7] GDP, CPI, and the exchange rate are downloaded from http://eng.stat.gov.tw; data of money aggregates from http://www.cbc.gov.tw; and data of international trade from http://cus93.trade.gov.tw.
[8] For Korea, it is the average shares of trade for two periods, 1990-1993 and 1997-2003, because of missing data for 1994-1996.

Before estimating the model, unit root tests[9] are conducted to check whether or not the variables are of unit-root processes or non-stationary. All of the series are shown to be non-stationary in levels except the CPI of Japan, which is stationary. The logarithms of most series are non-stationary except for the logarithms of real GDP for Japan and Taiwan, and those of the CPI for Korea and Taiwan. Then, all data are transformed into the log-difference form to de-trend. The log differences of real GDP, the real effective exchange rate, and real money balance are stationary at the 5% level. The log differences of CPI for China, Japan, and Taiwan are stationary at the 10% level. The log differences of the CPI for Korea are not stationary.

Table 1.4 reports the mean and standard deviation of changes of the variables. Economic growth, real effective exchange rate changes, real money balance growth, and inflation are expressed as the changes in the logarithms of real GDP, real effective exchange rate, real money balance and CPI. The mean of real GDP growth shows that China enjoys the highest economic growth among the four economies, and the growth rate of Japan is the lowest. The standard deviation suggests that China and Japan have more stable growth than Korea and Taiwan. The real effective exchange rate of China has increased the fastest, which means that the Chinese yuan has depreciated faster than the other currencies during the sample period. The average rate of changes in Japan's real effective exchange rate is negative. This implies that the Japanese yen appreciated during the sample period, which is different from the other three currencies. The standard deviation indicates that the currency value of the Japanese yen and the new Taiwan dollar is more stable than that of the Chinese yuan and the Korean won. The average real money growth rate is the highest in China and the lowest in Japan. Taiwan exhibits more volatile real money supply than China,

[9] Augmented Dickey-Fuller tests are used.

Japan, and Korea. The average rate of inflation of Korea is much higher than those of the other three economies. The standard deviation shows that the price level of Taiwan is less stable than that of China, Japan and Korea.

Table 1.5a-1.5d reports the correlation coefficients of real GDP growth, changes in the real effective exchange rate, real money balance growth, and inflation rates among the four Northeast Asian economies. Japan, Korea and Taiwan display high correlations in growth rates. The real growth rate of China is relatively separated from this group. It is only correlated with that of Taiwan. The real effective exchange rates of the four economies are relatively idiosyncratic. Only China and Taiwan are correlated. For real money balance, Japan, Korea and Taiwan are highly correlated with each other, while China seems to be independent of them. Japan, Korea and Taiwan also exhibit high correlation coefficients in inflation rates. This preliminary result indicates that Japan, Korea and Taiwan have a potential to form an optimal currency area. Whether or not they are ready for a currency union depends on the nature and degree of symmetry between the same-category shocks across countries.

1.6 Empirical Results

1.6.1 Currency union

Importance of Shocks

First, the structure of various shocks is examined. The ultimate purpose of forming a currency union is to stabilize economic growth in the common currency area. The shocks that can explain the most variances of real GDP growth are considered to be more important than other shocks. If shocks affecting real GDP growth are the same for all the economies, the adoption of a uniform policy can stabilize the economic growth of all the economies. If shocks affecting real GDP

growth are different, a uniform policy may not stabilize economic growth of all the economies in the region. We apply variance decomposition analysis to check the similarity of the shocks that can significantly affect real GDP growth for the four Northeast Asian economies. The results are listed in Table 1.6.

Supply shocks are shown to explain most of forecast error variances of real GDP growth of China (80%). For China, supply shocks are the most important in stabilizing fluctuations in real GDP growth. Both exports and imports of China grow fast. The finding that supply shocks are important for China is consistent with the fact that China has become a manufacturing center and a successful export-oriented economy. Exports are important for real GDP growth.

For Japan, demand shocks are the most important in the short-run, which can explain 56% of the forecast error variance of real GDP growth. In the long-run, both supply and demand shocks are important. They can explain more than 70% of forecast error variances. In the short-run, demand shocks are the main disturbances that affect growth. High-tech products account for a larger part of exports in Japan. Supply shocks are shown to affect growth in the long-run.

In the short-run, monetary shocks can explain more than 50% of forecast error variances for Korea. In the long-run, both monetary shocks and demand shocks are most important in Korea. Each of the two shocks can explain more than 30% of the forecast error variance of real GDP growth.

For Taiwan, both demand and supply shocks are important in the short-run. In the long-run, however, supply shocks are the most important, which can explain more than 50% of the forecast error variance. This reflects Taiwan as one of the fast-growing economies with the solid industrial base in the region.

Variance decomposition analysis shows that the types of shocks that affect real GDP growth are very different among the four economies. A uniform monetary policy may not be able to stabilize fluctuations in real GDP growth for all the Northeast Asian economies.

Adjustment Processes to Shocks

We use impulse response analysis is used to investigate the adjustment processes of the macroeconomic variables in response to different shocks in each of the four Northeast Asian economies. If the responses to shocks are similar across economies, then the adjustment process of these economies to different types of shocks are similar. Then a uniform policy may be introduced to all the economies. Figure 1.3a-1.3d show the results of impulse response function analysis.

It is found that positive supply shocks improve real GDP growth in the short-run, but the effect dissipates over time. Supply shocks increase China's real GDP growth more than those of the other three economies because supply shocks turn out to be the most important shocks for economic growth. Supply shocks have similar effects on the real GDP growth of Japan, Korea and Taiwan. The effects of demand shocks and exchange rate shocks on real GDP growth of China are also different from those on the real GDP growth of Japan, Korea and Taiwan. The responses to real GDP growth to monetary shocks are similar across the four economies. The adjustment processes of real GDP growth to different types of shocks are similar among Japan, Korea and Taiwan. The adjustment processes of China are different.

The responses of the real effective exchange rate of Korea and Taiwan to supply shocks are similar. The reactions of China or Japan are different. There some similarities in responses of the real effective exchange rate to the exchange rate shock, the monetary shock and the demand shock among China, Japan and Taiwan. The

responses of the real effective exchange rate of Korea are different. It turns out that the adjustment processes of the real effective exchange rate to various shocks are different among the four economies.

The responses of real money balance to supply shock are similar among the four economies. There are some similarities in the reactions of real money balance to exchange rate shocks of Japan and Taiwan. The responses of China or Korea are different. The responses of real money balance to monetary shocks and demand shocks are similar among Japan, Korea and Taiwan. The adjustment processes of real money balance to different shocks are not similar among the Northeast Asian economies.

The responses of inflation to the supply shock are similar for the China-Korea pair and the Japan-Taiwan pair. There are some similarities in responses of inflation of the four Northeast Asian economies to the exchange rate shock and the demand shock. The reactions of inflation to the monetary shock are similar among Japan, Korea and Taiwan. China is different from the other three economies. It is found that there are some similarities among Japan, Korea and Taiwan. Overall, the adjustment processes of inflation to various shocks are not similar among the four economies.

Impulse response analysis shows that the response of real GDP growth, changes in the real effective exchange rate, real money balance, and inflation to various shocks turns out to be quite different across the four Northeast Asian economies although there have some similarities. The adjustment processes to various shocks are not similar for the four Northeast Asian economies, which indicates that the economic structure and the adjustment processes to different types of macroeconomic shocks lack similarities among the Northeast Asian economies.

Correlation of Shocks

To investigate whether or not China, Japan, Korea and Taiwan can form a currency union like the Euro area, we estimate various shocks using the SVAR model. We choose one lag for all of the four economies, since the Akaike information criterion (AIC) and the Schwarz criterion (SC) indicate that one lag is optimal for all the economies except China.

To examine the degree of symmetry of shocks, we estimated the correlation coefficients of each individual shock among the Northeast Asian economies. If the correlation coefficients are significant and positive, the shocks are considered to be symmetric between the two economies. If the correlation coefficient is negative or insignificant, the shock is viewed as asymmetric. Tables 1.7a-1.7d report the correlation coefficients of supply shocks, exchange rate shocks, monetary shocks, and demand shocks, respectively.

Table 1.7a reports the correlation coefficients of supply shocks among the four economies. The supply shocks are positively and significantly correlated between Korea and Taiwan. The correlation coefficient between Japan and Taiwan is also positive and statistically significant. The correlation coefficient between China and Japan is significant but negative. There is no other significant correlation. Supply shocks are not symmetric among the four economies. Since a supply shock is invariant to monetary and fiscal policies, it is considered to be more informative than other shocks (Bayoumi and Eichengreen 1994). Supply shocks of the euro area are highly correlated (Huang and Guo, 2006). Although the correlation coefficient between Japan and Korea is not significant, it is positive and the coefficient is close to that of the Japan-Korean pair and the Korea-Taiwan pair. We see an evidence that Japan, Korea, and Taiwan have the potential to for a currency union in the long-run. China is negatively correlated with Japan and Korea, and is not correlated with

Taiwan. China seems to be an outlier from the group in the correlation of supply shocks.

Table 1.7b reports the correlation coefficients of exchange rate shocks between different pairs of the Northeast Asian economies. Only the correlation coefficient between China and Taiwan is significant and positive. There is no significant correlation coefficient among Japan, Korea and China, or among Japan, Korea and Taiwan. Exchange rate shocks are not symmetric among these economies. This may be caused by differences in the exchange rate regime. The Chinese yuan had been pegged to the U.S. dollar since 1994[10] until July 2005 when the fixed exchange rate system was changed to a managed floating exchange rate system; Japan has adopted a free floating exchange rate regime; Korea switched from managed floating to a free floating regime in December 1997; and Taiwan changed its exchange rate system to a floating rate system in 1989.

Table 1.7c displays the cross correlation coefficients of monetary shocks. The results do not indicate any significant and positive correlations among these economies. Monetary shocks are not symmetric among China, Japan, Korea and Taiwan. Although these economies become more integrated, none of them has the leading role in the Northeast Asian capital market.

Table 1.7d shows the correlation coefficients of demand shocks. Japan and Taiwan display a positive and significant correlation coefficient. The correlation between China and Japan is also significant, but it is negative. There are no other significant correlations among these economies. Demand shocks include the effects of fiscal and monetary policies, and they are less reliable then supply shocks (Bayoumi and Eichengreen 1994).

[10] China switched to a currency basket in July 2005.

So supply shocks are symmetric between Japan and Taiwan, and between Korea and Taiwan. Exchange rate shocks are symmetric between China and Taiwan. Monetary shocks are not symmetric among the four economies. Demand shocks are symmetric only between Japan and Taiwan. The results suggest that there is no combination of the four economies that have all four shocks symmetric among them.

Variance decomposition analysis indicates that shocks that impact the fluctuations in real GDP growth are somewhat different for the four Northeast Asian economies. The adoption of a uniform monetary policy is not expected to stabilize economic growth for all the Northeast Asian economies. Impulse response analysis suggests that the adjustment processes to different shocks are not similar for the four economies. Economic structures, especially shocks adjustment mechanisms, are different for all four economies. The correlation analysis of various shocks suggests that the four economies are not ready to form a currency union, because there is not a group of economies within which all underlying shocks are symmetric.

The economic structures of these economies are still different. Although China developed rapidly after the 1990s, China is not as developed as Japan, and Korea. As an emerging market, China's market is still subject to some intervention by the government. China's currency value is also under the control of its central bank. The Chinese yuan was pegged to the U.S. dollar until July 2005. Now the Chinese yuan is pegged to a currency basket containing the U.S. dollar, the Japanese yen, the euro, the Korean won and other currencies. Japan, Korea and Taiwan adopt a flexible exchange rate regime. These facts seem to be some of the main reasons why China and the other three economies are subject to asymmetric shocks. Another reason is Taiwan. China, Japan and Korea become more integrated through economic cooperation organizations like CMI, NEAEF and free trade agreements with the ASEAN countries.

Taiwan is not a member of any of these organizations. It is trade and FDI that link Taiwan with the other three economies. This limits the cooperation among these four economies. Statistical analysis and the condition of these economies imply that even if China, Japan, Korea and Taiwan become more integrated (Zhang and Sato, 2005; Cheung and Yuen, 2004), it seems that the Northeast Asian economies are not ready yet to form a currency union.

The purpose of monetary cooperation is to reduce exchange rate fluctuations within the area and with the rest of the world (Eichengreen, 2006). Although it is still not the right time for Northeast Asia to adopt a common currency, there is another option for monetary cooperation among these economies, which is an exchange rate union. Under the exchange rate union, all currencies will be pegged to the same currency or a common currency basket (currency index). An example of an exchange rate union is the European Currency Unit (ECU). By forming an exchange rate union, the currency value is kept relatively stable within this area. They can keep their own currency although they still sacrifice some independence in monetary policy. An exchange rate union can reduce fluctuations in the currency value, trade volume and real GDP growth, although it is not as effective as a currency union because the supply of money is still determined by the central bank of each individual economy. When the currency index is generally accepted and used in accounting, transactions, and financial instruments, it can be developed into a single currency. An exchange rate union can be viewed as a preliminary stage of a currency union.

Sub-sample Analysis

The financial crisis of 1997 had a substantial impact on the East Asian economies. To examine whether the financial crisis affect the result of this study, the structural VAR model is applied to the period before 1997. The result is shown in Table 1.13a-d.

Before the crisis, supply shocks of Japan and Taiwan are positively and significantly correlated. The coefficient is higher than that of the whole sample. For the whole sample, supply shocks of Korea and Taiwan are also correlated. The correlation coefficient between China and Taiwan is smaller than that of the whole sample. So after the crisis, Taiwan became more correlated with China and Korea. This is because Taiwan increased trade with China and Korea. The increase in the coefficient between Japan and Korea and that between Korea and Taiwan indicates that Korea became more correlated with Japan and Taiwan after the crisis.

There is no significant correlation of exchange rate shocks before the crisis. For the whole sample, exchange rate shocks of China and Taiwan are correlated. This change is also because of the increase in trade between China and Taiwan after the crisis. The share of China in the trade of Taiwan increases from 2% in 1997 to 12% in 2003.

There is no positive and significant correlation of monetary shocks. This result is similar to that of the whole sample. The coefficients of the whole sample for China, Japan, and Korea are larger than those of the sub-sample. The improvement of financial cooperation among the three countries after the crisis may be one reason for this change.

For demand shocks, only Korea and Taiwan are positively and significantly correlated. For the whole sample study, Japan and Taiwan are correlated. After the crisis, demand shocks of Taiwan are more correlated with those of Japan and less correlated with Korea.

The comparison of the whole sample and the sub-sample shows that after the crisis the improvement in trade and financial cooperation increase the correlation among the Northeast Asian economies in some aspects.

1.6.2 Exchange rate union

For an exchange rate union, there are several options for the choice of an anchor currency – a single currency or a currency basket, or internal currencies, or external currencies. If a currency or a currency basket is found for these economies, they can form an exchange rate union by jointly pegging to this currency anchor. To investigate whether the currencies of China, Japan, Korea and Taiwan can be pegged to the same currency or a common currency basket, we use the SVAR model:

$$\Delta x_t = C(L)\varepsilon_t$$

where $\Delta x_t = \{ \Delta y_t^*, \Delta m_t^*, \Delta p_t^*, \Delta y_t, \Delta m_t, \Delta p_t \}$. Δy_t^* is the log difference of foreign output; Δm_t^* is the log difference of the foreign real money balance; Δp_t^* is the log difference of the foreign price level; Δy_t is the log difference of the domestic real GDP; Δm_t is log difference of the domestic real money balance; Δp_t is the log difference of the domestic price level. $C(L)$ is a 6×6 coefficient matrix. ε_t is a vector containing unobserved shocks and $\varepsilon_t = \{ \varepsilon_t^{y*}, \varepsilon_t^{m*}, \varepsilon_t^{p*}, \varepsilon_t^{y}, \varepsilon_t^{m}, \varepsilon_t^{p} \}$. ε_t^{y*} is a supply shock from foreign countries; ε_t^{m*} represents a foreign monetary shock; ε_t^{p*} is a foreign demand shock; ε_t^{y}, ε_t^{m}, and ε_t^{p} represent a domestic supply shock, a monetary shock and a demand shock, respectively.

It is assumed that domestic shocks do not affect foreign variables, since these economies are small compared with the global and regional economies. It is also assumed that the demand shock and monetary shock do not affect output in the long-run, and that the demand shock does not affect real money balance in the long-run. Then the coefficient matrix can be expressed as

$$C(L)=\begin{bmatrix} C(l)_{11} & 0 & 0 & 0 & 0 & 0 \\ C(l)_{21} & C(l)_{22} & 0 & 0 & 0 & 0 \\ C(l)_{31} & C(l)_{32} & C(l)_{33} & 0 & 0 & 0 \\ C(l)_{41} & C(l)_{42} & C(l)_{43} & C(l)_{44} & 0 & 0 \\ C(l)_{51} & C(l)_{52} & C(l)_{53} & C(l)_{54} & C(l)_{55} & 0 \\ C(l)_{61} & C(l)_{62} & C(l)_{63} & C(l)_{64} & C(l)_{65} & C(l)_{66} \end{bmatrix}$$

Following Chow and Kim (2003) and Kim and Sun (2005), we use forecast error variance decomposition to measure the degree of symmetry of shocks between each economy and its anchor currency. If shocks from foreign countries can explain more forecast error variance in real GDP growth, then the domestic currency should be pegged to the anchor currency or a common currency basket. If domestic shocks are dominant, then its currency should not be pegged to the anchor currency or a common currency basket.

Single Currency Peg

First, we investigate the possibility of pegging to a single currency. Since the Northeast Asian economies mainly trade with the U.S. and Japan, the U.S. dollar and the Japanese yen are chosen as possible anchor currencies. The results of variance decomposition are presented in Table 1.8 and 1.9.

Table 1.8 shows the results of variance decomposition when the U.S. dollar is the anchor currency. For China, the U.S. supply shock, monetary shock and demand shock can explain more than 50% of forecast error variances of real GDP growth in both short-run and long-run. The forecast error variances of Japan and Korea are mainly explained by domestic specific shocks. For Taiwan, forecast error variances of real GDP growth are mainly explained by shocks from the U.S. instead of domestic shocks. The higher explanatory power of foreign shocks implies a higher probability of pegging the domestic currency to the foreign currency. Variance decomposition

analysis indicates that the Chinese yuan and the new Taiwan dollar can be pegged to the U.S. dollar, while the Japanese yen and Korean won may not be pegged to the U.S. dollar. Thus the U.S. dollar turns out not to be a currency anchor for the exchange rate union.

Table 1.9 reports the results of variance decomposition when the Japanese yen is chosen as the anchor. Shocks from Japan can explain most of forecast error variances of China and Taiwan. The forecast error variance is mainly explained by domestic specific shocks. So the Chinese yuan and the new Taiwan dollar can be pegged to the Japanese yen, while the Korean won should not be pegged.

China and Taiwan can peg their currenies to both major currencies. But Korea and Japan cannot peg to either of the currencies. It turns out that none of the two major currencies can be chosen as a currency anchor for the potential exchange rate union including all four economies. A single currency peg does not seem to be a feasible choice for these economies.

On the other hand, pegging to a single currency may be risky. The experience of the crisis of 1997 shows that the fluctuations in the yen-dollar rate causes instability in the trade balance of Japan's competitors that peg their currencies to the U.S. dollar. The Chinese yuan was pegged to the U.S. dollar and switched to a currency-basket peg in 2005. The reality indicates that a single currency peg is not a good choice for the four economies. Since neither the U.S. dollar nor the Japanese yen turns out to be an option for an anchor currency for the Northeast Asian economies, we examine whether a currency basket needs is a reasonable option for an anchor currency or not.

Regional Currency Basket

The ADB plans introduce the ACU in 2006. Like the European Currency Unit (ECU), the ACU is also a basket of regional currencies, and it provides a benchmark

for participating countries to stabilize their currency values. The ECU was first adopted as a unit of account, while the ACU will be used as an indicator of the stability of the regional currencies. Unlike the ECU, it is not likely that the ACU will be used in transactions in the near future. However, the introduction of the ACU helps to stabilize the exchange rate and promote intra-regional trade and investment. Based on the idea of the ECU and the ACU, a currency basket containing all four regional currencies, the Chinese yuan, the Japanese yen, the Korean won, and the new Taiwan dollar, can be considered as an anchor currency.

We use a simple VAR model for China, Korea and Taiwan. For Japan, the Vector Error Correction (VEC) model is used because all of the series are I(1) and there are cointegration relationships among the series. The sample period is from 1977 to 2005. The variables of the currency basket are constructed by the geometric averages of the variables of all four economies. The weight is the relative size of the economy, which is the share of real GDP[11]. If the share of real GDP of the economy is high, the economy is important in this area and it can affect the other economies. So it deserves a higher weight in the currency basket.

The results of variance decomposition are reported in Table 1.10. The forecast error variance of China is mainly explained by the domestic shock in the short-run. In the long run, regional shocks explain most of the forecast error variance. For Japan, the forecast error variance is mainly explained by regional shocks. Regional shocks also explain most of the forecast error variance of Korea. The forecast error variance of Taiwan is mainly explained by domestic shocks. But the percentage explained by domestic shocks (56%) and that explained by regional shocks (44%) are very close,

[11] The share of each currency is as follows: the Chinese yen 11.2%, the Japanese yen 79.2%, the Korean won 6.1%, and the new Taiwan dollar 3.5%.

and the percentage explained by regional shocks is increasing over time. So in the long-run, the new Taiwan dollar can be pegged to the regional currency basket.

Variance decomposition analysis shows that the currencies of all four economies can be pegged to the regional currency basket in the long-run. So the regional currency basket can be used as the anchor for the exchange rate union in the region.

For the common currency basket to be effective, a system like the European Exchange Rate Mechanism (ERM) should be established. It is unlikely that such a system can be established in the near future. So the economies are not forced to respond when their currency value deviates from the benchmark, which means that in practice, it is not feasible to adopt a regional currency basket before a system like the ERM is established.

Major External Currency Basket

The U.S. dollar is still the most-used invoicing currency in international trade in East Asia. At the same time, the Northeast Asian economies trade a lot with the U.S., Japan and the euro Area. The fluctuation of exchange rates against these currencies can significantly affect their exports and imports. A major currency basket containing the U.S. dollar, the Japanese yen, and the euro can also serve as an anchor currency.

The variables of the currency basket are calculated as the geometric average of the variables from the three economies. The weight is the share of trade with all four economies for two periods, 1990-1993 and 1997-2003[12].

The SVAR model[13] is used for China, Korea, and Taiwan. For Japan, a simple VAR model is used since the assumption that domestic variables do not affect foreign variables does not hold for Japan.

[12] Data for 1994-1996 are dropped because of missing data. The share of the U.S. is 52.2%; the share of the Japanese yen is 21.4%; and the share of the Euro is 26.4%.
[13] Only supply shocks and demand shocks are examined, because the data of M2 for European countries are not available.

The results are reported in Table 1.11. For all four economies, the forecast error variance is mainly explained by domestic shocks in the short-run. The shares explained by domestic shocks and that are explained by foreign shocks are quite similar. The shares explained by foreign shocks increase over time. In the long-run, forecast error variances of Japan and Taiwan are mainly explained by foreign shocks, while those of China and Korea are mainly explained by domestic shocks. But the share of domestic shocks and that of foreign shocks are nearly half and half.

The variance decomposition indicates that the four economies will not be worse off if they peg to the currency basket containing major external currencies. Pegging to this currency basket helps to stabilize the currency value within the exchange rate union, and exchange rates against currencies of the major trading partners. So the currency basket of the major external currencies is expected to promote both intra-regional trade and trade with countries outside this area.

Compared with the local currency basket, the major currency basket has the advantage that it can reduce fluctuations of both exchange rates among the four currencies and the exchange rates of the four currencies against major trading partners. The central banks of the four economies should hold additional foreign reserves in the currencies of the currency basket, no matter which currency basket they choose (Eichengreen, 2006). If they peg to a regional currency basket, they have to hold foreign reserves in the other three currencies. Neither of them is the major currency in foreign reserves, especially the Chinese yuan, the Korean won, and the new Taiwan dollar. Before adopting the local currency basket, they have to enhance the convertibility and respectability of their currencies. For the present, the major currency basket seems to be a more suitable option for this exchange rate union among the Northeast Asian economies. In the long-run, with the increases in intra-

regional trade and a more integrated economy, a regional currency basket should become a better choice.

1.6.3 Comparison with other studies

Japan, Korea and Taiwan have a long-run potential to form a currency union. This result is similar to that of Bayoumi and Eichengreen (1994). In this study the correlation coefficient of supply shocks between Japan and Taiwan is 0.33, that between Korea and Taiwan is 0.41, and that between Japan and Korea is 0.20 which is not very significant. Bayoumi and Eichengreen (1994) find that in Europe, Austria, Belgium, Denmark, Germany, the Netherlands, and Switzerland can form a currency union (Table 1.12). The minimum correlation coefficient is 0.37 (Belgium and Denmark) and the maximum is 0.68 (Denmark and Germany). The coefficients are higher than those of the Northeast Asian economies. They also find that in Southeast Asia Hong Kong, Indonesia, Malaysia, and Singapore can form a currency union. The coefficients range from 0.46 (Japan and Korea) to 0.71 (Malaysia and Singapore), which are also much higher than those of the Northeast Asian economies. For the demand shock, Japan, Korea and Taiwan are not correlated with each other. We find that Japan and Taiwan are correlated only in demand shock and supply shock.

Kwack (2004) finds that demand shocks of Japan, Korea, and Taiwan and supply shocks of Korea and Japan are correlated. His result is different from that of this study. In this study, demand shocks of Japan and Taiwan, and supply shocks of Japan and Taiwan, and Korea and Taiwan are correlated. For some ASEAN countries, namely Indonesia, Malaysia, and Thailand are correlated with both supply shocks and demand shocks. Kwack (2004) examine only supply shocks and demand shocks.

Zhang, Sato, and McAleer (2004) take into account demand, supply and monetary shocks. They calculate the correlation of supply shocks and demand shocks for the East Asia and the European economies. The correlation coefficients of supply shocks range from 0.24 (Switzerland and Portugal) to 0.5 (Belgium and France). Although the correlation coefficients of supply shocks for Europe are larger than those of Northeast Asia, supply shocks are not correlated for all the countries of the euro area. For East Asia, the correlation coefficients are about 0.3, similar to those of Northeast Asia. They find that Japan, the leading economy, is not significantly correlated with other East Asian economies in the demand shock. For Europe, neither demand shocks nor monetary shocks are correlated among all the economies. For both regions, monetary shocks are less symmetric than demand shocks. We find that there are no significant correlations in monetary shocks, and only Japan and Taiwan are correlated in demand shocks. The results are similar.

Huang and Guo (2006) consider global supply shocks, domestic supply shocks, demand shocks and monetary shocks. They find that supply shocks of 9 countries in Europe are highly correlated, except those of Finland and Portugal, and those of Italy and Portugal. Supply shocks of East Asia are correlated among Hong Kong, Korea, Indonesia, Malaysia, Singapore, and Thailand. Supply shocks are more symmetric in the euro area. The correlation coefficients of both regions are higher than those of this study. They find that demand shocks of the ASEAN countries are highly correlated, Korea is correlated with the ASEAN countries, and China and Japan are not correlated with other countries. Only 5 European countries are correlated in demand shocks. For the monetary shock, they find that the ASEAN countries are correlated with each other, Japan is correlated with the ASEAN countries and Korea, and not all

European countries are correlated. We did not find any significant correlations in the monetary shock among the Northeast Asian economies.

The comparison of literature shows that supply shocks in the euro zone are more symmetric than those in Northeast Asia. It is also found that the shocks are not symmetric for all the countries in the euro area. Figure 1.4 indicates that real GDP growth, changes in the real effective exchange rate, growth of real money balance, and inflation of the four economies tend to converge over time. When the Northeast Asian economies become more symmetric, it is still possible to form a currency union.

1. 7 Conclusion

Although several studies have found that certain combinations of the East Asian countries are eligible for common currency area, these combinations contain both the Northeast Asian economies and the ASEAN countries. It is unlikely that these countries will form a common currency area and adopt uniform monetary policies because of divergence in the political environment, economic standards and cultural background. China, Japan, Korea, and Taiwan are the major economies of Northeast Asia. They have significantly increased economic and financial linkages among them in recent years with relatively similar cultural background, certain ongoing political agenda notwithstanding. It seems to be more feasible for these economies to form a currency union than all other Southeastern Asian countries.

We apply SVAR model with proper identification assumptions to investigate the possibility of a currency union among the Northeast Asian economies. Variance decomposition indicates that the fluctuations of real GDP growth of the four economies are affected by different shocks. Impulse response analysis suggests that the adjustment processes to various shocks are different across economies. The

analysis of the correlation of supply, exchange rate, monetary, and demand shocks shows that shocks of these economies are not symmetric. These imply that Northeast Asia is not ready to form a common currency union. Japan, Taiwan and Korea have the potential to form a currency union in the long-run. China is still separated from this group because its economic structure and the shock adjustment mechanism turn out to be quite different from those in the other three economies.

Although Northeast Asia is not a common currency area, China, Japan, Korea, and Taiwan can form an exchange rate union, where each economy still has its own currency and all of the currencies are pegged to the same anchor currency or currency basket. Variance decomposition analysis suggests that both the regional currency basket containing all four currencies and the major currency basket can be adopted as the anchor for the exchange rate union. The major currency basket should be a better choice for the short-run because it can stabilize both exchange rates within the area and exchange rates with trading partners. It is also because regional currencies are not attractive enough to be foreign reserve currencies. But with an increase in intra-regional trade, a regional currency basket will be more suitable in the long-run.

An exchange rate union is only an intermediate stage. As the Northeast Asian economies become more integrated, the regional currency basket can serve as a currency unit for the area, similar to the ECU. The Northeast Asian economies have taken efforts to achieve this goal. The possibility of establishing NEADB and the Northeast Asia Free Trade area are currently discussed. They improve cooperation in both economic and social aspects through NEAEF and agreements with the ASEAN. When the area has a fully integrated goods market, financial market, labor market, and more similar economic structure, the regional currency unit can develop into a single common currency. In that stage, the four Northeast Asian economies will give

up their independent monetary policies and a central bank for the area would be established. The Northeast Asian Economies need to enhance the macroeconomic convergence and increase financial and monetary cooperation before they reach the stage of introducing a currency union in the region.

CHAPTER 2: BALANCE SHEETS AND EXCHANGE RATE REGIMES: ESTIMATING THE INTERRELATIONSHIPS

2.1 Introduction

Over the past decades foreign currency liabilities and currency mismatches on domestic agents' balance sheets have become a defining characteristic of the emerging markets of Latin America, Eastern Europe, and Asia. At the same time, more countries that claim to have a flexible exchange rate are instead floating with a lifejacket, that is, they use their international reserves and interest rates to manage their exchange rates. Several papers have documented the high variability of the international reserves and interest rates relative to that of the exchange rate, also called fear of floating (e.g. Calvo and Reinhart, 2002, Hausmann et al., 2001, and more recently Levy-Yeyati and Sturzenegger, 2005). These studies suggest that liability dollarization (debt denominated in foreign currencies) and currency mismatches are possible causes of fear of floating. When domestic agents have foreign currency-denominated debt, but their returns are in domestic currency, a depreciation of the domestic currency will adversely affect their balance sheets by increasing the relative value of debt to assets. This rise in debt to assets could further trigger defaults and financial instability. The central bank might want to limit fluctuations of the exchange rate to reduce the adverse effects on partially dollarized balance sheets.

Many theoretical studies incorporate liability dollarization and currency mismatches in the study of the choice and the effects of monetary and exchange rate policy. Moron and Winkelried (2005) examine alternative monetary policy rules for economies with different degrees of international liability dollarization, and find the defense of real exchange rate optimal in a highly dollarized economy. Similarly, Cook

(2004) shows that fixed exchange rate regimes offer more stability to an economy with high international liability dollarization. Fernadez-Arias and Talvi (1999) present a model where the government chooses the mode of adjustment to external shocks in order to minimize the adverse impact of a deflationary shock on corporate balance sheets.

Other studies then examine the effectiveness and transmission channels of monetary policy in the presence of balance sheet effects (e.g., Aghion et al., 2004, and Cespedes at al., 2004).

All these studies assume *exogenous* mismatches and further study the choice and effectiveness of alternative monetary and exchange rate arrangements. But when agents make portfolio allocations, they form expectations about future exchange rates. If they expect exchange rates to be stable, they are more likely to borrow in foreign currencies without hedging their currency exposure.

Along this line, other papers argue that implicit or explicit guarantees provided by central banks create moral hazard: banks and firms take too much risk and hold unhedged positions (e.g., McKinnon and Pill, 1999, Burnside et al., 2001, Schneider and Tornell, 2004). A (credible) fixed exchange rate regime eliminates the need to hedge the exchange rate exposure; hence banks and firms end up with excessive foreign currency debt on their balance sheets. These effects can be further reinforced by incomplete markets, lack of hedging instruments, so that agents cannot hedge their exposure even if they would choose to hedge were they to have derivatives (Caballero and Krishnamurthy, 2003). These studies, however, take as *given* monetary and exchange rate policies.

Only a few recent theoretical papers combine the two strands in literature by exploring the interrelationships between balance sheets and monetary and exchange

rate policy. Chang and Velasco (2005) construct a model where the optimal choice of the exchange rate policy by a benevolent central bank depends on the existence and extent of currency mismatches, which are in turn determined by the optimizing decisions of domestic borrowers and their expectations about the exchange rate policy. They find that currency mismatches in assets and liabilities may not only give rise to fear of floating, but that they themselves may emerge because of the rational anticipation of that fear.

Along a similar line, Chamon and Hausmann (2005) focus on the decision by the central bank, which cares about preventing bankruptcy, of whether to let the exchange rate depreciate following a shock to the expected future exchange rate, and on optimal portfolio allocations driven by these changes in expectations. When the central bank has a strong preference for exchange rate stability (e.g., because of large currency mismatches), domestic agents will denominate their liabilities in dollars.

Ize (2005) examines balance sheets under endogenous policy choices and different institutional and market environments: risk aversion, imperfect information, and moral hazard. In Cowan and Do (2003), imperfect information (bad priors about the central bank) induces excessive dollarization, which in turn restricts the ability of central bank to conduct monetary policy. The conclusion of these four studies is the same: balance sheets effects and fear of floating co-exist and reinforce each other.

Despite extensive theoretical work on balance sheets and policy choices, the empirical work is scant. Empirical findings so far are best summarized by Ize and Levy-Yeyati (2005): “While there is a clear statistical cross-country link *between dollarization and fear of floating* (…), the direction of causality has not been tested and the specific dynamics through which these two variables interact not fully identified”. Hausmann et al. (2001) document a very strong and robust relationship

between the ability of a country to borrow internationally in its own currency and the way it manages its exchange rate system. The higher the ability to borrow abroad in its own currency and thus the lower the international liability dollarization (also called original sin), the higher the flexibility of the exchange rate regime. Reinhart et al. (2003) provide evidence that aggregate dollarization, measured by domestic plus external dollar liabilities of the private and public sectors is negatively correlated with the flexibility of the exchange rate regime. Honig (2005) finds negative effects from both domestic and external bank dollar liabilities to exchange rate flexibility, while Ganapolsky (2003) shows that banks' dollar debts which are not matched by dollar liabilities reduce the flexibility. While most papers acknowledge the possibility that balance sheet allocations are endogenous to policy choices, they ignore this problem.

Two studies that address the endogeneity of balance sheets are Levy-Yeyati et al. (2004) and Alesina and Wagner (2006). The first paper shows that bank liability dollarization is a good predictor of the "de facto" exchange rate regime, while instrumenting dollar liabilities by their own lagged values and a rule of law indicator. Alesina and Wagner (2006) also show that more foreign liabilities lead countries to prefer fixed over floating regimes, but their focus is on countries' incentive to misreport their exchange rate regimes. They examine the reverse effect from policy to portfolio choices (by instrumenting foreign liabilities by institution development measures) and find none.

Fewer empirical studies examine portfolio allocations for domestic agents *given* the exchange rate regime. Hausmann and Panizza (2003) find limited evidence that flexible exchange rate regimes reduce domestic dollar liabilities and no evidence of effects on external dollarization. According to Arteta (2003), bank domestic currency mismatches increase with exchange rate flexibility, as dollar deposits go up relative to dollar loans. However, Goldstein and Turner (2004) argue that exchange rate

flexibility reduces currency mismatches. Their argument is based on stylized facts for several countries and earlier work on firms' currency risk exposure under different exchange rate regimes (e.g., Martinez and Werner, 2002, and Cowan, 2003). Whether exchange rate flexibility affects portfolio choices remains an open question.

To summarize, only a few theoretical and no empirical studies explore the interrelationships between balance sheets and the degree of flexibility of the exchange rate regime. To our knowledge, our study is the first to examine carefully the dynamics through which these two variables interact and the direction of causality. We ask whether fear of floating generates currency mismatches on domestic agents' balance sheet, or whether currency mismatches lead to fear of floating, or whether effects go both ways. We use annual unbalanced panel data for up to 101 emerging and developing countries for the period 1975-2004 and standard measures of fear of floating (exchange rate flexibility), balance sheet mismatches, and liability dollarization.

Our methodology consists of two parts. We first show that the degree of flexibility of the exchange rate regime depends negatively on lagged bank currency mismatches, controlling for macroeconomic policies and institutions. We then show that currency mismatches and dollar liabilities depend negatively on lagged exchange rate flexibility, using the same controls. We use both simple pooled Ordinary Least Squares and system-Generalized-Method-of-Moments estimators. Having empirically established Granger causality, we next study the dynamic relationship between balance sheets and exchange rate regimes by estimating orthogonalized impulse-response functions using panel vector autoregression. Overall, we find statistical evidence that this lack of exchange rate flexibility reinforces mismatches and raises

the value of dollar liabilities, but not the reverse effect. We also find that the estimated economic effects are small.

The remainder of the paper is organized as follows. Section 2 describes data and the measures of balance sheets and exchange rate management used. Section 3 outlines the econometric models and the estimation methods. Section 4 presents the results, while Section 5 concludes.

2.2 Data

We use annual data for the period 1975-2004 for up to 101 emerging and developing countries, covering all types of exchange rate regimes (see Appendix A).[14] Most of our data come from the *International Financial Statistics* of the IMF and the *World Development Indicators* of the World Bank (see Appendix B for all data sources). The exchange rate is the bilateral rate to the German mark for the European countries, the French franc for several African countries, and the US dollar for all other countries (see Appendices A and B). We eliminate all offshore centers, countries with fewer than four years in the dataset, and remove outliers for several variables.

The time period for the Granger causality tests include periods of currency crises, such as the 1994-1995 crisis in Latin America, the 1997-1998 crisis in the East Asian, the 1998 crisis in Russia, and the 2001-2002 crisis in Argentina. Currency crises can affect the causal relationship between balance sheets and the exchange rate flexibility. During crisis periods the depreciation of the domestic currency can be very large. Under this condition, higher exchange rate flexibility results in larger currency

[14] The earlier papers exploring fear of floating (e.g., Calvo and Reinhart, 2002, and Hausman et al., 2001) include only countries that claim to be floaters but instead intervene heavily in the foreign exchange market. Our study is more general because it includes all countries for which data for our main indicators are available, irrespective of their "de jure" exchange rate regime.

mismatches and liability dollarization because the dollar liabilities are now larger in terms of domestic currency. Currency mismatches lead to more fixed exchange rate regimes only when the fixed exchange rate regime is sustainable. Currency value declines dramatically, if there is very high inflation during crisis episodes. The fixed exchange rate regime will collapse if the central bank fails to defend it. Large currency mismatches may increase the exchange rate flexibility if exchange rates are forced to float because of hyperinflation during currency crisis. Then currency mismatches might be positively associated with exchange rate flexibility during crisis periods. To eliminate the effects of currency crises on the relationship between balance sheets and exchange rate flexibility, we drop all the years in which there is a currency crisis. We use the measure of Reinhart and Rogoff (2004) to distinguish crisis periods and non-crisis periods. Reinhart and Rogoff (2004) introduce a new category of exchange rate regime, freely falling. An exchange rate regime is categorized as freely falling if the twelve-month inflation rate is 40% or higher. A year is viewed as crisis period if the exchange rate regime is classified as freely falling[15].

2.2.1 Exchange rate flexibility and balance sheet measures

As indicators of exchange rate regime flexibility, we use two standard measures in the literature. We first use an index of exchange rate flexibility, $FLEX1$, following the pioneering work of Calvo and Reinhart (2002), calculated as the ratio of the volatility of nominal exchange rate changes to the sum of volatility of the nominal interest rate and volatility of international reserve changes. A high value of this measure indicates large variance in the exchange rate relative to that in reserves and the interest rate, therefore a more flexible exchange rate regime. A value close to zero indicates little

[15] Data for freely falling regimes are extracted from the home page of C. Reinhart, http://www.wam.umd.edu/~creinhar/Links.html.

exchange rate volatility and/or heavy intervention in the foreign exchange market either through reserves or through the interest rate, and hence more fear of floating and exchange rate rigidity.

Following a more recent study by Levy-Yeyati and Sturzenegger (2005), we use another measure, $FLEX2$, defined as the ratio of volatility of exchange rate changes to volatility of net international reserve relative to monetary base changes. This latter measure improves upon $FLEX1$ by approximating as closely as possible changes in reserves that reflect foreign exchange intervention, and eliminating the interest rates, where changes have limited effect on exchange market conditions and much more often are unrelated to the management of the exchange rate (Levy-Yeyati and Sturzenegger, 2005).

Chang and Velasco (2005) argue that large currency mismatches rather than large dollar liabilities create fear of floating. However, as Levy-Yeyati et al. (2004) point out, holders of foreign assets and liabilities might not coincide, and a sudden depreciation is likely to hurt dollar debtors irrespective of the aggregate level of dollar assets. Hence, according to the latter study, empirical studies using aggregate data should consider (gross) dollar liabilities rather than (net) currency mismatches. We construct measures of both mismatches and liability dollarization. Moreover, we believe central banks are mostly concerned with the dollar liabilities and mismatches of *banks*, we only consider flows intermediated through local banks.

We construct four measures of liability dollarization and currency mismatches. $LIAB1$, defined as the ratio of bank foreign liabilities to money stock (similar to Levy-Yeyati et al., 2004, and Alesina and Wagner, 2006), captures the international

component of bank liability dollarization.[16] But many emerging markets have high levels of domestic dollar liabilities (see Arteta, 2003, and Honig, 2005), therefore our second measure, $LIAB2$, is defined as the ratio of bank foreign liabilities plus domestic dollar deposits to money stock (similar to Calvo et al., 2004).[17] $MISM1$ and $MISM2$ are rough measures of currency mismatches. The first is defined as the ratio of bank foreign liabilities to bank foreign assets; the latter is the ratio of bank foreign liabilities plus domestic dollar deposits to bank foreign assets.[18]

A simple correlation analysis shows that our measures of dollar liabilities and currency mismatches are positively correlated, and so are the two flexibility measures (see Table 2.1). Moreover, we confirm the negative relationship between balance sheets, in particular currency mismatches and external liabilities and the exchange rate flexibility[19], which is also shown in Figure 2.1 and Figure 2.2.

2.2.2 Data on other variables

Other potential determinants of exchange rate regimes, based on extensive prior work are inflation, fiscal deficit as a percent of GDP, real GDP growth, and trade openness (e.g., Canales-Kriljenko and Habermeier, 1999). Balance sheets, on the

[16] The "original sin" literature shows that very few emerging and developing countries manage to borrow in domestic currencies in international financial markets. Hence, foreign currency-denominated external liabilities can be approximated by total external liabilities.

[17] Calvo et al. (2004) calculate bank dollar liabilities relative to domestic GDP. For consistency purposes, we use the money stock instead of the GDP, but the two measures are highly correlated and the results are very similar.

[18] Our strategy is to use measures for which data are available for a large number of countries as opposed to more carefully constructed measures of mismatches but with limited data availability (e.g., Hausmann et al., 2001, and Goldstein and Turner, 2004). Therefore, our currency mismatch measures do not include some dollar bank assets, such as dollar-denominated government securities, which are quite significant in several Latin American countries (Reinhart et al., 2003). Neither do they include the off-balance sheet positions of banks. We on purpose choose not to include domestic dollar credit in our measure of bank dollar assets, as a large share of this credit goes to firms from nontradable industries, directly increasing firms' and indirectly banks' exposure to the currency risk (Goldstein and Turner, 2004).

[19] Total mismatches are positively correlated with total liabilities. This may be caused by crisis, when high inflation leads to depreciation of the domestic currency, which raises the value of foreign liabilities.

other hand, are affected by domestic macroeconomic policies and institutions (Goldstein and Turner, 2004).

We include *Inflation*, which is the inflation rate calculated using the consumer price index. *FiscalBudget* controls for fiscal policy, and represents the government budget relative to GDP, with a positive (negative) number indicating a budget surplus (deficit). *RealGDPGr* represents the annual growth rate of real GDP per capita. In addition, to capture real shocks we also include the growth rate of terms of trade, *TotGr*, defined as the export price index to the import price index (Levy-Yeyati et al., 2004). *TradeOpen* measures the real openness of the economy, that is, export plus imports as a share of GDP. Two additional variables that are likely to be relevant for emerging and developing economies are *CALiberaliz*[20], the first principle component of four IMF binary variables, the existence of multiple exchange rates, restrictions on current account, capital account transactions, and the requirement of the surrender of export proceeds (Chinn and Ito 2006), and *FinanDevelop*, an index which measures domestic financial development by combining the ratio of bank liquid liabilities to GDP with the ratio of domestic credit to private sector to GDP, following Demirgüç-Kunt and Levine (1996) (see Appendix B).

In general, we find that exchange rate flexibility is positively correlated with the rate of inflation and financial development, and negatively correlated with trade openness and capital account liberalization. Currency mismatches and dollar liabilities are significantly higher in countries with open capital account and a higher inflation rate. Trade openness is positively correlated with liabilities, but negatively correlated with mismatches. Financial development and the other controls are not significantly correlated with our main variables.

[20] Data of capital account liberalization are extracted from the home page of M. Chinn http://www.ssc.wisc.edu/~mchinn/research.html.

2.3 Methodology

2.3.1 Granger causality tests

We run multivariate Granger causality tests by estimating the following equations

$$FLEX_{it} = \alpha_0 + \alpha_{11} FLEX_{it-1} \ldots + \alpha_{1j} FLEX_{it-j} + \alpha_{21} MISM_{it-1} \ldots + \alpha_{2j} MISM_{it-j} + \alpha_3' d_{it-1} + p_t + \nu_{it} \quad (1)$$

$$MISM_{it} = \beta_0 + \beta_{11} MISM_{it-1} \ldots + \beta_{1j} MISM_{it-j} + \beta_{21} FLEX_{it-1} \ldots + \beta_{2j} FLEX_{it-j} + \beta_3' d_{it-1} + p_t + \varepsilon_{it} \quad (2)$$

where $FLEX \in \{FLEX1, FLEX2\}$, $MISM \in \{MISM1, MISM2\}$, d_{it} is the set of control variables, p_t is the time-fixed effect, ε_{it} and ν_{it} are error terms, the subscripts *i* and *t* represent country and time period, respectively, while *j* is the number of lags. Additionally, we estimate our model with *LIAB*1 and *LIAB*2 instead of $MISM1$ and $MISM2$.

We estimate Eqs.(1) and (2) first by pooled OLS (with errors adjusted for heteroskedasticity and cluster serial correlation), which assumes that past errors are uncorrelated with regressors. That is, *MISM* and *LIAB* are exogenous variables in Eq.(1) and there is no feedback effect from the exchange rate policy to balance sheets. At the same time, the exchange rate regime is exogenous in Eq.(2), as balance sheets do not affect future choices of exchange rate policy.

If, however, the explanatory variables are endogenous, the estimated coefficients will be biased. Therefore, we also estimate the model using the system-Generalized-Method-of-Moments (system-GMM) estimator for dynamic panel data implemented by Roodman (2005) based on Arrelano and Bover (1995) and Blundell and Bond (1998). This estimator only requires weak exogeneity: the explanatory variables can now be correlated with past and present errors. The estimator uses as instruments in

the first-difference equations lagged levels of the dependant and endogenous variables, and lagged differences in the level equations.

The dynamic panel approach offers advantages to OLS and improves on previous efforts to examine the link between balance sheets and exchange rate flexibility. First, we eliminate any unobserved country fixed effects, which were included in the error terms before and were a source of bias in the OLS estimated coefficients. Second, we control for potential endogeneity of the explanatory variables. Moreover, by using the system-GMM, which combines the regression in differences with the regression in levels, instead of the difference-GMM estimator, we reduce the bias associated with weak instruments due to the high persistence in some of the explanatory variables (see Blundell and Bond, 1998, for a further discussion of the estimator). The system-GMM is also more efficient than the difference-GMM.

We check consistency of the system-GMM estimator with two specification tests suggested by Arrelano and Bover (1995) and Blundell and Bond (1998): a Hansen test of over-identifying restrictions, which checks the overall validity of instruments, and the Arrelano-Bond test of serial correlation in the error term, verifying that the differenced error term is not second-order serially correlated (while, by construction, the differenced error term should be first-order serially correlated).

2.3.2 Orthogonalized impulse-response functions

To further study the dynamic relationships between balance sheets and exchange rate flexibility, we estimate a panel vector autoregression (panel VAR) model

$$z_{it} = \Gamma_0 + \Gamma_{11} z_{it-1} + ...\Gamma_{1j} z_{it-j} + c_i + r_t + e_{it} \qquad (3)$$

where z_{it} is a vector $\{FLEX_{it}, MISM_{it}, d_{it}\}$, d_{it} is the set of control variables assumed now all endogenous, c_i is the unobserved country-fixed effect, r_t is the time

fixed-effect, and e_{it} is the error term. Alternatively, we replace *MISM* by *LIAB* and re-estimate the model.

We estimate a reduced-form VAR with restrictions imposed on the structural model parameters in order to achieve identification. The identification assumption is that variables that come earlier in the ordering affect the following variables contemporaneously, as well as with lags, while the variables that come later only affect the previous variables with lags. In our first specification we assume that balance sheets do not contemporaneously affect exchange rates. Second, we assume that exchange rates do not contemporaneously affect balance sheets. Note that with this methodology we rule out *two-way* contemporaneous causality between currency mismatches and dollar liabilities and exchange rate regimes.

To estimate the model above, we proceed as follows. First, the unobserved time effects are removed by time-demeaning the data. Second, the unobserved country fixed effects are removed by forward mean-differencing. This latter procedure, also called the Helmert procedure, avoids the bias in the system-GMM coefficients introduced by first-differencing (Arrelano and Bover, 1995). The model is then estimated by system-GMM. We further estimate and present the orthogonalized impulse-response functions, which describe the reaction of one variable in the system to innovations in another variable in the system, assuming that all other shocks are zero. The impulse-response functions are estimated under the two different specifications (orderings). Standard errors of the impulse-response functions are computed using Monte-Carlo simulations. We then perform a variance decomposition to evaluate the respective contribution of each variable to the observed variance in outcomes.

2.4 Results

2.4.1 Granger causality tests

The estimation results for multivariate Granger causality tests conducted using pooled OLS and system-GMM are reported in Tables 2.2a through 2.3b. We initially set the number of lags *j* equal to 4 since we have at least 4 observations for each variable and test for joint significance of lagged independent variables. We successively lower *j*, re-estimate the model, and stop when we find significant effects or when *j* equals 1 and the effects are insignificant. Tables 2.2a and 2.2b reports the effects of balance sheets, $MISM1$ and $MISM2$, and $LIAB1$ and $LIAB2$ respectively, on the exchange rate regime. Tables 2.3a and 2.3b report the reverse effects from exchange rate flexibility to balance sheets. We rely more on the measure $MISM1$ which has more observations. Overall, we find evidence for Granger causality running from balance sheets to exchange rate flexibility, but not the other direction.

First, we do not find the negative impact of balance sheets on exchange rate flexibility This is different from the previous finding that balance sheets have a negative relationship with exchange rate flexibility (Table 2.3). Only external mismatches and external dollar liabilities have a negative and significant effect on $FLEX1$; and there is no other significant effect (see Table 2.4a and 2.4b). Note that the effects of balance sheet on exchange rate flexibility are insignificant with the system-GMM estimator in all cases. This is not a surprising finding given their extremely high persistence (see the coefficients of $MISM_{t-1}$ and $LIAB_{t-1}$ in Table 2.5a and 2.5b), which questions the validity of the instruments. It suggests that a static analysis is not appropriate and there are important dynamic effects that need to be considered.

Second, we find a negative effect from policy choices to external mismatches and dollar liabilities (see Table 2.5a and 2.5b), which previous studies either ignored (e.g., Ganapolsky, 2005, and Honig, 2005) or failed to find (Alesina and Wagner, 2006). We find that both $FLEX1$ and $FLEX2$ have a negative effect on external mismatches, but not on total mismatches. The effects are significant with both OLS and GMM estimators. The negative impact of flexibilities on balance sheets is more obvious for liabilities. Both $FLEX1$ and $FLEX2$ have a negative effect on both external and total dollar liabilities. The effects are significant with OLS estimators in all cases.

While the statistical effects are negative and significant, the economic effects in both directions are rather small. We find that a 1 standard deviation increase in $MISM1$ is associated with only a 0.02 standard deviation reduction in exchange rate flexibility and a 1 standard deviation increase in $LIAB1$ is associated with a 0.1 standard deviation reduction in flexibility. The reverse effect is small as well: a 1 standard deviation increase in flexibility is associated with a 0.02-0.06 standard deviation reduction in mismatches and a 0.03-0.05 standard deviation reduction in dollar liabilities. Our findings suggest, contrary to Hausmann et al. (2001), that mismatches have to be really large to have any economically relevant effects on policy choices.

We also find that capital account liberalization and domestic financial development have significant effects on exchange rate flexibility. Higher capital account openness reduces the exchange rate flexibility while more developed financial markets increase it. Developing countries with large capital flows tend to adopt more fixed exchange rate regime to protect domestic agents. Countries with more developed financial markets do not do this since domestic hedges are available.

Trade openness has a negative effect on exchange rate flexibility both $FLEX1$ and $FLEX2$, but it is not significant statistically in most cases.

2.4.2 Orthogonalized impulse-response functions

Next, we estimate a reduced form panel VAR model using Love (2001). The set of control variables, assumed now all endogenous, includes the statistically significant variables from the earlier specifications: *FinanDevelop, CALiberaliz, TradeOpen,* and *Inflation*.

We estimate a panel VAR and report the orthogonalized impulse-response functions, which describe the reaction of one variable in the system to innovations in another variable in the system, assuming that all other shocks are zero. This allows us to better study the dynamic effects between balance sheets and exchange rates. As discussed before, this methodology requires special assumptions about contemporaneous effects in order to achieve identification. We estimate the panel VAR for the number of lags equal to 1 through 4, and report the result of the number of lags that generates the least correlated residuals.

Figures 2.3-2.10 report impulse response functions. Figures 2.3, 2.5, 2.7, and 2.9 assume no contemporaneous effects from balance sheets to flexibility, while Figures 2.4, 2.6, 2.8, and 2.10 assume no contemporaneous effects from flexibility to balance sheets.

Figures 2.3 and 2.4 presents the impulse-response functions for the panel VAR estimated using external mismatches $MISM1$ and the exchange rate flexibility measures, $FLEX1$ and alternatively $FLEX2$. We choose 1 lag for $MISM1$ and $FLEX1$, and 4 lags for $MISM1$ and $FLEX2$. We find that exchange rates become less flexible in response to an increase in mismatches and this effect is not statistically significant with $FLEX1$. But it is significant with $FLEX2$ in short and mid-term. Mismatches

decrease with exchange rate flexibility and this effect is statistically significant with $FLEX1$ in the short run.

Figures 2.5 and 2.6 reports the impulse-response functions for exchange rate flexibility and total mismatches $MISM2$. We choose 3 lags for $MISM2$ and $FLEX1$, and 2 lags for $MISM2$ and $FLEX2$. We do not find any effect between exchange rate flexibility and total mismatches. The model might be misspecified as the residuals in the equations for exchange rate flexibility and mismatches are highly correlated, for both $FLEX1$ and $FLEX2$. This might also be caused by the lack of variability of some controls, especially financial development and trade openness. We re-estimate the panel VAR without the two controls. The residuals are not correlated, and currency mismatches are negatively correlated with exchange rate flexibility. But the effects are not statistically significant.

The impulse-response functions for exchange rates flexibility and both external and total liabilities are presented in Figures 2.7-2.10. We choose 4 lags for $LIAB1$ and $FLEX1$, 1 lag for $LIAB1$ and $FLEX2$, and 4 lags for $LIAB2$. We find that both external and total liabilities decline when exchange rates become more flexible, for both $FLEX1$ and $FLEX2$. But the effects are not statistically significant. There is no contemporaneous effect from external liabilities to exchange rate flexibility. In the short-run total liabilities have a negative effect on exchange rate flexibility. In the long run the effects of both external and total liabilities on exchange rate flexibility are positive. None of the effect is statistically significant. This might be also caused by the lack of variability of trade openness and financial development. When the two controls are dropped, the effects of external liabilities on exchange rate flexibility become negative. The two-way effect between $LIAB1$ and $FLEX1$ is significant with 1

lag. But the effects between total liabilities and exchange rate flexibility do not change.

The economic effects are small, as documented by variance decompositions performed over 10 years and reported in Table 2.6 separately for each pair $(FLEX, MISM)$.[21] In most cases, the variation in both exchange rate flexibilities and mismatches is mainly explained by their own innovations. For external mismatches, and both external and total dollar liabilities, less than 6 percent of balance sheet variation is explained by innovations in exchange rate flexibilities, with a maximum of 5.71 percent variation in $LIAB2$ explained by innovations to $FLEX1$. Less than 2 percent of the exchange rate variation is explained by balance sheet innovations, with a maximum of 1.69 percent variation in $FLEX1$ explained by innovations to $MISM1$. This is not true for total mismatches $MISM2$.

In the cases of total mismatches, the variance of balance sheets or exchange rate flexibility is not mainly explained by their own innovations. The variation of these variables is mostly explained by capital account liberalization and financial development. This may be related to the lack of volatility of financial development and trade openness. We drop these two variables and re-estimate panel VAR. We find that the variation of both balance sheets and exchange rate flexibilities is mostly explained by themselves. Since the result of impulse response does not change much, we keep the two controls.

2.5 Concluding Remarks

Over the past couple of years there has been extensive theoretical and empirical literature that explores either the effects of balance sheets on exchange rate regimes or

[21] The reported effects are for the panel VAR estimated assuming that mismatches do not contemporaneously affect exchange rates. The effects are very similar when the ordering is reversed.

the role of exchange rate flexibility on balance sheets and portfolio choices. However, there are only several recent theoretical papers and no empirical studies that explore the interrelationships between balance sheets and exchange regimes.

This paper empirically studies the interrelationships between balance sheets, more precisely banks' domestic and external dollar liabilities and currency mismatches, and the degree of flexibility of the exchange rate regime. We ask whether dollarized portfolios lead to fear of floating, or whether fear of floating generates currency mismatches on domestic agents' balance sheet, or whether effects go both ways. We use annual panel data for up to 101 emerging and developing countries for the period 1975-2004 and standard measures of exchange rate flexibility and balance sheets. We examine the interrelationship only for tranquil period by eliminating periods of currency crisis.

We do not find the negative effect of balance sheets on exchange rate flexibility except for external mismatches. We find evidence that the fear of floating or lack of flexibility of the exchange rate regime affects agents' portfolios and amplifies mismatches which is found both for external mismatches and dollar liabilities, both external and total liabilities. However, while this effect is statistically significant, their economic relevance is rather low.

In this paper, annual data are used. When high frequency data are available, the measures of balance sheets can be recalculated. For future study, new control variables, such as institutions, can be used.

CHAPTER 3: AN OPTIMAL CURRENCY BASKET FOR EMERGING MARKET ECONOMIES

3.1 Introduction

Emerging market economies are those that experienced economic and policy reform, and are moving from closed to open market. These economies are in the transitional stage between developing and developed economy. According to the World Bank, the largest five emerging market economies are China, India, Indonesia, Brazil and Russia. Usually these economies enjoy high growth rate, depend heavily on exports and have large amount of capital inflows. The choice of exchange rate regime is important for them to maintain high volume of exports and steady economic growth. The more open they are, the more they are affected by exchange rate fluctuations. Therefore, a stable exchange rate is essential for these economies to maintain a stable trade and income growth.

Some emerging market economies adopt a free floating exchange rate regime, where exchange rates are free from the intervention of the central bank. Many other emerging market economies adopt a fixed exchange rate regime, where exchange rates are under the control of the central bank. There are a lot of concerns about these corner solutions.

An independent floating exchange rate regime increases the fluctuations of exchange rates, which harms international trade (Rose, 2000). Almost all emerging market economies depend on exports to improve economic growth. A flexible exchange rate regime leads to more volatile exchange rates, which will change relative prices and cause fluctuations in trade balance and income. An appreciation of the domestic currency reduces exports and income. Nowadays outsourcing is quite common among multinational national companies (MNC). Since most emerging

market economies have the advantage of low production costs, many MNCs move their factories to these economies. Production is carried out in several countries. Then emerging market economies have large imports of intermediate products. A depreciation of domestic currency raises the price of imports, then increases prices of outputs, and leads to inflation. This instability in trade and output associated with fluctuations of exchange rates makes it difficult to keep steady economic growth.

Usually emerging market economies are unable to borrow abroad using domestic currencies, and they lack instruments to hedge foreign exchange risk. A depreciation of the domestic currency leads to an increase in foreign currency debt in terms of the domestic currency and a decline in wealth. Therefore, a freely floating exchange rate regime is not a good choice for emerging market economies.

Compared with the flexible exchange rate regime, the fixed exchange rate regime or a hard peg has its advantage. Since exchange rates are stable, there are fewer fluctuations in international trade. Under a fixed exchange rate regime, there is no foreign exchange risk. Then there is no need to hedge the risk, which reduces transaction costs of international trade. That is why many emerging market economies claim that they adopt a flexible exchange rate regime but actually use interest rate or foreign currency reserves to manage exchange rates. This is the so called “fear of floating” (Calvo and Reinhart, 2002). Since there is no foreign exchange risk, domestic agents tend to borrow more from abroad and investors from foreign countries tend to invest more in emerging market economies. That is why emerging market economies with a fixed exchange rate have high capital inflows. According to the “impossible trinity”, economies with free capital flow will lose independent monetary policy if they adopt a fixed exchange rate regime. On the other hand, defending a fixed exchange rate regime is costly. Central banks need to hold a large

amount of foreign currency reserves. If they run out of reserves, exchange rates would be out of control and become even more unstable. Fixed exchange regimes tend to incur speculative attack. If the central bank chooses to defend the fixed exchange rates, the economy is at risk of a free-falling of exchange rate, dramatic rise in foreign debt and decline in output. Then the large capital inflows might reverse, which could lead to bankruptcy of domestic banks and firms. This is what happens during currency and banking crises.

Emerging market economies vary in size, growth rate, the standards of living, and institutions. However, many of them experienced financial crises during the 1990s. Examples include Mexico in 1994, East Asia in 1997, Russia in 1998 and Brazil in 1999. These economies suffered large capital outflows and a slow-down in economic growth. Before the crises, they all adopted de facto fixed exchange rate regime (Reinhart and Rogoff, 2004; Levy-Yeyati and Sturzenegger, 2005). Pegged exchange rate regime was blamed as a main reason of crises. So the IMF recommended currency basket peg as a better form of peg.

Currency basket peg is an intermediate exchange rate regime. By pegging to a basket of currency, a country can increase the flexibility of its exchange rates and reduce the exposure to speculative attack caused by a fixed exchange rate regime. At the same time, it can also reduce fluctuations of exchange rates caused by a flexible exchange rate regime. A currency basket peg leads to more volatile exchange rates than a hard peg, which reduces capital inflows and reduces the possibility of increases in the value of foreign currency debt and large capital outflows caused by a depreciation of the domestic currency. It seems that a currency basket peg is a more feasible exchange rate regime for emerging market economies.

Now many economies adopt a basket of currencies as an anchor to manage their currencies. Table 3.1 shows countries classified by the IMF as managing exchange rates against a currency basket in 2004. In addition, the Bank of Russia announced in 2005 that the exchange rates of the Russian ruble have been managed against a basket of currency containing the U.S. dollar and the euro; in July 2005, the People's Bank of China declared that the Chinese yuan would be pegged to currency basket containing the U.S. dollar, the Japanese yen, the euro, the Korean won and some other currencies; and the Singapore dollar is monitored by the Monetary Authority of Singapore against a trade-weighted basket of currencies. However, Daniels, Toumanoff, and von der Ruhr (2001) argue that some of the East Asian economies had adopted currency basket before the crisis, and it was the large weight of the U.S. dollar in the basket that caused the problem. Therefore, it is important to find the optimal weights for currency baskets of these emerging market economies.

Many emerging market economies have liberalized their capital account, which has led to increased capital inflows into these economies. FDI, an important component of capital inflows, increases by 60-400% during the period 1994-2004 for the five largest emerging market economies[22]. Capital inflows, especially FDI, are essential to the development of emerging market economies given the undeveloped financial markets of these economies. Capital account liberalization can be successful only when there are strong domestic financial markets. Undeveloped financial market and the lack of tools to hedge exchange risk leads to fear of floating. Without capital controls, large amount of capital inflows tends to incur currency crises. Another reason for imposing capital controls is to reduce turbulence in financial markets caused by disturbances, such as asymmetric information, political instability, and poor

[22] Indonesia is an exception of this group. It was affected by the Asian crisis and experienced FDI out flows from 1998 to 2003.

institutions (Von Hagen and Zhou, 2005). According to the Annual Reports on Exchange Arrangements and Exchange Restrictions (AREAE) of the IMF, these economies still have some kind of capital controls.

Capital controls can take different forms. AREAE divides capital controls into 11 categories, which include controls on capital market securities, money market instruments, collective investment securities, derivatives and other instruments, commercial credits, financial credits, guarantees, securities, and financial backup facilities, direct investment, liquidation of direct investment, real estate transactions, and personal capital transactions. They can be imposed on capital inflows or on outflows. According to the IMF, capital controls can be imposed on short-term inflows to limit the size and volatility of inflows. Chile applied a tax on capital inflows during the period of 1991-1998 to prevent appreciation the Chilean peso. Brazil used a number of capital control measures on short-term inflows from 1993 to 1997 to stabilize interest rate differentials and reduce appreciation pressure. Examples of this kind of capital controls also include Columbia (1993-1998), Malaysia (1994), and Thailand (1995-1997). Controls on outflows are used to reduce the depreciation pressure on domestic currencies during financial crises. After the Asian financial crisis, Malaysia imposed capital control on outflows in 1998 to get some monetary autonomy. Capital controls of Spain (1992) and Thailand (1997-1998) are also of this type (Ariyoshi et al, 2000).

The main reason why many emerging market economies impose controls on capital inflow is keep the competitiveness of domestic firms (Herrera and Valdés, 2000). Another reason for controls on inflows is that temporary capital inflows tend to incur reversals of inflows (Reinhart and Smith, 2001). A temporary tax on inflows can reduce this risk through increasing the cost of foreign currency debt and reducing the

amount of inflows (Reinhart and Smith, 1998). Von Hagen and Zhou (2005) find that capital controls are most likely to be adopted by economies with intermediate exchange rate regime. Therefore the existence of capital control should not be neglected in the choice of the optimal currency basket.

This paper tries to find the optimal weights of a currency basket for emerging markets. The model is based on the work of Turnovsky (1982). He uses a general equilibrium macro model for a small open economy to derive the optimal weights for a currency basket by minimizing the variance of output. His model is extended by adding trade balance as another target of objective function. In addition, Turnovsky (1982) assumes perfect capital mobility, while this paper assumes imperfect capital mobility, allowing domestic country to impose a reserve requirement which is led in different currencies on capital inflows. The model of the domestic interest rate with capital control is based on Gregorio, Edwards, and Valdés (2000). Their model examines the effect of a single–currency reserve requirement, while the model in this paper investigates the effect of a two-currency reserve requirement.

In this paper, a general equilibrium model for small open economy is used to derive the optimal weight for a two-currency basket. The optimal weight is derived by minimizing the loss from variance of output and trade balance. The results show that under the condition of imperfect capital mobility, the optimal weights are affected by variance of the cross exchange rate between the two major currencies, the covariance between inflations in the two large countries and the cross exchange rate, the relative weights assigned to trade and output, and price and exchange rate elasticities of trade, demand and supplies.

The remainder of this paper is organized as follows. Section 2 reviews existing literature about the optimal choice a currency basket; Section 3 establishes the

theoretical model for a small open economy with a currency basket and derives the optimal weights; Section 4 discusses some properties of the optimal weights; and Section 5 summarize the findings of this paper.

3.2 Literature Review

There are two types of models in existing literature on the optimal weights for a currency basket. One type of models uses welfare as a criterion for determining the optimal exchange rate regime. Welfare is maximized to get the optimal weight for each component of the currency basket. Devereux and Engel (1998) investigate the effects of price setting on the optimal choice of exchange rate regime. Teo (2004) constructs a three-country sticky price general equilibrium model and use the expected lifetime utility of households as the criterion to investigate the impact of the U.S. dollar as an invoicing currency on the optimal currency basket of East Asian economies.

Another type of models constructs a loss function of some macroeconomic variables. The loss from these variables is minimized to get the optimum weights. To get the optimal weight, first a target has to be chosen. Different macroeconomic variables are used as targets, the most commonly used being the trade balance. Ogawa and Ito (2002) use a two-country game theory model to derive the optimal weights for a currency basket including the U.S. dollar and the yen by minimizing trade balance fluctuations. Another target usually considered is the output. Turnovsky (1982) uses a three country model to get the optimal weight for a currency basket of a small open economy by minimizing the volatility in income. A third choice is inflation. However, Masson, Savastano and Sharma (1997) claim that for most developing countries,

inflation targeting is not suitable because central banks lack the ability to conduct an independent monetary policy.

Other authors choose multiple targets. Bhandari (1985) adopts a three-country stochastic equilibrium model and chooses a loss function which includs a trade-weighted real effective exchange rate and output. Branson and Katsli (1981) and Han (2000) use a multi-country model and get the optimal currency basket by minimizing trade balance and aggregate price level together. Daniel, Toumanoff, and von der Ruhr (2001) extend the model of Turnovsky (1982) and get the optimal currency basket by minimizing the volatility of domestic consumer prices and that of foreign reserves. Bénassy-Quéré (1999) uses a loss function including trade and external debt. Bird and Rajan (2002) extend the model of Bénassy-Quéré (1999) and derive a loss function of imports, exports and foreign currency debt from the loss from output and inflation.

These papers assume perfect capital mobility or neglect the effect of capital mobility. Turnovsky (1982), Bhandari (1985), Bird and Rajan (2002), and Daniel, Toumanoff, and von der Ruhr (2001) all assume perfect capital mobility so that uncovered interest rate parity holds. Bénassy-Quéré (1999), Ogawa and Ito (2002), and Teo (2004) do not take into account the effect of capital flows. However, if there are controls on capital mobility, the domestic interest rate should be higher than the world interest rate. Since capital controls are common in emerging market economies, they should be taken into account when choosing the optimal currency basket.

For emerging market economies, the growth rate is important for improving development. Fluctuations in output are harmful to economic growth. Most of these countries improve economic growth by increasing exports. Fluctuations in trade balance can also slow down the economic growth. So both output and trade are

important. In this paper, the second type of model is used. The optimal weights of a currency basket for emerging market economies are derived by minimizing the loss function of the volatility of both output and trade balance.

3.3. The Model

A three-country model is used in this paper. There is one small open economy and two large economies. The domestic country is the small economy. Country 1 and Country 2 are large economies. It is assumed that the domestic country does not have an impact on either Country 1 or Country 2. Macroeconomic aggregates and prices in Country 1 and Country 2 are viewed as exogenous. The domestic currency is pegged to a currency basket composed of the currencies of both large countries, Currency1 and Currency 2, respectively.

3.3.1 Setup of the model

This model is based on Turnovsky (1982) and Bhandari (1985). The analysis focuses on the goods sector only. The specification of the aggregate demand and aggregate supply functions follows the model of Turnovsky (1982), while that for exports and imports follows the model of Bhandari (1985).

$$Y_t = C_t + I_t + NX_t - \varphi P_t + w_t \tag{1}$$

$$C_t = \alpha Y_t \tag{2}$$

$$I_t = -\delta R_t \tag{3}$$

$$Y_t = \theta P_t + \varepsilon_t \tag{4}$$

$$M_{1t} = \beta_1^m P_{1t} + \beta_2^m E_{1t} + \beta_3^m P_t \qquad \beta_1^m,\ \beta_2^m < 0;\ \ \beta_3^m > 0 \tag{5a}$$

$$M_{2t} = \beta_1^m P_{2t} + \beta_2^m E_{2t} + \beta_3^m P_t \tag{5b}$$

$$X_{1t} = \beta_1^x P_{1t} + \beta_2^x E_{1t} + \beta_3^x P_t + \gamma^x Y_{1t} \qquad \beta_1^x,\ \beta_2^x > 0;\ \ \beta_3^x < 0;\ \gamma^x > 0 \tag{5c}$$

$$X_{2t} = \beta_1^x P_{2t} + \beta_2^x E_{2t} + \beta_3^x P_t + \gamma^x Y_{2t} \quad (5d)$$

$$NX_t = X_{1t} + X_{2t} - M_{1t} - M_{2t} \quad (6)$$

$$\overline{E} = \lambda_1 E_{1t} + \lambda_2 E_{2t} \qquad \lambda_1 + \lambda_2 = 1 \quad (7)$$

$$E_{3t} = \frac{E_{2t}}{E_{1t}} \quad (8)$$

Y_t : domestic output at time *t*,

Y_{it} : income of country *i*, *i* =1, 2,

P_t : domestic price level,

P_{it} : price level of country *i*, *i* =1,2,

R_t : gross domestic interest rate,

M_{it} : imports from country *i*, *i* = 1, 2,

X_{it} : exports to country *i*, *i* =1, 2,

NX_t : trade balance,

E_{it} : exchange rate between domestic currency and currency *i* at time *t*, measured in units of domestic currency per unit of currency i, *i* =1, 2,

$\overline{E}$: the currency bask in terms of the domestic currency, expressed as price of one unit of the basket

E_{3t} : the cross exchange rate between currency 1 and 2 measured by units of currency 1 per unit of currency 2.

w_t : stochastic disturbance in domestic aggregate demand,

ε_t : stochastic disturbance in domestic aggregate supply.

Equation (1) describes the demand for domestic goods. The demand for domestic goods is the sum of consumption which is positively related to domestic income Y_t

(equation 2), investment which is negatively related to the domestic interest rate R_t (equation 3), and trade balance NX_t. Y_t is nominal domestic income. So the demand for domestic goods also depends negatively on the domestic price level P_t. The demand for domestic goods is subject to a stochastic demand shock w_t. Equation (4) is the supply function of the economy, which is affected by domestic price level and a supply shock ε_t. w_t and ε_t are assumed to be *iid* and follow a normal distribution.

$$w_t \sim N(0, \sigma_w^2)$$

$$\varepsilon_t \sim N(0, \sigma_\varepsilon^2)$$

Equations (5a)-(5d) describe imports and exports between the domestic country and the two large countries. Imports M_{it} and exports X_{it} are modeled following Bhandari (1985). For simplicity, imports depend only on the real exchange rate. Exports depend on the real exchange rate and foreign income. Equation (6) is the trade balance.

A two-currency basket is shown in equation (7). It is pegged to currencies of both countries with a weight λ_1 for Currency 1 and λ_2 for Currency 2. The currency basket $\overline{E}$, which is assumed to be constant, is the weighted average of exchange rates between domestic currency and the two foreign currencies E_{1t} and E_{2t}. If one of the weights is 0, the currency basket becomes a single currency peg. The monetary authorities of the domestic country choose the weights to minimize the loss from fluctuations in output and trade balance.

Equation (8) shows the cross exchange rate between Currency 1 and Currency 2. The cross exchange rate E_{3t} is taken as given by the domestic small open economy.

From equations (1)-(3), demand for domestic goods can be expressed as

$$Y_t = \alpha Y_t - \delta R_t + NX_t - \varphi P_t + w_t \tag{9}$$

Substituting equations (5a)-(5d) into equation (6)

$$NX_t = \beta_1(P_{1t} + P_{2t}) + \beta_2(E_{1t} + E_{2t}) + 2\beta_3 P_t + 2\gamma^x(Y_{1t} + Y_{2t}) \tag{10}$$

where $\beta_1 = \beta_1^x - \beta_1^m > 0$; $\beta_2 = \beta_2^x - \beta_2^m > 0$; and $\beta_3 = \beta_3^x - \beta_3^m < 0$.

The domestic price level P_t, output Y_t and net exports NX_t can be derived from the equilibrium of goods market. From Equation (9), (4) and (10), we can get

$$P_t = \frac{\beta_1(P_{1t} + P_{2t}) + \beta_2(E_{1t} + E_{2t}) + \gamma^x(Y_{1t} + Y_{2t}) - \delta R_t + w_t - (1-\alpha)\varepsilon_t}{(1-\alpha)\theta - 2\beta_3 + \varphi} \tag{11}$$

$$Y_t = \frac{\theta}{(1-\alpha)\theta - 2\beta_3 + \varphi}[\beta_1(P_{1t} + P_{2t}) + \beta_2(E_{1t} + E_{2t}) + \gamma^x(Y_{1t} + Y_{2t}) - \delta R_t + w_t] + \frac{\varphi - 2\beta_3}{(1-\alpha)\theta - 2\beta_3 + \varphi}\varepsilon_t \tag{12}$$

$$NX_t = \frac{(1-\alpha)\theta + \varphi}{(1-\alpha)\theta - 2\beta_3 + \varphi}[\beta_1(P_{1t} + P_{2t}) + \beta_2(E_{1t} + E_{2t}) + \gamma^x(Y_{1t} + Y_{2t})] + \frac{2\beta_3}{(1-\alpha)\theta - 2\beta_3 + \varphi}[w_t - (1-\alpha)\varepsilon_t - \delta R_t] \tag{13}$$

From equation (7) and (8), the domestic exchange rates with the other two currencies E_{1t} and E_{2t} can be solved.

$$E_{1t} = \frac{\overline{E}}{\lambda_1 + (1-\lambda_1)E_{3t}} \tag{14a}$$

$$E_{2t} = \frac{\overline{E}E_{3t}}{\lambda_1 + (1-\lambda_1)E_{3t}} \tag{14b}$$

3.3.2 The effects of capital controls

In this section, models of Turnovsky (1982) and Bhandari (1985) are extended, which assume perfect capital mobility. This model extends their work to account for

capital controls. Therefore, the domestic country imposes a reserve requirement on capital inflows from Country 1 and Country 2 and the reserve must be held in currencies of both countries. When investors invest in the domestic country, they should deposit a fraction (u) of their investment in an account at the central bank. This account bears no interest. Investors get back the reserve requirement when they take their capital out of the domestic country. ρ_1 of the reserve should be held in Currency 1 and ρ_2 ($\rho_2 = 1-\rho_1$) in Currency 2. Since the reserve bears no interest, it works as a tax on capital inflows. With this reserve requirement, investors request an interest rate higher than the interest rate of the world market. Uncovered interest rate parity does not hold here.

The domestic interest R_t, at which foreign investors from Country 1 and Country 2 are indifferent between investing in their home countries and the domestic country, satisfies the following conditions:

$$(1-u)(1+R_t)\frac{E_{1t}}{E^e_{1t+1}} + \rho_1 u + (1-\rho_1)u\frac{E^e_{3t+1}}{E_{3t}} = (1+R_{1t}) \tag{15a}$$

$$(1-u)(1+R_t)\frac{E_{2t}}{E^e_{2t+1}} + \rho_1 u\frac{E_{3t}}{E^e_{3t+1}} + (1-\rho_1)u = (1+R_{2t}) \tag{15b}$$

E^e_{1t+1} and E^e_{2t+1} are expected exchange rates of the domestic currency against Currency1 and Currency 2 respectively at $t+1$ based on expectations at time t. E^e_{3t+1} is the expected cross exchange rate at $t+1$. The exchange rates at $t+1$ equals exchange rates at t plus a stochastic disturbance v_t. Then the exchange rates at $t+1$ are

$$E_{1t+1} = E_{1t} + v_{1t} \tag{16a}$$

$$E_{2t+1} = E_{2t} + v_{2t} \tag{16b}$$

where $v_{1t} \sim (\bar{v}_1, \sigma^2_{v_1})$ and $v_{2t} \sim (\bar{v}_2, \sigma^2_{v_2})$. The expected exchange rates are

$$E^e_{1t+1} = E(E_{1t+1}) = E_{1t} + \bar{v}_1 \tag{17a}$$

$$E^e_{2t+1} = E(E_{2t+1}) = E_{2t} + \bar{v}_2 \tag{17b}$$

The cross exchange rate between Currency 1 and Currency 2 at $t+1$, E_{3t+1}, is

$$E_{3t+1} = \frac{E_{2t+1}}{E_{1t+1}} = E_{3t} + v_{3t} \tag{18a}$$

where $v_{3t} \sim N(0, \sigma^2_{v_3})$. Then the expected cross exchange rate at $t+1$, E^e_{3t+1} can be expressed as

$$E^e_{3t+1} = E(E_{3t+1}) = E\left(\frac{E_{2t+1}}{E_{1t+1}}\right) = E_{3t} \tag{18b}$$

Then, the domestic interest rate in terms of the interest rate of Country 1 and that of Country 2 can be derived from equations (14a) through (17b) and (10)-(13).

$$R_t = \frac{(1-u+R_{1t})[\lambda_1 + (1-\lambda_1)E_{3t}]\bar{v}_1 + R_{1t}\bar{E}}{(1-u)\bar{E}} \tag{19a}$$

$$R_t = \frac{(1-u+R_{2t})[\lambda_1 + (1-\lambda_1)E_{3t}]\bar{v}_2 + R_{2t}\bar{E}E_{3t}}{(1-u)\bar{E}} \tag{19b}$$

The domestic interest rate R_t is affected by the reserve requirement, the choice of the weights of the currency basket, and the cross exchange rate between Currency 1 and Currency 2, as well as foreign interest rate. Because of the assumption that the expected value of the disturbance of the cross exchange rate is zero, the domestic interest is not affected by the share of each currency in the reserve, ρ_1, and ρ_2. Since interest rate determines investment, the total output of the domestic country under capital control is different from that under free capital mobility. Since (19a) and (19b) are equal,

$$R_{2t} = \frac{(1-u+R_{1t})[\lambda_1+(1-\lambda_1)E_{3t}]\bar{v}_1 + R_{1t}\bar{E} - (1-u)[\lambda_1+(1-\lambda_1)E_{3t}]\bar{v}_2}{[\lambda_1+(1-\lambda_1)E_{3t}]\bar{v}_2 + \bar{E}E_{3t}} \qquad (15c)$$

Substitute equation (15a), (15b) and (19a) into equation (12) and (13), we can get the expression for output and trade balance.

$$Y_t = \frac{\theta}{(1-\alpha)\theta - 2\beta_3 + \varphi}\{\beta_1(P_{1t}+P_{2t}) + \frac{\beta_2\bar{E}(1+E_3)}{\lambda_1+(1-\lambda_1)E_3} + \gamma^x(Y_{1t}+Y_{2t}) + w_t -$$

$$-\frac{\delta\bar{v}_1(1-u+R_1)[\lambda_1+(1-\lambda_1)] + \delta R_{1t}\bar{E}}{(1-u)\bar{E}}\} + \frac{\varphi-2\beta_3}{(1-\alpha)\theta-2\beta_3+\varphi} \qquad (20)$$

$$NX_t = \frac{(1-\alpha)\theta+\varphi}{(1-\alpha)\theta-2\beta_3+\varphi}[\beta_1(P_{1t}+P_{2t}) + \frac{\beta_2\bar{E}(1+E_3)}{\lambda_1+(1-\lambda_1)E_3} + \gamma^x(Y_{1t}+Y_{2t})] +$$

$$\frac{2\beta_3}{(1-\alpha)\theta-2\beta_3+\varphi}\{w_t - (1-\alpha)\varepsilon_t - \frac{\delta\bar{v}_1(1-u+R_1)[\lambda_1+(1-\lambda_1)] + \delta R_{1t}\bar{E}}{(1-u)\bar{E}}\} \qquad (21)$$

3.3.3 Solution of the model

The volatility of trade balance and output can be derived from equations (20) and (21). It is assumed that the cross exchange rate E_{3t} is correlated with the foreign price level P_{1t} and P_{2t}. For simplicity, all other variables are assumed to be independent of each other. Therefore, all covariance are assumed to be zero except for $\sigma_{P_1E_3}$ and $\sigma_{P_2E_3}$.

$$\sigma_Y^2 = [\frac{\theta}{(1-\alpha)\theta-2\beta_3+\varphi}]^2\{\beta_1^2(\sigma_{P_1}^2+\sigma_{P_2}^2) + (\gamma^x)^2(\sigma_{Y_1}^2+\sigma_{Y_2}^2) + \sigma_w^2 + \delta^2\{\frac{[\lambda_1+(1-\lambda_1)E_3]+\bar{E}}{(1-u)\bar{E}}\}^2\sigma_{R_1}^2$$

$$+\{\frac{-\beta_2\bar{E}(1-\lambda_1)(1+E_3)}{[\lambda_1+(1-\lambda_1)E_3]^2} + \frac{\beta_2\bar{E}}{\lambda_1+(1-\lambda_1)E_3} - \frac{\delta\bar{v}_1(1-u+R_1)(1-\lambda_1)}{(1-u)\bar{E}}\}^2\sigma_{E_3}^2 +$$

$$2\beta_1\theta^2\{\frac{-\beta_2\bar{E}(1-\lambda_1)(1+E_3)}{[\lambda_1+(1-\lambda_1)E_3]^2} + \frac{\beta_2\bar{E}}{\lambda_1+(1-\lambda_1)E_3} - \frac{2\beta_3\delta\bar{v}_1(1-u+R_1)(1-\lambda_1)}{(1-u)\bar{E}}\}(\sigma_{P_1E_3}+\sigma_{P_2E_3})$$

$$+[\frac{\varphi-2\beta_3}{(1-\alpha)\theta-2\beta_3+\varphi}]^2\sigma_\varepsilon^2 \qquad (22)$$

$$\sigma_{NX}^2 = [\frac{(1-\alpha)\theta+\varphi}{(1-\alpha)\theta-2\beta_3+\varphi}]^2\{\beta_1^2(\sigma_{P_1}^2+\sigma_{P_2}^2)+(\gamma^x)^2(\sigma_{Y_1}^2+\sigma_{Y_2}^2)]+$$

$$[\frac{2\beta_3}{(1-\alpha)\theta-2\beta_3+\varphi}]^2\{\sigma_w^2+(1-\alpha)^2\sigma_\varepsilon^2+\delta^2\{\frac{[\lambda_1+(1-\lambda_1)E_3]v_1+\overline{E}}{(1-u)\overline{E}}\}^2\sigma_{R_1}^2\}+$$

$$\{\frac{(1-\alpha)\theta+\varphi}{(1-\alpha)\theta-2\beta_3+\varphi}\{\frac{-\beta_2\overline{E}(1-\lambda_1)(1+E_3)}{[\lambda_1+(1-\lambda_1)E_3]^2}+\frac{\beta_2\overline{E}}{\lambda_1+(1-\lambda_1)E_3}\}-\frac{2\beta_3\delta\overline{v}_1(1-u+R_1)(1-\lambda_1)}{[(1-\alpha)\theta-2\beta_3+\varphi](1-u)\overline{E}}\}^2\sigma_{E_3}^2$$

$$+\frac{2\beta_1[(1-\alpha)\theta+\varphi]^2}{[(1-\alpha)\theta-2\beta_3+\varphi]^2}\{\frac{-\beta_2\overline{E}(1-\lambda_1)(1+E_3)}{[\lambda_1+(1-\lambda_1)E_3]^2}+\frac{\beta_2\overline{E}}{\lambda_1+(1-\lambda_1)E_3}\}(\sigma_{P_1E_3}+\sigma_{P_2E_3})$$

$$-\frac{2\beta_1\beta_2\delta\overline{v}_1[(1-\alpha)\theta+\varphi](1-u+R_1)(1-\lambda_1)}{[(1-\alpha)\theta-2\beta_3+\varphi]^2(1-u)\overline{E}}(\sigma_{P_1E_3}+\sigma_{P_2E_3}) \qquad (23)$$

σ^2 's represents the volatility of variables. The expressions of σ_{nx}^2 and σ_y^2 indicate that domestic shocks do not affect the optimal choice of the weights λ_1 and λ_2. This is because domestic shocks have no impact on the cross exchange rate, since the domestic economy is small. Therefore, the covariance between the cross exchange rate and domestic shocks is zero. But the volatility of foreign interest rate affects the choice of the optimal weights as the domestic interest rate is affected by the cross exchange rate.

To find the optimal weight λ_1, a loss function is specified. The loss function is minimized to get the optimal weights, as existing literature does (Turnovsky, 1982; Bénassy-Quéré, 1999; Daniel, Toumanoff, and von der Ruhr, 2001; and Ogawa and Ito, 2002; etc). Here a loss function for the volatility of trade balance σ_{NX}^2 and that of output σ_Y^2 is adopted. The loss function is expressed as the weighted average of the fluctuation in the growth of trade and that of output, with the weight of η_1 for σ_{NX}^2 and η_2 for σ_Y^2.

$$L = \eta_1\sigma_Y^2 + \eta_2\sigma_{NX}^2 \qquad (24)$$

where $\eta_1 + \eta_2 = 1$. The aim of the domestic policymakers is to find an optimal currency basket to minimize the loss from the volatilities of trade balance and output. To find the optimal weights equation (24) is minimized. From the first order condition,

$$\frac{\partial L}{\partial \lambda_1} = \frac{2\delta^2 \sigma_{E_2}^2 \overline{v}_1 (\eta_1 \theta^2 + 4\eta_2 \beta_3^2)(1-E_3)}{[(1-\alpha)\theta - 2\beta_3 + \varphi]^2 [(1-u)\overline{E}]^2} + \frac{2\sigma_{E_3}^2}{[(1-\alpha)\theta - 2\beta_3 + \varphi]^2} \{\eta_1 \theta^2 \{\frac{-\beta_2 \overline{E}(1-\lambda_1)(1+E_3)}{[\lambda_1 + (1-\lambda_1)E_3]^2} +$$

$$\frac{\beta_2 \overline{E}}{\lambda_1 + (1-\lambda_1)E_3} - \frac{\delta \overline{v}_1 (1-u+R_1)(1-\lambda_1)}{(1-u)\overline{E}}\} \times \{\frac{2\beta_2 \overline{E}(1-\lambda_1)(1-E_3^2)}{[\lambda_1 + (1-\lambda_1)E_3]^3} + \frac{2\beta_2 \overline{E} E_3}{[\lambda_1 + (1-\lambda_1)E_3]^2} + \frac{\delta \overline{v}_1 (1-u+R_1)}{(1-u)\overline{E}}\}$$

$$+ \eta_2 \{[(1-\alpha)\theta + \varphi]\{\frac{-\beta_2 \overline{E}(1-\lambda_1)(1+E_3)}{[\lambda_1 + (1-\lambda_1)E_3]^2} + \frac{\beta_2 \overline{E}}{\lambda_1 + (1-\lambda_1)E_3}\} - \frac{2\beta_3 \delta \overline{v}_1 (1-u+R_1)(1-\lambda_1)}{(1-u)\overline{E}}\} \times$$

$$\{[(1-\alpha)\theta + \varphi]\{\frac{2\beta_2 \overline{E}(1-\lambda_1)(1-E_3)}{[\lambda_1 + (1-\lambda_1)E_3]^3} + \frac{2\beta_2 \overline{E} E_3}{[\lambda_1 + (1-\lambda_1)E_3]^2} + \frac{2\beta_3 \delta \overline{v}_1 (1-u+R_1)}{(1-u)\overline{E}}\}\} +$$

$$\frac{2\beta_1 (\sigma_{P_1 E_3} + \sigma_{P_2 E_3})}{[(1-\alpha)\theta - 2\beta_3 + \varphi]^2} \{\{\eta_1 \theta^2 + \eta_2 [(1-\alpha)\theta + \varphi]^2\}\{\frac{2\beta_2 \overline{E}(1-\lambda_1)(1-E_3^2)}{[\lambda_1 + (1-\lambda_1)E_3]^3} + \frac{2\beta_2 \overline{E} E_3}{[\lambda_1 + (1-\lambda_1)E_3]^2} +$$

$$\frac{\delta \overline{v}_1 \{\eta_1 \theta^2 + 2\eta_2 \beta_3 [(1-\alpha)\theta - 2\beta_3 + \varphi]\}(1-u+R_1)}{(1-u)\overline{E}}\} = 0 \qquad (25)$$

The optimal weight is affected by the relative importance of the volatility of output in the loss function η_1, the volatility of the cross exchange rate between the foreign currencies $\sigma_{E_3}^2$, the reserve requirement for capital inflows u, and the relationship between foreign price level and the cross exchange rate $\sigma_{P_1 E_3}$ and $\sigma_{P_2 E_3}$.

Equation (25) is too complicated to be solved analytically. Numerical solver is used to derive the relationship between η_1, $\sigma_{E_3}^2$, u, $\sigma_{P_1 E_3}$ and $\sigma_{P_2 E_3}$. The results of simulation are shown in Table 3.2a and 3.2b.The values assigned to parameters are also shown in the tables.

The results of simulation show that the optimal weight λ_1 changes with the covariance between the cross exchange rate and the price level of the two large economies, $\sigma_{P_1 E_3}$ and $\sigma_{P_2 E_3}$ when other variables are constant. λ_1 decreases with $\sigma_{P_1 E_3}$

and increases with the absolute value of $\sigma_{P_2E_3}$. Because of the definition of E_{3t}, the price changes in Country 1, P_{1t} is positively related to E_{3t}, while P_{2t} is negatively related to E_{3t}. When there is inflation in Country 1, Currency 1 will depreciate relative to Currency 2, and E_{3t} will increase. When there is inflation in Country 2, Currency 1 will appreciate relative to Currency 2 and E_{3t} will decrease. So $\sigma_{P_1E_3}$ is positive and $\sigma_{P_2E_3}$ is negative. When $\sigma_{P_1E_3}$ is higher, which means that the value of Currency 1 is more affected by inflation, Currency1 becomes relatively weaker than Currency 2. A lower weight should be assigned to Currency1. When the absolute value of $\sigma_{P_2E_3}$ is higher, which means that Currency 2 is more affected by inflation. Currency 1 is relatively stronger than Currency 2. A higher weight should be assigned to Currency 1. More weight should be assigned to the currency that is less affected by inflation.

Table 3.2a shows the relationship between λ_1 and η_1 an $\sigma^2_{E_3}$, when $(\sigma_{P_1E_3} + \sigma_{P_2E_3})$ is positive. Table 3.2b shows the relationship between λ_1 and η_1 an $\sigma^2_{E_3}$, when $(\sigma_{P_1E_3} + \sigma_{P_2E_3})$ is negative. The results suggest that the relationship between the optimal weight and these variables differ when the sign of $(\sigma_{P_1E_3} + \sigma_{P_2E_3})$ changes. When $(\sigma_{P_1E_3} + \sigma_{P_2E_3})$ is positive, λ_1 decreases with η_1 and increases with $\sigma^2_{E_3}$, while when $(\sigma_{P_1E_3} + \sigma_{P_2E_3})$ is negative, λ_1 increases with η_1, and decreases with $\sigma^2_{E_3}$. The relationship between the reserve requirement u and λ_1 is not affected by the sign of $(\sigma_{P_1E_3} + \sigma_{P_2E_3})$. λ_1 always decreases when u increases. When the tax on capital inflows becomes higher, less weight should be assigned to Currency 1. As u increases, the domestic interest rate tends to increase. The domestic currency is

subject to an appreciation pressure. Currency 1 is more valuable than Currency 2. Reducing the weight of Currency 1 will increase the flexibility of the domestic currency and reduce the pressure of the central bank to defend the exchange rates.

Since $\sigma_{P_1E_3}>0$ and $\sigma_{P_2E_3}<0$, $(\sigma_{P_1E_3}+\sigma_{P_2E_3})$ can be both positive and negative. The effects of the relative importance of the volatility of output η_1 and the volatility of the cross exchange rate $\sigma_{E_3}^2$ on the choice of the optimal weight are affected by the sign of $(\sigma_{P_1E_3}+\sigma_{P_2E_3})$. If $\sigma_{P_1E_3}>\left|\sigma_{P_2E_3}\right|$, $(\sigma_{P_1E_3}+\sigma_{P_2E_3})$ is positive, which means that the cross exchange rate is more affected by the inflation in Country 1. If $\sigma_{P_1E_3}<\left|\sigma_{P_2E_3}\right|$, $(\sigma_{P_1E_3}+\sigma_{P_2E_3})$ is negative, which means that the cross exchange rate is less affected by the inflation in Country 1. The result shows that more weight should be assigned to the currency of the country whose inflation has more effects on the fluctuations of the cross exchange rate when the cross exchange rate becomes more volatile, and less weight should be assigned to that currency if the stability of output is more important. When the cross exchange rates become more volatile, pegging to the less stable currency can increase the flexibility of the domestic currency, avoid speculative attack, reduce the risk of currency crises, and minimize the variance of output and trade balance.

3.4 Conclusion

In this paper, a three-country model is used to find the optimal weights in a currency basket for emerging market economies. For emerging economies, volatilities of trade balance and output can affect growth adversely. To determine the optimal weights, a loss function including the volatility of trade balance and output is minimized. The assumption of perfect capital mobility in Turnovsky (1982) is relaxed.

Capital inflows are subject to a tax in the form of a reserve requirement, which is held in the same currencies that enter in the currency basket. Uncovered interest rate parity does not hold because of this tax. The domestic interest rate is affected by the reserve requirement, and then trade balance, output, and the optimal weight of the currency basket are affected.

The optimal choice of weights is affected by relative importance of the volatility of output in the loss function, the volatility of the cross exchange rate between the foreign currencies, the reserve requirement for capital inflows, and the relationship between foreign price level and the cross exchange rate. The relative relationship between foreign price level and the cross exchange rate can influence the effects of the volatility of the cross exchange rate and the reserve requirement on the choice of the optimal weight. Other things constant, more weight should be assigned to the currency that is less affected by inflation. More weight should be assigned to the currency of the country whose inflation has more effects on the fluctuations of the cross exchange rate when the cross exchange rate becomes more volatile, and less weight should be assigned to that currency if the stability of output is more important.

For future study, the model can be extended by letting the reserve requirement vary over time, so that it becomes a variable instead of a constant. In this paper, the domestic price is not affected by exogenous variables. The model can be revised by making the domestic price affected by foreign prices. The assumption that the cross exchange rate is not correlated with foreign interest rate can be relaxed so that the covariance between the cross exchange rate and foreign interest rate will affect the optimal weight.

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Appendix A: Tables

Table 1.1 Openness of Northeast Asia

	1980	1990	1995	1997	1998	2000	2001	2002	2003
China	15.48	35.52	45.68	41.38	39.21	49.06	48.54	54.77	66.13
Japan	28.16	18.32	16.80	20.42	19.56	20.18	20.16	21.13	22.01
Korea	70.92	55.82	58.75	65.39	79.46	78.49	73.31	69.12	73.81
Taiwan	-	59.12	65.06	61.44	52.67	66.366	54.26	55.93	62.02

Note: Data of China, Japan, and Korea are from the Development Indicator of World Bank. Openness of Taiwan is calculated using data from http://eng.stat.gov.tw and http://cus93.trade.gov.tw.

Table 1.2 Shares of trade (%)

		China	Japan	Korea	Taiwan	Intra-regional	U.S.	Euro Area	Other
China	1991	-	14.96	2.47	0.44	17.87	10.44	10.42	61.27
	1997	-	18.71	7.39	1.40	27.50	15.08	10.68	46.74
	2003	-	15.69	7.43	3.80	26.92	14.87	12.25	45.96
Japan	1991	4.14	-	5.89	5.09	15.12	26.44	13.99	44.45
	1997	8.36	-	5.36	5.36	19.09	25.58	10.95	44.38
	2003	15.52	-	6.16	5.20	26.88	20.69	11.16	41.27
Korea	1991	2.35	23.31	-	2.12	25.74	27.78	11.10	21.17
	1997	8.16	14.76	-	2.56	25.48	17.96	9.18	47.38
	2003	15.35	14.42	-	3.57	33.34	15.96	9.58	41.12
Taiwan	1991	0.43	20.17	2.18	-	22.78	26.21	12.39	38.62
	1997	1.92	17.21	3.13	-	22.26	22.32	11.91	43.51
	2003	11.93	16.41	4.89	-	33.23	15.76	9.51	41.50

Note: Shares of trade are calculated using data form Direction of Trade Statistics Yearbook, International Monetary Fund (IMF). Shares of trade of Taiwan are calculated using data from http://cus93.trade.gov.tw.

Table 1.3 The weight of each currency in the real effective exchange rate

	China	Japan	Korea	Taiwan
U.S. Dollar	0.34	0.70	0.43	0.42
Euro	0.26	0.30	0.21	0.22
Japanese yen	0.40	-	0.36	0.36

Note: Calculated using data from Direction of Trade Statistics Yearbook, IFM

Table 1.4 Summary statistics (log difference)

	Real GDP Growth		Real Effective Exchange Rate Changes	
	Mean	Std. Dev.	Mean	Std. Dev.
China	0.0904	0.0263	0.0669	0.1403
Japan	0.0300	0.0228	-0.0064	0.1191
Korea	0.0678	0.0357	0.0204	0.1588
Taiwan	0.0709	0.0348	0.0156	0.1055
	Real Money Balance Growth		Inflation	
	Mean	Std. Dev.	Mean	Std. Dev.
China	0.1625	0.0663	0.0486	0.0499
Japan	0.0416	0.0481	0.0331	0.0452
Korea	0.1080	0.0723	0.0808	0.0652
Taiwan	0.1160	0.0895	0.0458	0.0726

Table 1.5a Correlation of real GDP growth

	China	Japan	Korea	Taiwan
China	-			
Japan	-0.08 (0.96)	-		
Korea	0.20 (0.33)	0.37 (0.03)	-	
Taiwan	0.33 (0.09)	0.62 (0.00)	0.42 (0.01)	-

Note: Numbers in parentheses are p-values.

Table 1.5b Correlation of real effective exchange rate growth

	China	Japan	Korea	Taiwan
China	-			
Japan	-0.17 (0.41)	-		
Korea	0.21 (0.30)	-0.08 (0.66)	-	
Taiwan	0.54 (0.00)	-0.23 (0.19)	0.14 (0.43)	-

Note: Numbers in parentheses are p-values.

Table 1.5c Correlation of real money balance growth

	China	Japan	Korea	Taiwan
China	-			
Japan	-0.18 (0.37)	-		
Korea	-0.21 (0.30)	0.33 (0.06)	-	
Taiwan	-0.18 (0.38)	0.67 (0.00)	0.48 (0.00)	-

Note: Numbers in parentheses are p-values.

Table 1.5d Correlation of inflation

	China	Japan	Korea	Taiwan
China	-			
Japan	-0.03 (0.90)	-		
Korea	-0.06 (0.77)	0.71 (0.00)	-	
Taiwan	0.04 (0.84)	0.80 (0.00)	0.71 (0.00)	-

Note: Numbers in parentheses are p-values.

Table 1.6 Variance decomposition of real GDP growth

	S.E	Supply Shock	Exchange Rate Shock	Monetary Shock	Demand Shock
China					
1	0.023	79.69	8.05	9.19	3.06
5	0.029	82.19	6.50	7.10	4.20
10	0.029	81.79	6.44	7.06	4.72
Japan					
1	0.016	21.39	10.38	11.51	56.71
5	0.021	39.12	8.27	15.53	37.08
10	0.021	39.81	8.15	15.34	36.70
Korea					
1	0.033	11.46	19.36	50.22	18.96
5	0.039	12.92	15.60	37.63	33.85
10	0.039	15.06	15.21	36.58	33.14
Taiwan					
1	0.025	38.51	0.68	13.53	47.28
5	0.035	51.26	10.76	12.00	25.98
10	0.036	53.15	10.37	11.41	25.07

Table 1.7a Correlation of supply shocks 1971-2004

	China	Japan	Korea	Taiwan
China	-			
Japan	-0.36 (0.07)	-		
Korea	-0.22 (0.29)	0.20 (0.27)	-	
Taiwan	0.05 (0.81)	0.33 (0.06)	0.41 (0.02)	-

Note: Numbers in parentheses are p-values.

Table 1.7b Correlation of exchange rate shocks 1971-2004

	China	Japan	Korea	Taiwan
China	-			
Japan	0.07 (0.73)	-		
Korea	0.09 (0.65)	-0.05 (0.78)	-	
Taiwan	0.45 (0.02)	0.06 (0.74)	0.16 (0.36)	-

Note: Numbers in parentheses are p-values.

Table 1.7c Correlation of monetary shocks 1971-2004

	China	Japan	Korea	Taiwan
China	-			
Japan	0.08 (0.71)	-		
Korea	0.09 (0.65)	0.19 (0.29)	-	
Taiwan	-0.50 (0.01)	0.09 (0.61)	-0.07 (0.69)	-

Note: Numbers in parentheses are p-values.

Table 1.7d Correlation of demand shocks 1971-2004

	China	Japan	Korea	Taiwan
China	-			
Japan	-0.34 (0.09)	-		
Korea	-0.0 8(0.71)	0.27 (0.13)	-	
Taiwan	- 0.01 (0.96)	0.53 (0.00)	0.28 (0.12)	-

Note: Numbers in parentheses are p-values.

Table 1.8 Variance decomposition of real GDP for exchange rate union of the U.S. dollar

	S.E.	U.S. Supply Shocks	U.S. Monetary Shocks	U.S. Demand Shocks	Domestic Supply Shocks	Domestic Monetary Shocks	Domestic Demand Shocks
China							
1	0.022	14.59	39.49	2.13	33.42	8.66	1.71
5	0.030	15.87	35.90	2.03	38.05	6.89	1.27
10	0.030	15.96	35.92	2.03	37.95	6.87	1.27
Japan							
1	0.016	1.91	15.25	4.38	24.27	16.09	38.10
5	0.022	1.78	12.50	14.04	31.65	17.07	22.97
10	0.022	1.74	12.12	16.54	30.74	16.55	22.31
Korea							
1	0.036	1.05	10.15	2.214	68.21	17.06	1.32
5	0.041	2.47	12.96	3.85	60.73	18.64	1.35
10	0.041	4.23	12.76	4.23	59.25	18.20	1.33
Taiwan							
1	0.026	0.24	48.92	16.50	1.74	22.83	9.78
5	0.035	10.06	30.59	14.12	20.19	17.03	8.01
10	0.036	9.50	29.45	18.73	18.91	15.92	7.49

Table 1.9 Variance decomposition of real GDP for exchange rate union of the Japanese yen

	S.E.	Japan Supply Shocks	Japan Monetary Shocks	Japan Demand Shocks	Domestic Supply Shocks	Domestic Monetary Shocks	Domestic Demand Shocks
China							
1	0.019	57.67	0.82	14.32	22.69	0.01	4.49
5	0.033	34.49	14.61	28.46	17.54	2.44	2.46
10	0.036	29.70	17.81	28.05	14.42	6.56	3.48
Korea							
1	0.036	9.67	6.26	13.49	56.31	13.58	0.69
5	0.040	8.01	11.50	13.75	49.86	15.91	0.98
10	0.040	8.53	11.43	13.87	49.42	15.77	0.98
Taiwan							
1	0.026	17.08	5.34	26.80	19.40	28.46	2.92
5	0.034	23.67	13.48	18.16	17.18	24.27	3.26
10	0.035	25.19	13.26	18.21	16.65	23.51	3.19

Table 1.10 Variance decomposition of real GDP growth for the exchange rate union with a regional currency basket

	S.E.	Regional Supply Shocks	Regional Monetary Shocks	Regional Demand Shocks	Domestic Supply Shocks	Domestic Monetary Shocks	Domestic Demand Shocks
China							
1	0.019	23.70	0.45	6.48	69.36	0.00	0.00
5	0.033	18.40	12.45	18.62	42.30	4.02	4.21
10	0.036	18.55	13.05	20.80	35.14	5.80	6.67
Japan							
1	0.011	84.95	0.69	3.07	11.29	0.00	0.00
5	0.019	32.56	41.49	2.28	15.00	8.32	0.35
10	0.020	29.67	38.83	4.46	15.80	9.43	1.81
Korea							
1	0.036	41.29	1.77	7.35	49.59	0.00	0.00
5	0.046	32.27	10.65	8.11	31.57	9.96	7.44
10	0.0466	32.22	11.17	8.01	30.91	10.13	7.55
Taiwan							
1	0.023	3.83	2.38	28.29	65.51	0.00	0.00
5	0.031	8.97	8.14	20.49	40.80	14.65	6.96
10	0.034	9.87	8.36	25.82	35.05	13.88	7.02

Table 1.11 Variance decomposition of real GDP growth for the exchange rate union with a major currency basket

	S.E.	External Supply Shocks	External Demand Shocks	Domestic Supply Shocks	Domestic Demand Shocks
China					
1	0.032	0.00	42.37	56.89	0.74
5	0.034	0.69	47.65	50.98	0.68
10	0.035	1.13	48.81	49.38	0.68
Japan					
1	0.018	31.15	5.52	63.33	0.00
5	0.022	40.79	3.87	46.87	8.48
10	0.022	40.80	3.93	45.86	9.42
Korea					
1	0.032	30.81	12.30	12.58	44.31
5	0.041	25.70	22.64	10.76	40.90
10	0.042	25.91	24.09	10.32	39.68
Taiwan					
1	0.031	48.14	1.09	45.55	5.22
5	0.035	45.44	3.57	43.63	7.36
10	0.035	45.84	4.85	42.19	7.12

Table 1.12 Literature of currency union in Asia

	Model	Variables	Region	Result
Bayoumi & Eichengreen (1994)	SVAR	Demand and supply shocks	Europe, East Asia and Pacific	**Northeast Asia**: Japan, Korea, and Taiwan; **Southeast Asia**: Hong Kong, Indonesia, Malaysia, Singapore; **Europe**: Austria, Belgium, Denmark, Germany, the Netherlands, Switzerland
Chow & Kim (2003)	SVAR	Global, regional, and domestic supply shocks	East Asia and Western Europe	No currency union
Kwack (2004)	SVAR	Demand and supply shocks	East Asia	No currency union
Zhang, Sato, & McAleer (2004)	SVAR	Supply, demand, and monetary shocks	East Asia and Europe	No currency union among the 9 East Asian economies
Huang & Guo (2005)	SVAR	World supply shocks, domestic supply, demand, and monetary shocks	East Asia	Hong Kong, Indonesia, Korea, Malaysia, Singapore, Thailand

Table 1.13a Correlation of supply shocks 1971-1996

	China	Japan	Korea	Taiwan
China	-			
Japan	-0.44 (0.07)	-		
Korea	0.35 (0.15)	-0.22 (0.29)	-	
Taiwan	0.03 (0.90)	0.46 (0.02)	0.19 (0.36)	-

Note: Numbers in parentheses are p-values.

Table 1.13b Correlation of exchange rate shocks 1971-1996

	China	Japan	Korea	Taiwan
China	-			
Japan	0.14 (0.58)	-		
Korea	0.16 (0.53)	-0.04 (0.84)	-	
Taiwan	0.15 (0.56)	-0.04 (0.83)	-0.01 (0.96)	-

Note: Numbers in parentheses are p-values.

Table 1.13c Correlation of monetary shocks 1971-1996

	China	Japan	Korea	Taiwan
China	-			
Japan	0.07 (0.80)	-		
Korea	0.08 (0.76)	0.01 (0.97)	-	
Taiwan	-0.63(0.00)	0.21 (0.31)	-0.02 (0.92)	-

Note: Numbers in parentheses are p-values.

Table 1.13d Correlation of demand shocks 1971-1996

	China	Japan	Korea	Taiwan
China	-			
Japan	-0.38 (0.12)	-		
Korea	0.10(0.70)	0.02 (0.94)	-	
Taiwan	- 0.03 (0.91)	0.33 (0.11)	0.61 (0.00)	-

Note: Numbers in parentheses are p-values.

Table 2.1 List of countries

	Country Name
Emerging market economies	Argentina, Brazil, Chile, Colombia, Czech Republic(*), Egypt, Indonesia, Israel, Jordan, Korea, Malaysia, Mexico, Morocco(**), Pakistan, Peru, Philippines, Poland (*), South Africa, Thailand, Turkey, and Venezuela
Developing economies	Algeria, Angola, Armenia, Bangladesh, Belarus, Belize, Benin(**), Bhutan, Bolivia, Botswana, Bulgaria(*), Burkina Faso(**), Burundi, Cambodia, Cameroon(**), Central African Republic(**), Chad(**), Republic of Congo(**), Costa Rica, Cote d'Ivoire(**), Croatia(*), Dominica, Dominican Republic, Ecuador, El Salvador, Equatorial Guinea(**), Estonia(*), Ethiopia, Fiji, Ghana, Grenada, Guatemala, Guinea-Bissau(**), Honduras, Jamaica, Kazakhstan, Kenya, Kyrgyz Republic, Latvia, Lesotho, Lithuania, Madagascar(**), Malawi, Maldives, Mali(**), Moldova(*), Mongolia, Mozambique, Namibia, Nepal, Nicaragua, Niger(**), Nigeria, Oman, Papua New Guinea, Paraguay, Romania(*), Rwanda, Samoa, Senegal(**), Seychelles, Sierra Leone, Slovak Republic(*), Slovenia(*), Solomon Islands, Sri Lanka, St. Kitts and Nevis, St. Lucia, St. Vincent & Grenadines, Sudan, Suriname, Swaziland, Togo(**), Trinidad and Tobago, Tunisia(**), Uganda, Ukraine, Uruguay, Zambia, and Zimbabwe.[23]

[23] * denotes exchange rate against German mark; **denotes exchange rate against French Franc.

Table 2.2 Data definitions and sources

Variable	Definition	Sources
Exchange rates	End-of-period bilateral nominal exchange rates, versus the German mark for the European countries(*), versus the French franc for selected African countries(**), and versus the US dollar for all others	IFS (line ae)
Foreign reserves	Gross foreign reserves minus gold	IFS (line 1L.d)
Interest rates	Money market interest rate; if not available, Treasury-bill rate if available, or deposit rate if available, or lending rate	IFS (lines 60B, 60C, 60L, or 60P)
FLEX1	The ratio of standard deviation of monthly percent changes in nominal exchange rate to the sum of standard deviation of monthly percent change in foreign reserves and standard deviation in monthly interest rate	
FLEX2	The ratio of standard deviation of monthly percent changes in nominal exchange rate to the standard deviation of monthly percent changes in reserves relative to the monetary base in the previous period. Reserves are calculated as central bank's foreign assets net of foreign liabilities and government deposits at the central bank.	IFS (lines 11, 14, 16c, 16d)
MISM1	Ratio of bank foreign liabilities to bank foreign assets	IFS (lines 21.ZF, 26C.ZF)
MISM2	Ratio of bank foreign liabilities plus domestic foreign currency-denominated deposits to bank foreign assets	IFS (lines 21.ZF, 26C.ZF) and Levy-Yeyati (2006)
LIAB1	Ratio of bank foreign liabilities to M2	IFS (lines 26C.ZF, 34 and 35)
LIAB2	Ratio of bank foreign liabilities plus domestic foreign currency-denominated deposits to M2	IFS (lines 26C.ZF, 34 and 35) and Levy-Yeyati (2006)
TradeOpen	Ratio of total exports and imports of goods and services to GDP	WDI
CALiberaliz	The first principle component of four IMF binary variables, the existence of multiple exchange rates, restrictions on current account, capital account transactions, and the requirement of the surrender of export proceeds	Chinn and Ito (2006)
FinanDevelop	Sum of (standardized indices of) ratio of liquid liabilities to GDP and ratio of domestic credit to private sector to GDP	IFS (lines 22D.ZF) and WDI
Inflation	Rate of change in consumer price index	IFS (line 64..XZF)
FiscalBudget	Overall budget balance, including grants, to GDP	WDI
TotGr	The growth rate of exports as a capacity to import (the current price value of exports of goods and services deflated by the import price index, in domestic currency)	WDI
RealGDPGr	Rate of growth of real GDP per capita (in thousands of constant 1995 US dollars)	WDI

Table 2.3 Summary statistics and correlation analysis

Variable	Obs.	Mean	Std. Dev.	Min.	Max.	Correlation with:				
						FLEX1	FLEX2	MISM1	MISM2	LIAB1
FLEX1	1669	0.19	0.32	0.00	2.98					
FLEX2	1669	24.49	44.55	0.00	397.32	0.56** (0.00)				
MISM1	1669	1.26	1.62	0.00	21.07	-0.09** (0.00)	-0.04 (0.12)			
MISM2	778	2.73	3.37	0.04	35.41	-0.09** (0.01)	-0.02 (0.51)	0.48** (0.00)		
LIAB1	1669	0.12	0.13	0.00	1.28	-0.07** (0.00)	0.00 (0.95)	0.21** (0.00)	0.01 (0.88)	
LIAB2	778	0.37	0.27	0.01	1.57	-0.07** (0.05)	0.08** (0.02)	0.04 (0.30)	0.29** (0.00)	0.67** (0.00)

p-values are reported in parentheses below coefficients. ** Significant coefficient at 5% significance level.

Table 2.4a Multivariate Granger causality tests: Effects of balance sheets on exchange rate flexibility

Dependent Variable: FLEX								
	MISM1				MISM2			
	FLEX1-OLS	FLEX1-GMM	FLEX2-OLS	FLEX2-GMM	FLEX1-OLS	FLEX1-GMM	FLEX2-OLS	FLEX2-GMM
FLEX t-1	0.0487	0.1055***	0.1543**	0.2059***	0.1804**	0.2904	0.3425***	0.3098**
	(0.0675)	(0.0387)	(0.0742)	(0.0714)	(0.0879)	(0.2422)	(0.0956)	(0.1528)
FLEX t-2	0.0591							
	(0.0682)							
FLEX t-3	-0.0003							
	(0.0634)							
FLEX t-4	-0.0662							
	(0.0664)							
MISM t-1	-0.0047	-0.0118	-0.7839	-1.1435	-0.0029	-0.0076	0.5295	-0.8219
	(0.0048)	(0.0076)	(0.7505)	(1.0385)	(0.0044)	(0.0067)	(0.5493)	(3.6159)
MISM t-2	-0.0096**							
	(0.0040)							
MISM t-3	-0.0072*							
	(0.0041)							
MISM t-4	-0.0009							
	(0.0011)							
TradeOpen	-0.0005	-0.0005	-0.0098	-0.1315*	0.0001	-0.0029*	-0.2535	-0.2523
TotGr	0.0005	0.0000	-0.1288	-0.0008	0.0001	0.0002	0.0361	-0.0517
RealGDPGr	-0.0043	0.0013	-0.4264	0.0239	-0.0070	0.0018	-0.6440	-0.9095
Inflation	-0.0014	0.0000	-0.0073	0.0166***	-0.0000	0.0000	-0.0227**	0.0078
FiscalBudget	-0.0019	0.0058	-0.4043	-0.7108	-0.0036	-0.0021	0.6026	-1.2629
FinanDevelop	0.0764	0.0634*	3.9346	4.8108*	0.2419***	0.0931	32.3809**	7.8377
CALiberaliz	-0.0129	-0.0122	-0.4876	-2.1843	-0.0646**	-0.0285*	-2.7912	-1.3016
Observations	515	677	695	695	309	309	312	312
MISM GC FLEX	**Y**	**N**	**N**	**N**	**N**	**N**	**N**	**N**

Robust standard errors (adjusted for heteroskedasticity and cluster serial correlation) for all specifications are reported in parentheses. Year dummies are included.
*** Significant at 1%, ** Significant at 5%, * Significant at 10%

Table 2.4b Multivariate Granger causality tests: Effects of balance sheets on exchange rate flexibility

Dependent Variable: FLEX								
	LIAB1				LIAB2			
	FLEX1-OLS	FLEX1-GMM	FLEX2-OLS	FLEX2-GMM	FLEX1-OLS	FLEX1-GMM	FLEX2-OLS	FLEX2-GMM
FLEX t-1	0.0161	0.0815**	0.1534**	0.2078***	0.1846**	0.1762	0.3418***	0.3150***
	(0.0409)	(0.0360)	(0.0752)	(0.0547)	(0.0841)	(0.1103)	(0.0907)	(0.0679)
FLEX t-2								
FLEX t-3								
FLEX t-4								
LIAB t-1	-0.2836**	-0.4055	-22.5728	-65.7917	-0.0269	-0.3689	-3.3786	2.4804
	(0.1349)	(0.3153)	(20.7530)	(52.7026)	(0.3216)	(0.2969)	(38.1976)	(24.1810)
LIAB t-2								
LIAB t-3								
LIAB t-4								
TradeOpen	0.0008	-0.0006	-0.0020	-0.0946	-0.0000	-0.0022***	-0.2207	-0.1319
TotGr	-0.0004	-0.0000	-0.1299	-0.0214	0.0000	0.0008	0.0365	0.0764
RealGDPGr	-0.0047	0.0031	-0.4440	0.0796	-0.0071	-0.0015	-0.5981	-0.6462
Inflation	0.0001	0.0001**	-0.0070	0.0154***	-0.0000	0.0000	-0.0224**	0.0062
FiscalBudget	-0.0046	0.0046	-0.4305*	-0.7347	-0.0031	-0.0030	0.4409	-1.7861
FinanDevelop	0.1065*	0.0866***	3.7371	6.4358**	0.2490***	0.0957**	30.5628**	7.7118**
CALiberaliz	-0.0412**	-0.0086	-0.6303	-0.9526	-0.0681**	-0.0076	-1.8715	-2.5054
Observations	677	677	695	695	309	309	312	312
LIAB GC FLEX	**Y**	**N**	**N**	**N**	**N**	**N**	**N**	**N**

Robust standard errors (adjusted for heteroskedasticity and cluster serial correlation) for all specifications are reported in parentheses. Year dummies are included.
*** Significant at 1%, ** Significant at 5%, * Significant at 10%

Table 2.5a Multivariate Granger causality tests: Effects of exchange rate flexibility on balance sheets

Dependent Variable: MISM								
	FLEX1		**FLEX2**		**FLEX1**		**FLEX2**	
	MISM1-OLS	MISM1-GMM	MISM1-OLS	MISM1-GMM	MISM2-OLS	MISM2-GMM	MISM2-OLS	MISM2-GMM
MISM t-1	0.4577***	0.6350***	0.2954**	0.4369***	0.7997***	0.9510***	0.8072***	0.9539***
	(0.0904)	(0.0654)	(0.1389)	(0.1437)	(0.0189)	(0.0367)	(0.0171)	(0.0667)
MISM t-2			0.2269***	0.3140**				
			(0.0474)	(0.1577)				
MISM t-3			0.1045					
			(0.1422)					
MISM t-4								
FLEX t-1	-0.0970**	-0.1775*	-0.0017**	-0.0020**	-0.1375	0.2950	-0.0006	0.0012
	(0.0477)	(0.1050)	(0.0008)	(0.0008)	(0.2733)	(0.5411)	(0.0012)	(0.0050)
FLEX t-2			-0.0008*	-0.0004				
			(0.0005)	(0.0004)				
FLEX t-3			-0.0005					
			(0.0004)					
FLEX t-4								
TradeOpen	0.0042	-0.0028**	0.0069**	-0.0011	0.0040	0.0038	0.0050	-0.0034
TotGr	-0.0016	-0.0005	-0.0012	-0.0003	0.0176	0.0205	0.0183	0.0136
RealGDPGr	0.0168	0.0079	0.0124	0.0127	0.0568	0.0486	0.0548	0.0159
Inflation	-0.0001	0.0000	0.0007	0.0001	0.0006	-0.0001	-0.0002	-0.0005
FiscalBudget	0.0144	0.0182	0.0113	0.0135	-0.0769	-0.0393	-0.0867	0.0124
FinanDevelop	0.1832	0.0926	0.0417	0.0477	0.1312	-0.1814*	0.0829	-0.1264
CALiberaliz	0.0584	0.0035	0.0242	-0.0023	-0.0690	-0.0669	-0.0694	0.0298
Observations	677	677	615	660	306	306	309	309
FLEX GC MISM	**Y**	**Y**	**Y**	**Y**	**N**	**N**	**N**	**N**

Robust standard errors (adjusted for heteroskedasticity and cluster serial correlation) for all specifications are reported in parentheses. Year dummies are included.
*** Significant at 1%, ** Significant at 5%, * Significant at 10%

Table 2.5b Multivariate Granger causality tests: Effects of exchange rate flexibility on balance sheets

Dependent Variable: LIAB								
	FLEX1		**FLEX2**		**FLEX1**		**FLEX2**	
	LIAB1-OLS	LIAB1-GMM	LIAB1-OLS	LIAB1-GMM	LIAB2-OLS	LIAB2-GMM	LIAB2-OLS	LIAB2-GMM
LIAB t-1	0.8380***	0.8624***	0.8527***	0.3939*	0.8619***	0.9451***	0.8782***	0.6870**
	(0.1184)	(0.0937)	(0.1000)	(0.2378)	(0.1394)	(0.0644)	(0.1402)	(0.2820)
LIAB t-2	-0.0672		-0.0683	0.2143	-0.1081		-0.1111	0.0904
	(0.1148)		(0.0999)	(0.1618)	(0.1340)		(0.1378)	(0.2445)
LIAB t-3	0.0069		-0.0259	0.0047	0.0448		0.0324	0.1404
	(0.0506)		(0.0677)	(0.1889)	(0.1128)		(0.0981)	(0.0884)
LIAB t-4	-0.0865*		-0.0473	0.1222	-0.0115		-0.0319	
	(0.0485)		(0.0459)	(0.1345)	(0.0903)		(0.0999)	
FLEX t-1	-0.0110***	-0.0056	-0.0001	-0.0001**	-0.0391***	-0.0000	-0.0000	0.0000
	(0.0036)	(0.0040)	(0.0001)	(0.0001)	(0.0083)	(0.0000)	(0.0002)	(0.0005)
FLEX t-2	0.0012		-0.0000***	-0.0001	0.0074		-0.0000	-0.0002
	(0.0042)		(0.0000)	(0.0001)	(0.0126)		(0.0002)	(0.0002)
FLEX t-3	-0.0044		-0.0001***	-0.0000	-0.0201		-0.0002***	-0.0002
	(0.0038)		(0.0000)	(0.0001)	(0.0148)		(0.0001)	(0.0001)
FLEX t-4	0.0084		-0.0000	0.0000	0.0192		0.0002	
	(0.0120)		(0.0000)	(0.0001)	(0.0124)		(0.0001)	
TradeOpen	0.0001	-0.0000	0.0001	-0.0001	-0.0019**	-0.0001	-0.0016*	-0.0001
TotGr	0.0001	-0.0000	0.0001	0.0001	0.0011**	-0.0000	0.0008	0.0003
RealGDPGr	0.0002	0.0007	0.0002	0.0002	0.0043*	0.0004	0.0049	-0.0001
Inflation	0.0008*	-0.0000**	0.0006*	-0.0001	-0.0015	0.0000	-0.0023	0.0002
FiscalBudget	0.0010	0.0012***	0.0010	0.0000	-0.0014	0.0005	-0.0028	-0.0025
FinanDevelop	0.0049	0.0054	0.0017	0.0159**	0.1874***	0.0033	0.1576**	-0.0030
CALiberaliz	0.0040	0.0036	0.0013	0.0075**	0.0092	0.0034	0.0067	-0.0080
Observations	514	677	570	570	207	695	212	242
FLEX GC LIAB	**Y**	**N**	**Y**	**Y**	**Y**	**N**	**Y**	**Y**

Robust standard errors (adjusted for heteroskedasticity and cluster serial correlation) for all specifications are reported in parentheses. Year dummies are included.
*** Significant at 1%, ** Significant at 5%, * Significant at 10%

Table 2.6 Variance decomposition for panel VAR (no contemporaneous effects from balance sheets to exchange rate flexibility)

		FLEX1	FLEX2	MISM1	MISM2	LIAB1	LIAB2
(1)	FLEX1	51.74		1.69			
	MISM1	0.28		89.07			
(2)	FLEX2		78.92	0.12			
	MISM1		4.11	85.54			
(3)	FLEX1	3.02			0.04		
	MISM2	1.91			2.08		
(4)	FLEX2		6.43		0.00		
	MISM2		0.36		3.00		
(5)	FLEX1	73.80				0.14	
	LIAB1	2.25				72.99	
(6)	FLEX2		78.74			0.31	
	LIAB1		0.17			88.47	
(7)	FLEX1	35.08					0.95
	LIAB2	5.71					65.95
(8)	FLEX2		75.61				2.12
	LIAB2		1.98				69.90

Each entry reports the percentage of variation in the row variable explained by column variable. Variance decomposition performed over a 10 year period. Also included in the estimations are FinanDevelop, CALiberaliz, TradeOpen, and Inflation.

Table 3.1 Countries pegging or managing against a currency basket

Country	Exchange Rate Regime	Currency	Composition of Currency Basket
Botswana	Crawling peg	pula	SDR and the South African rand
Fiji	Conventional peg	dollar	The Australian dollar, the yen , the New Zealand dollar, the euro and the U.S. dollar
Jordan	Conventional peg	dinar	SDR
Latvia	Conventional peg	lats	SDR
Libyan Arab Jamahiriya	Conventional peg	dinar	SDR
Malaysia	Conventional peg	ringgit	Unknown
Malta	Conventional peg	lira	The U.S. dollar, the euro, and the pound sterling
Morocco	Conventional peg	dirham	Currencies of trading partners
Myanmar	Managed floating	kyat	SDR
Samoa	Conventional peg	tala	The Australian dollar, the euro, the Fiji dollar, the New Zealand dollar, and the U.S. dollar
Seychelles	Conventional peg	rupee	The euro, the yen, the pound sterling, the Singapore dollar, the South African rand, and the U.S. dollar
Solomon Islands	Crawling peg	dollar	Currencies of its four major trading partners
Tonga	Pegged exchange rate within horizontal bands	pa'anga	The Australian dollar, the yen, the New Zealand dollar, and the U.S. dollar
Vanuatu	Conventional peg	vatu	Currencies of major trading partners

Source: IMF Annual Report on Exchange Arrangements and Exchange Restrictions, 2005

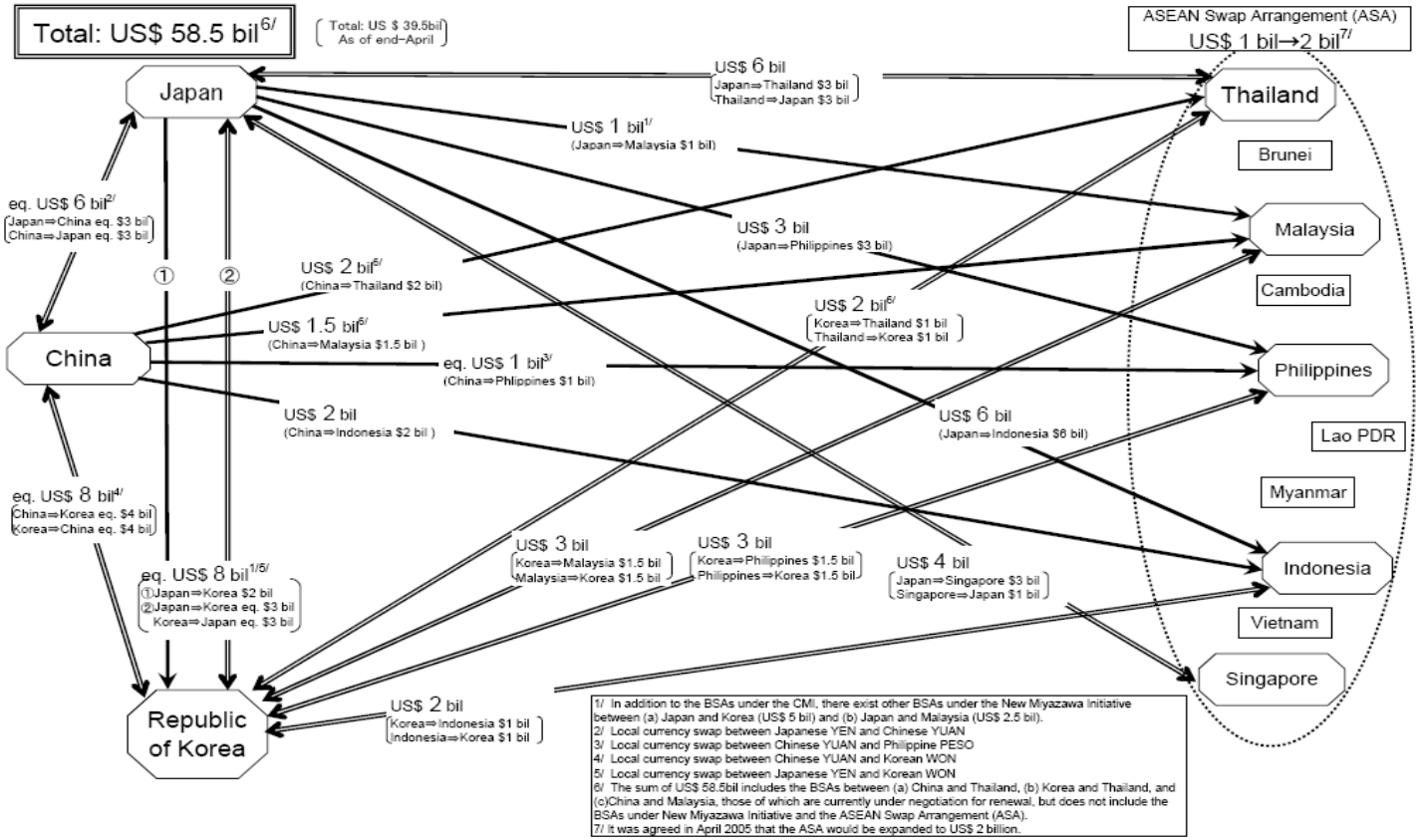
Table 3.2.a Result of simulation using numerical solver ($\sigma_{P_1E_3} + \sigma_{P_2E_3} > 0$)

$\sigma^2_{E_3} = 0.01;\ \sigma_{P_1E_3} = 0.05;$ $u = 0.02;\ \sigma_{P_2E_3} = -0.04$		$\eta_1 = 0.4;\ \sigma_{P_1E_3} = 0.05;$ $u = 0.02;\ \sigma_{P_2E_3} = -0.04$		$\eta_1 = 0.4; \sigma_{P_1E_3} = 0.05;$ $\sigma^2_{E_3} = 0.01;\ \sigma_{P_2E_3} = -0.04$		$\eta_1 = 0.4; \sigma^2_{E_3} = 0.01;$ $u = 0.02;\ \sigma_{P_2E_3} = -0.1$		$\eta_1 = 0.4; \sigma^2_{E_3} = 0.01;$ $u = 0.02;\ \sigma_{P_1E_3} = 0.1$	
η_1	λ_1	$\sigma^2_{E_3}$	λ_1	u	λ_1	$\sigma_{P_1E_3}$	λ_1	$\sigma_{P_2E_3}$	λ_1
0.05	0.4526	0.005	0.4044	0.01	0.4053	0.01	0.6854	-0.01	0.2596
0.10	0.4517	0.010	0.4464	0.02	0.4053	0.02	0.6815	-0.02	0.2724
1.15	0.4508	0.015	0.4629	0.03	0.4053	0.03	0.6765	-0.03	0.2869
0.20	0.4499	0.020	0.4716	0.04	0.4053	0.04	0.6699	-0.04	0.3035
0.25	0.4490	0.025	0.4770	0.05	0.4052	0.05	0.6610	-0.05	0.3226
0.30	0.4481	0.030	0.4807	0.06	0.4052	0.06	0.6480	-0.06	0.3451
0.35	0.4473	0.035	0.4833	0.07	0.4052	0.07	0.6284	-0.07	0.3722
0.40	0.4464	0.040	0.4853	0.08	0.4052	0.08	0.5975	-0.08	0.4053
0.45	0.4456	0.045	0.4869	0.09	0.4052	0.09	0.5515	-0.09	0.4464
0.50	0.4448	0.050	0.4881	0.10	0.4052	0.10	0.4968	-0.10	0.4968
0.55	0.4440	0.055	0.4892	0.11	0.4052	0.11	0.4464	-0.11	0.5515
0.60	0.4432	0.060	0.4900	0.12	0.4052	0.12	0.4053	-0.12	0.5975
0.65	0.4425	0.065	0.4908	0.13	0.4052	0.13	0.3722	-0.13	0.6284
0.70	0.4417	0.070	0.4914	0.14	0.4052	0.14	0.3451	-0.14	0.6480
0.75	0.4410	0.075	0.4920	0.15	0.4051	0.15	0.3226	-0.15	0.6610
0.80	0.4402	0.080	0.4924	0.16	0.4051	0.15	0.3035	-0.15	0.6699
0.85	0.4395	0.085	0.4929	0.17	0.4051	0.17	0.2869	-0.17	0.6765
0.90	0.4388	0.090	0.4932	0.18	0.4051	0.18	0.2724	-0.18	0.6815
0.95	0.4381	0.095	0.4936	0.19	0.4051	0.19	0.2596	-0.19	0.6854
1.00	0.4374	0.100	0.4939	0.20	0.4051	0.20	0.2481	-0.20	0.6885

Table 3.2.b Result of simulation using numerical solver ($\sigma_{P_1E_3} + \sigma_{P_2E_3} < 0$)

$\sigma^2_{E_3} = 0.01;\ \sigma_{P_1E_3} = 0.04;$ $u = 0.02;\ \sigma_{P_2E_3} = -0.05$		$\eta_1 = 0.4;\ \sigma_{P_1E_3} = 0.04;$ $u = 0.02;\ \sigma_{P_2E_3} = -0.05$		$\eta_1 = 0.4; \sigma_{P_1E_3} = 0.04;$ $\sigma^2_{E_3} = 0.01;\ \sigma_{P_2E_3} = -0.05$		$\eta_1 = 0.4; \sigma^2_{E_3} = 0.01;$ $u = 0.02;\ \sigma_{P_2E_3} = -0.1$		$\eta_1 = 0.4; \sigma^2_{E_3} = 0.01;$ $u = 0.02;\ \sigma_{P_1E_3} = 0.1$	
η_1	λ_1	$\sigma^2_{E_3}$	λ_1	u	λ_1	$\sigma_{P_1E_3}$	λ_1	$\sigma_{P_2E_3}$	λ_1
0.05	0.5323	0.005	0.5922	0.01	0.5516	0.01	0.6854	-0.01	0.2596
0.10	0.5347	0.010	0.5515	0.02	0.5515	0.02	0.6815	-0.02	0.2724
1.15	0.5373	0.015	0.5349	0.03	0.5515	0.03	0.6765	-0.03	0.2869
0.20	0.5399	0.020	0.5262	0.04	0.5514	0.04	0.6699	-0.04	0.3035
0.25	0.5426	0.025	0.5210	0.05	0.5514	0.05	0.6610	-0.05	0.3226
0.30	0.5454	0.030	0.5174	0.06	0.5513	0.06	0.6480	-0.06	0.3451
0.35	0.5484	0.035	0.5149	0.07	0.5513	0.07	0.6284	-0.07	0.3722
0.40	0.5515	0.040	0.5130	0.08	0.5512	0.08	0.5975	-0.08	0.4053
0.45	0.5548	0.045	0.5115	0.09	0.5511	0.09	0.5515	-0.09	0.4464
0.50	0.5583	0.050	0.5104	0.10	0.5511	0.10	0.4968	-0.10	0.4968
0.55	0.5620	0.055	0.5094	0.11	0.5510	0.11	0.4464	-0.11	0.5515
0.60	0.5659	0.060	0.5086	0.12	0.5510	0.12	0.4053	-0.12	0.5975
0.65	0.5701	0.065	0.5079	0.13	0.5509	0.13	0.3722	-0.13	0.6284
0.70	0.5746	0.070	0.5073	0.14	0.5508	0.14	0.3451	-0.14	0.6480
0.75	0.5795	0.075	0.5068	0.15	0.5508	0.15	0.3226	-0.15	0.6610
0.80	0.5848	0.080	0.5064	0.16	0.5507	0.15	0.3035	-0.15	0.6699
0.85	0.5906	0.085	0.5060	0.17	0.5506	0.17	0.2869	-0.17	0.6765
0.90	0.5972	0.090	0.5056	0.18	0.5506	0.18	0.2724	-0.18	0.6815
0.95	0.6045	0.095	0.5053	0.19	0.5505	0.19	0.2596	-0.19	0.6854
1.00	0.6131	0.100	0.5050	0.20	0.5504	0.20	0.2481	-0.20	0.6885

Appendix B: Figures



Source: The website of Ministry of Finance, Japan. http://www.mof.go.jp/english/if/CMI_051109.pdf

Figure 1.1 Network of bilateral swap arrangements under the Chiang Mai Initiative (as of November 9, 2005)

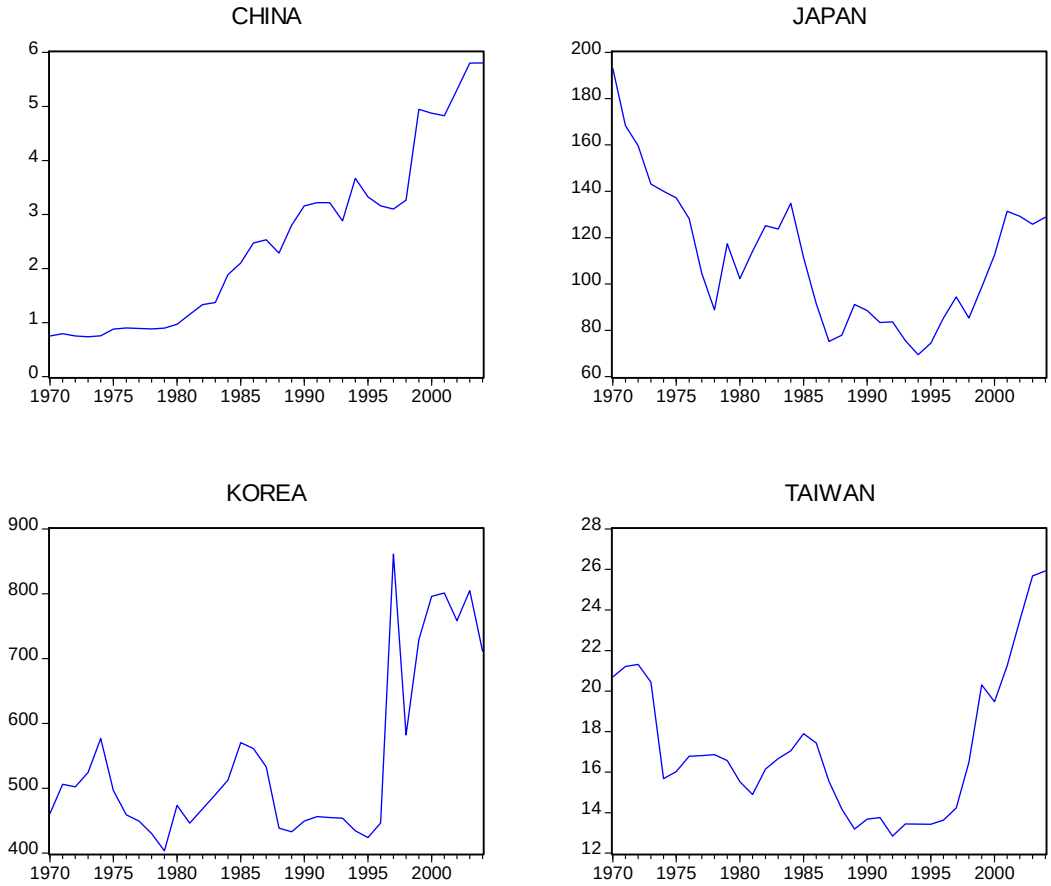


Figure 1.2 Real effective exchange rate (1970-2004)

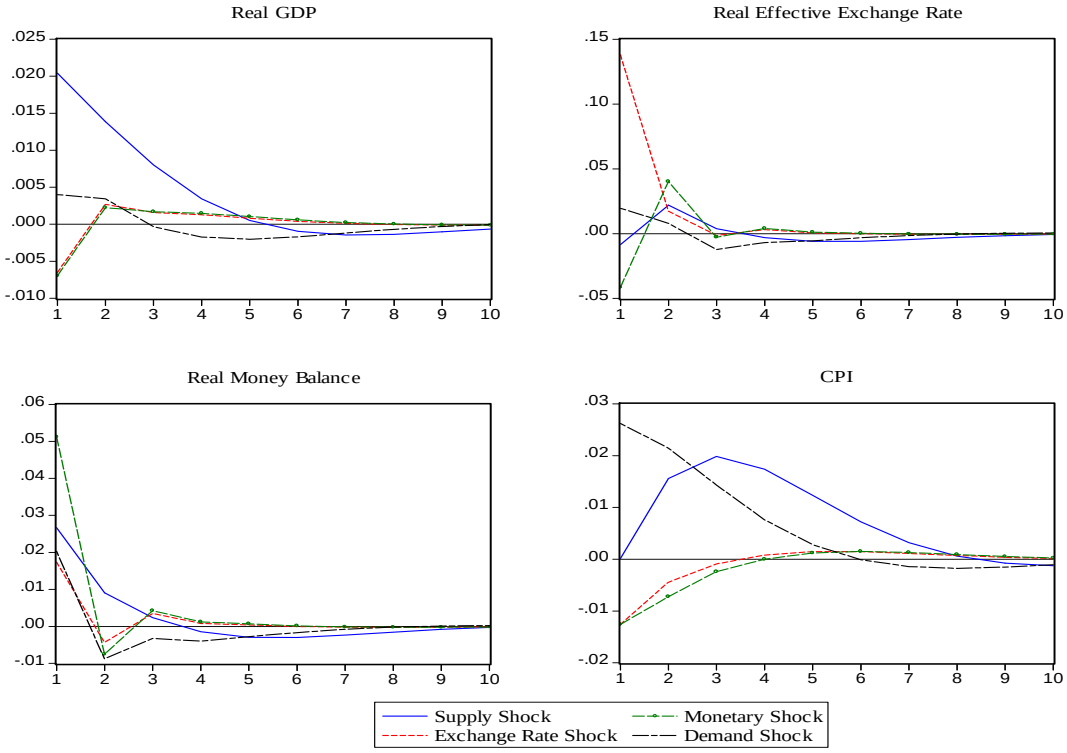


Figure 1.3a Impulse response analysis for China

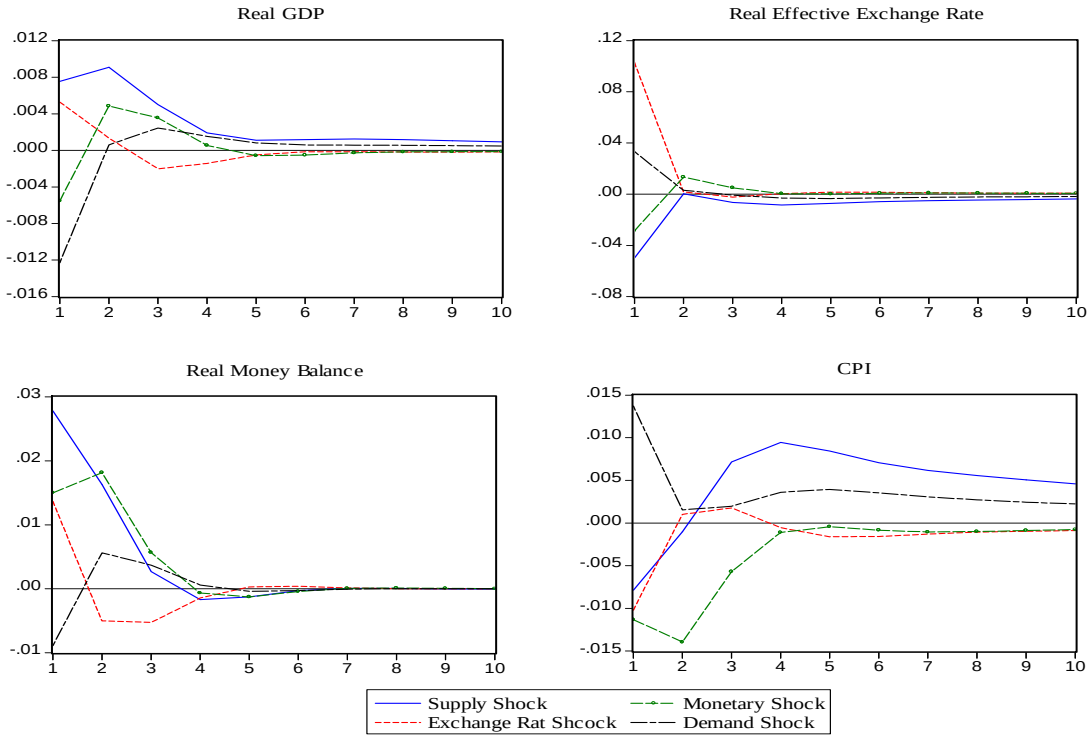


Figure 1.3b Impulse response analysis for Japan

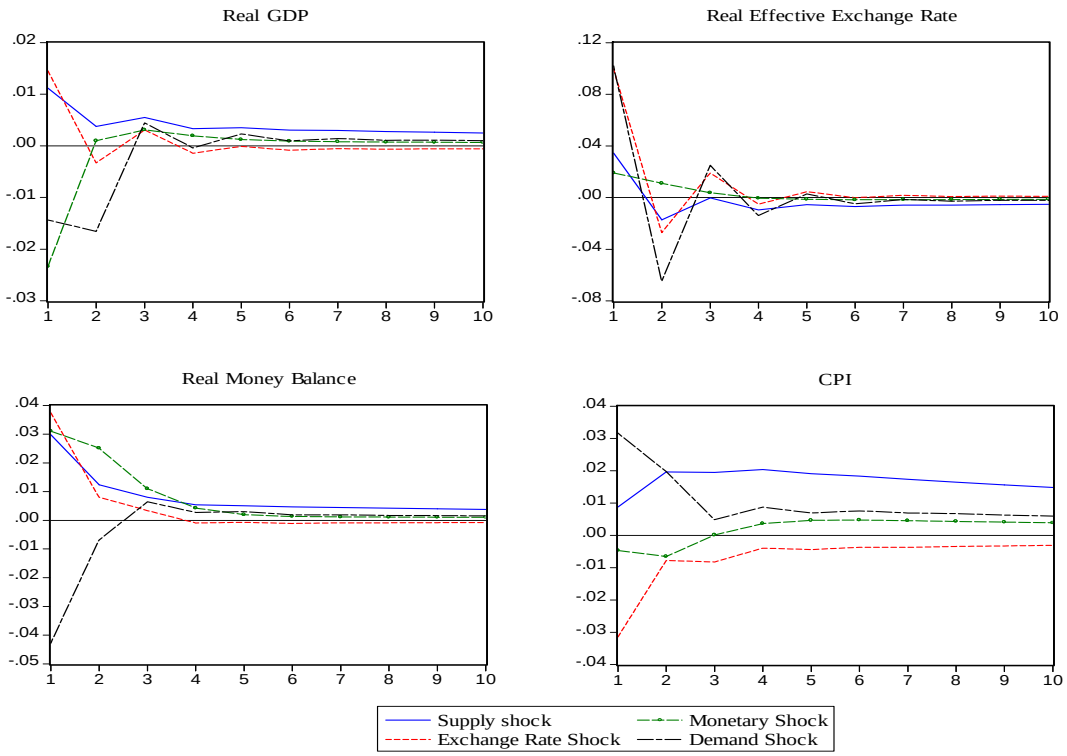


Figure 1.3c Impulse response analysis for Korea

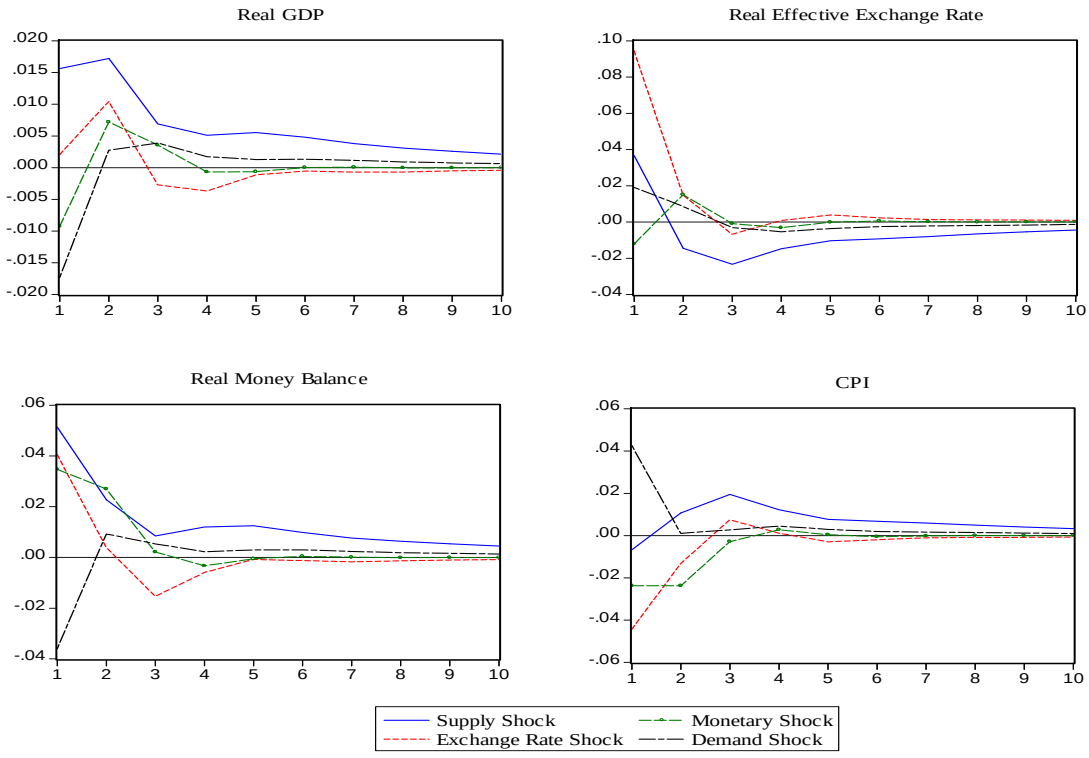
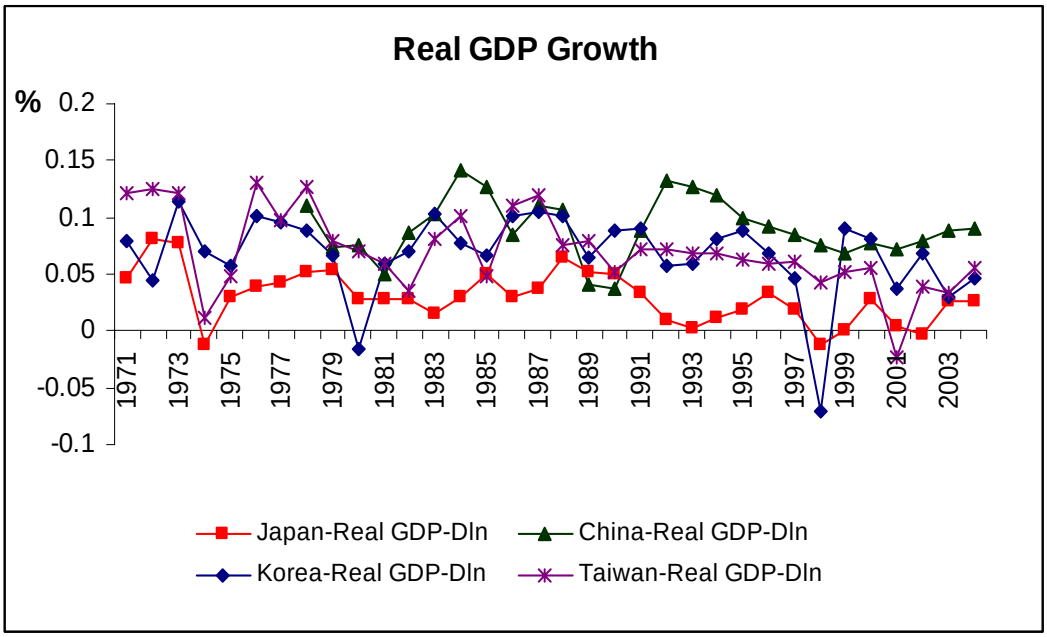


Figure 1.3d Impulse response analysis for Taiwan



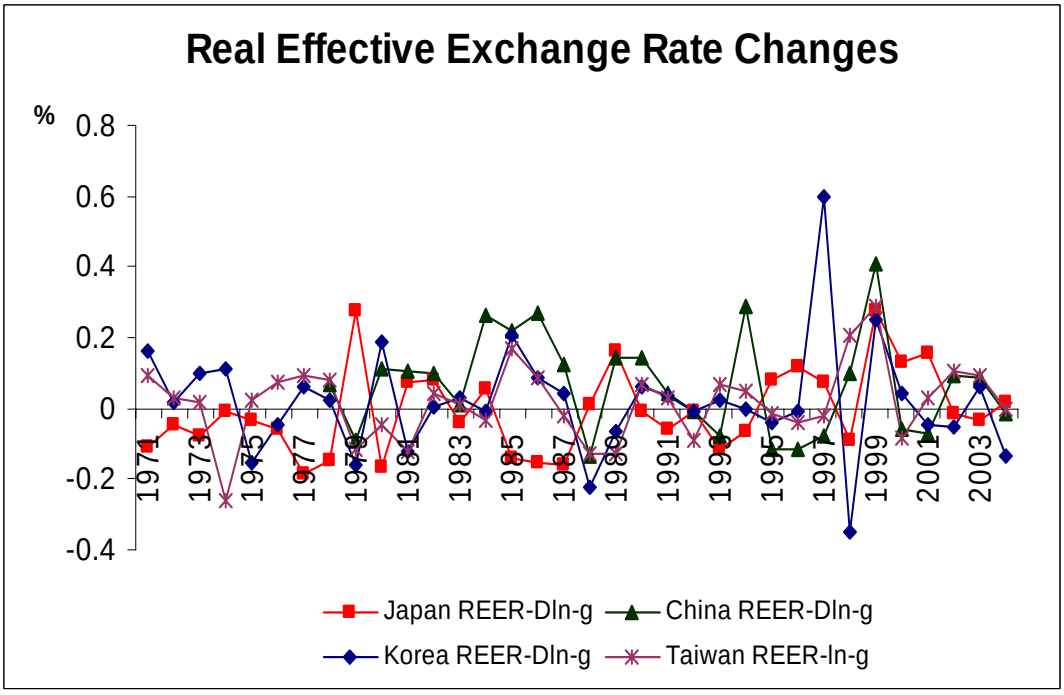
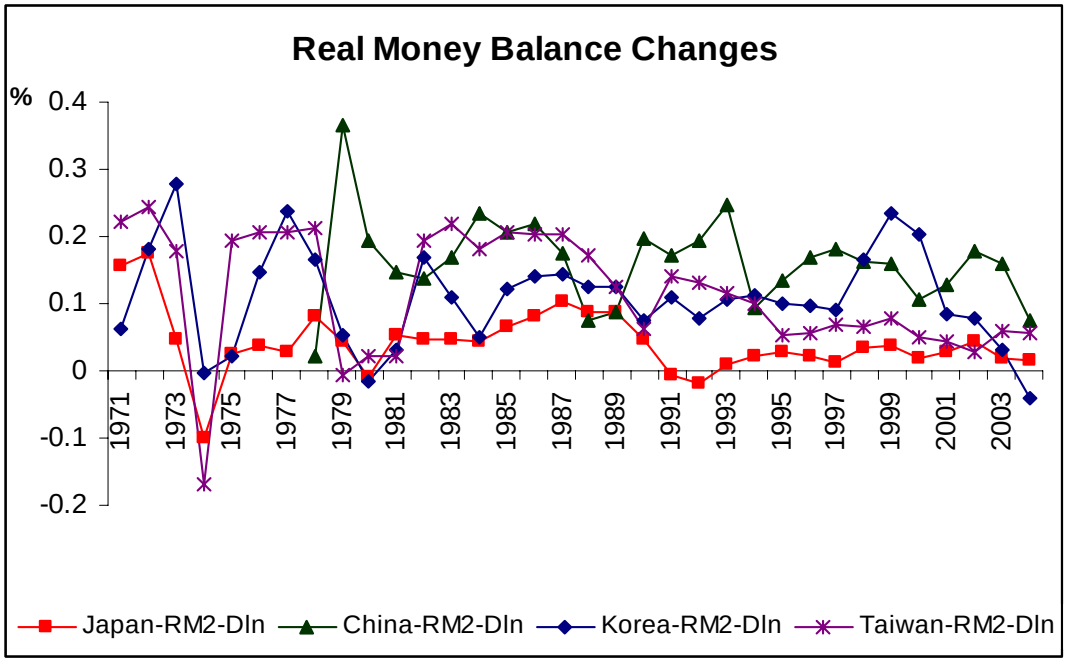


Figure 1.4 Convergence of variables (Continued)



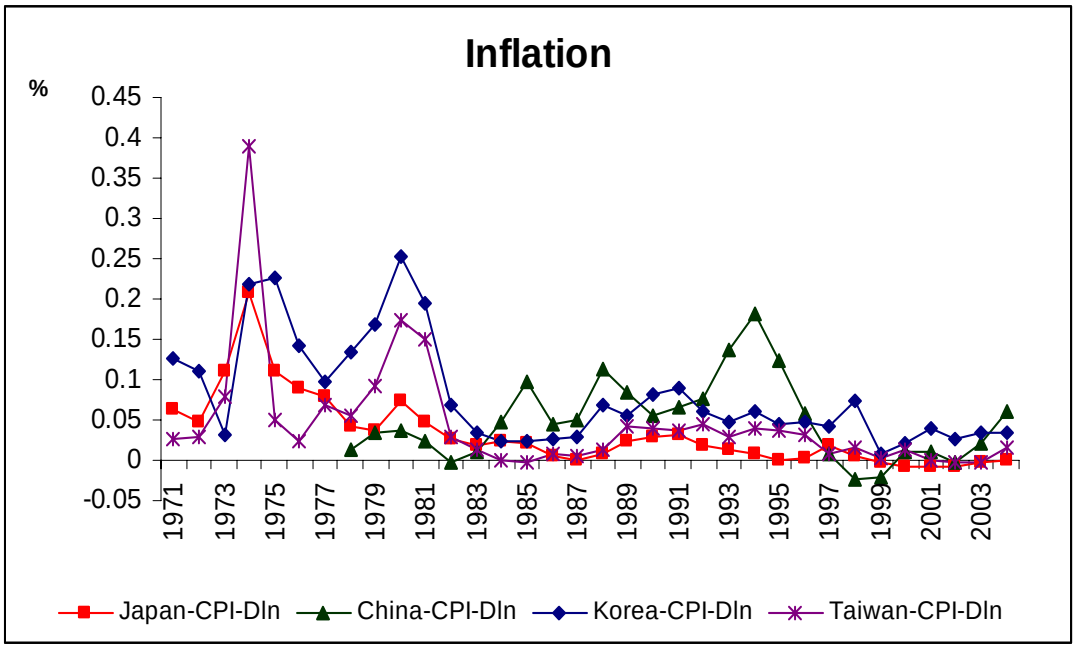


Figure 1.4 Convergence of variables (Continued)

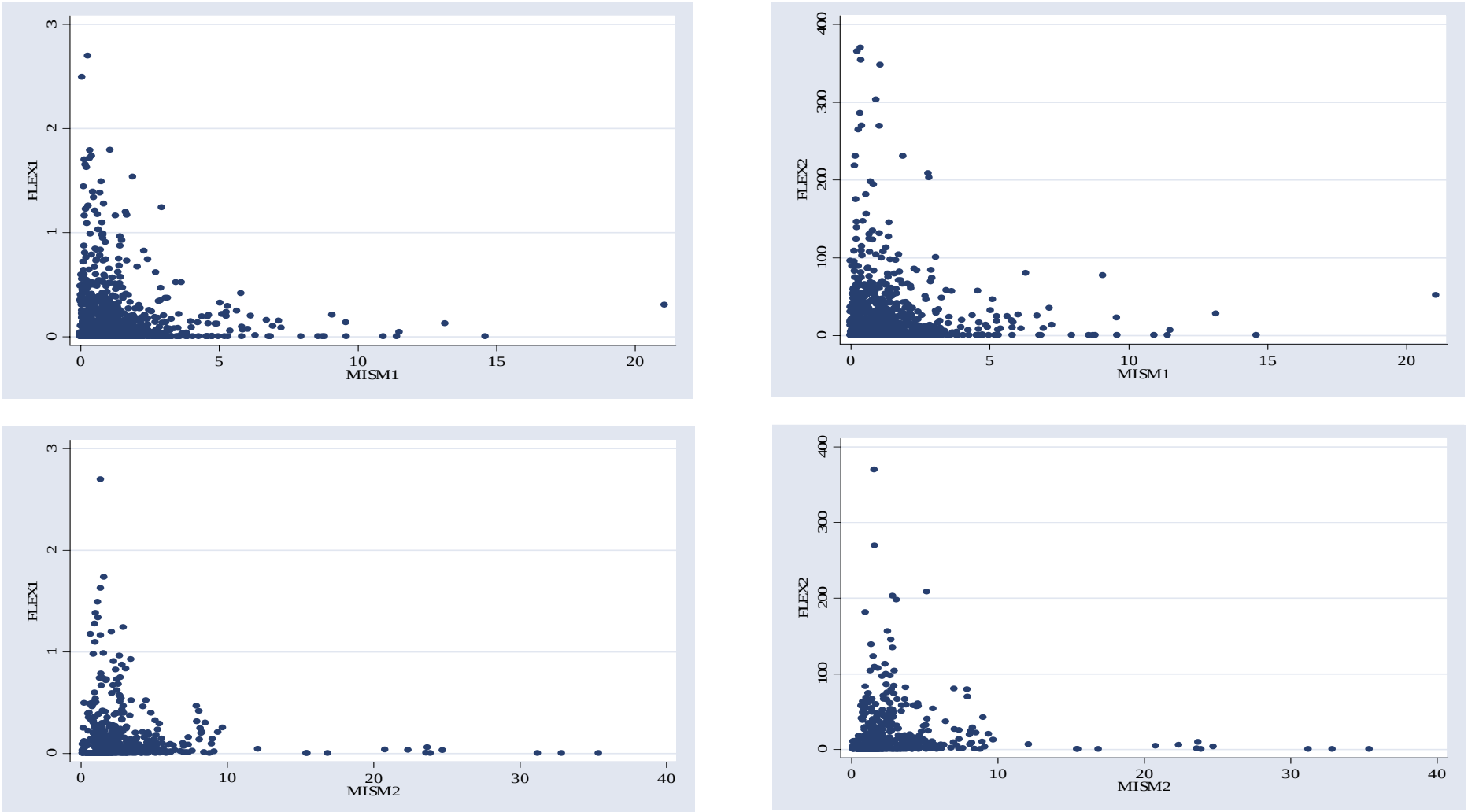


Figure 2.1 Currency mismatches and exchange rate flexibility

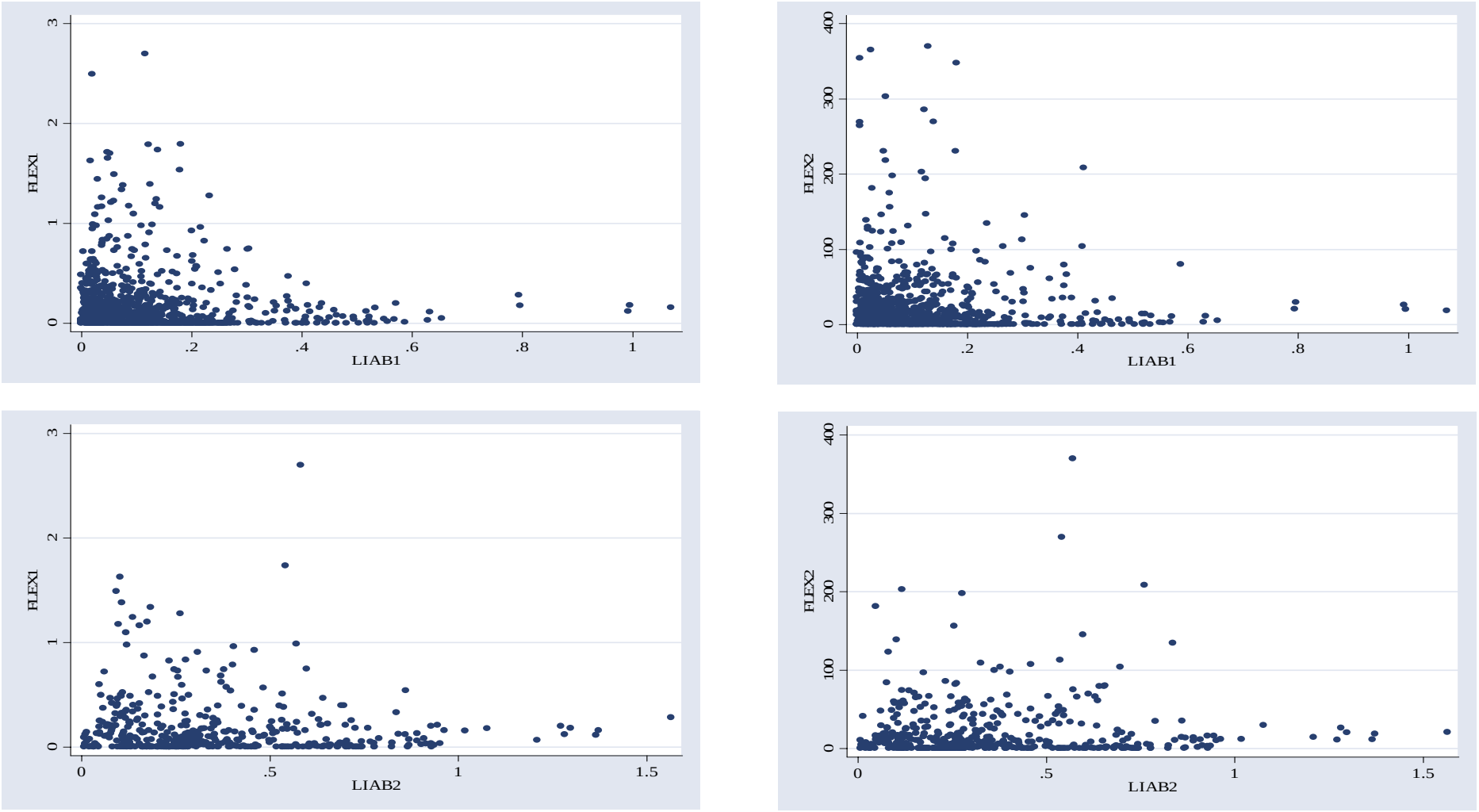
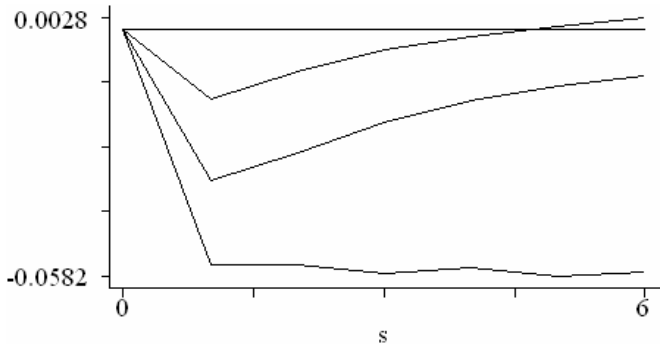
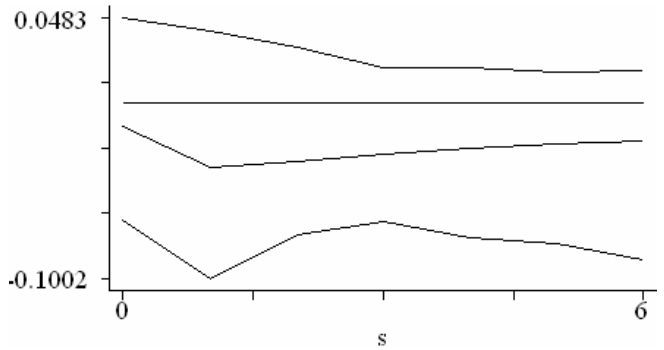


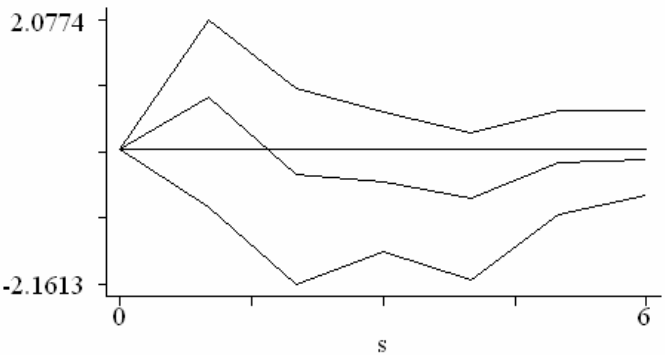
Figure 2.2 Liability dollarization and exchange rate flexibility



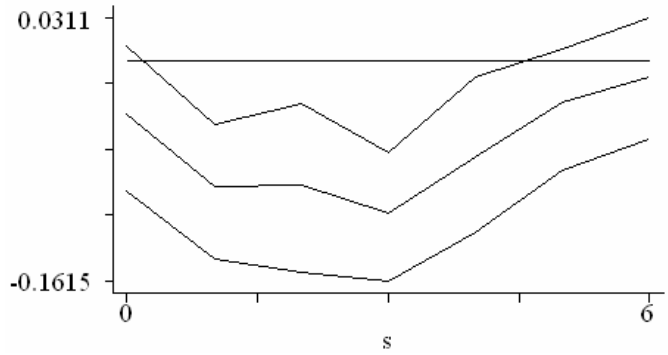
Response of FLEX1 to MISM1 shock



Response of MISM1to FLEX1 shock



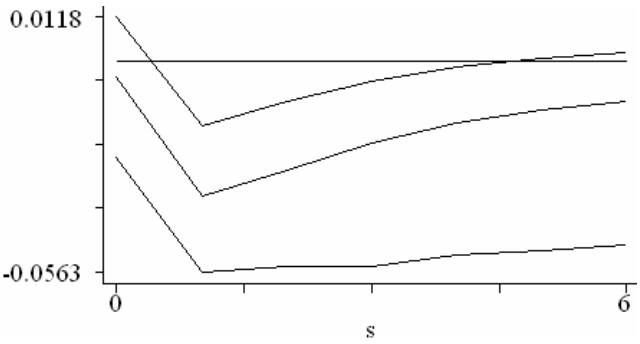
Response of FLEX2 to MISM1 shock



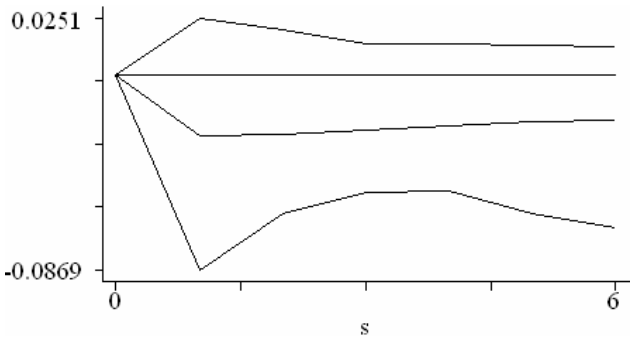
Response of MISM1 to FLEX2 shock

The panel VAR also includes FinanDevelop, CALiberaliz, TradeOpen, and Inflation. Errors are 5 percent on each side generated by Monte-Carlo with 200 repetitions. The number of lag for FLEX1 is 1, and that for FLEX2 is 4.

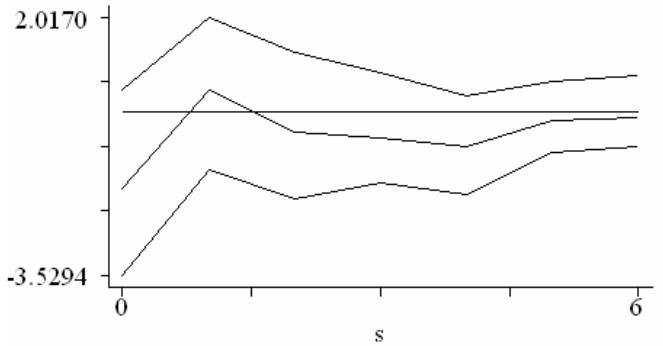
Figure 2.3 Impulse-response functions for external mismatches and exchange rate flexibility (no contemporaneous effects from mismatches to flexibility)



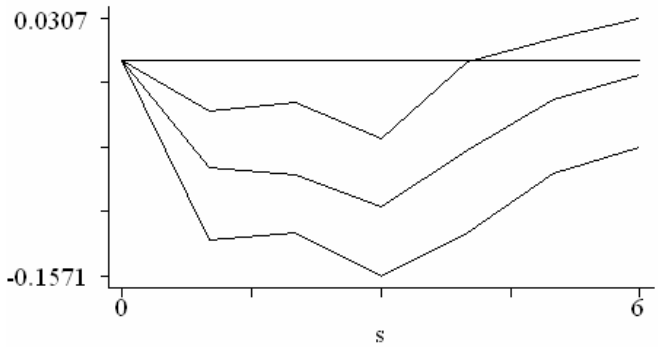
Response of FLEX1 to MISM1 shock



Response of MISM1 to FLEX1 shock



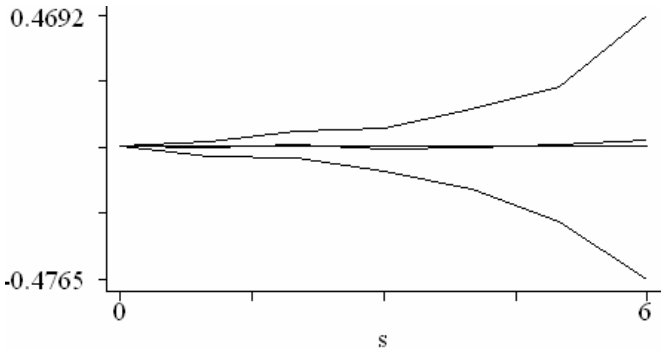
Response of FLEX2 to MISM1 shock



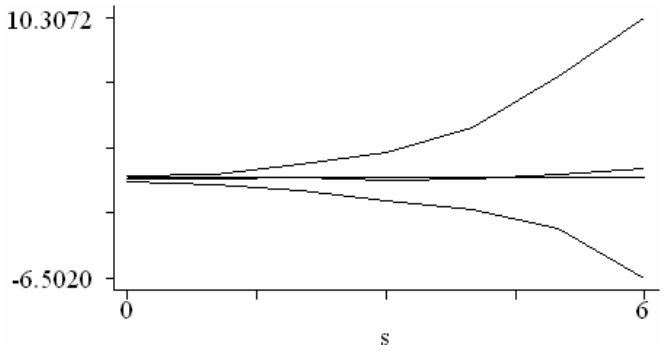
Response of MISM1 to FLEX2 shock

The panel VAR also includes FinanDevelop, CALiberaliz, TradeOpen, and Inflation. Errors are 5 percent on each side generated by Monte-Carlo with 200 repetitions. The number of lag for FLEX1 is 1, and that for FLEX2 is 4.

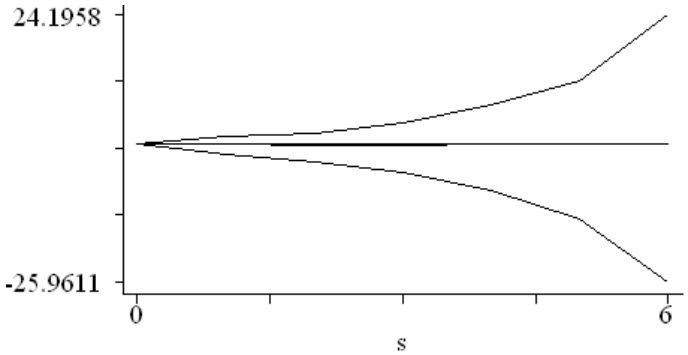
Figure 2.4 Impulse-response functions for external mismatches and exchange rate flexibility (no contemporaneous effects from flexibility to mismatches)



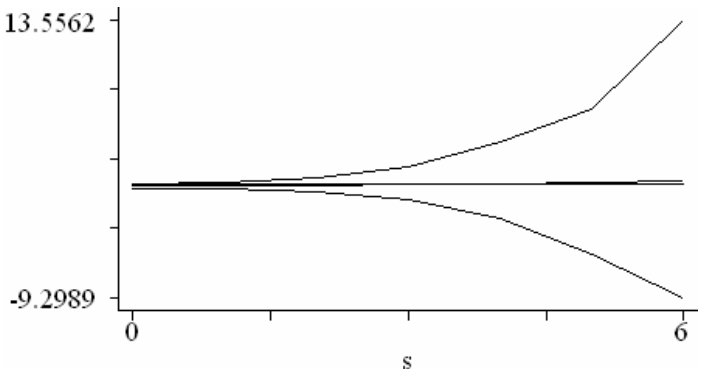
Response of FLEX1 to MISM2 shock



Response of MISM2 to FLEX1 shock



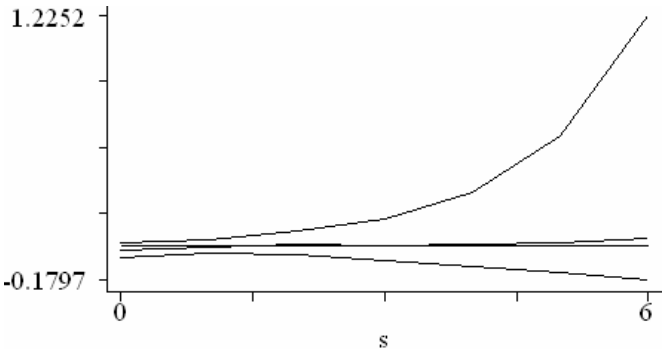
Response of FLEX2 to MISM2 shock



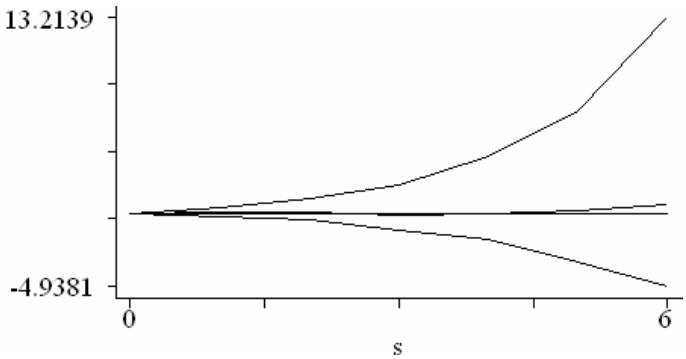
Response of MISM2 to FLEX2 shock

The panel VAR also includes FinanDevelop, CALiberaliz, TradeOpen, and Inflation. Errors are 5 percent on each side generated by Monte-Carlo with 200 repetitions. The number of lags for FLEX1 is 3, and that for FLEX2 is 2.

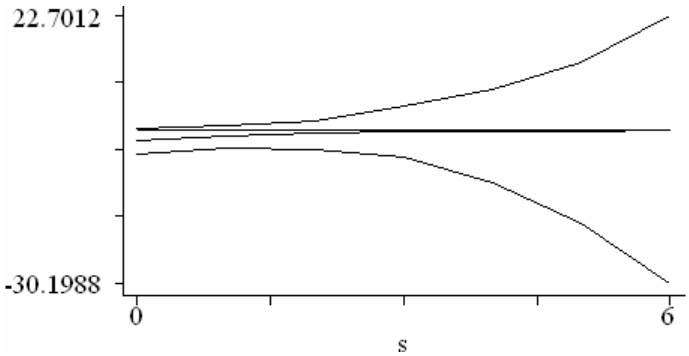
Figure 2.5 Impulse-response functions for total mismatches and exchange rate flexibility (no contemporaneous effects from mismatches to flexibility)



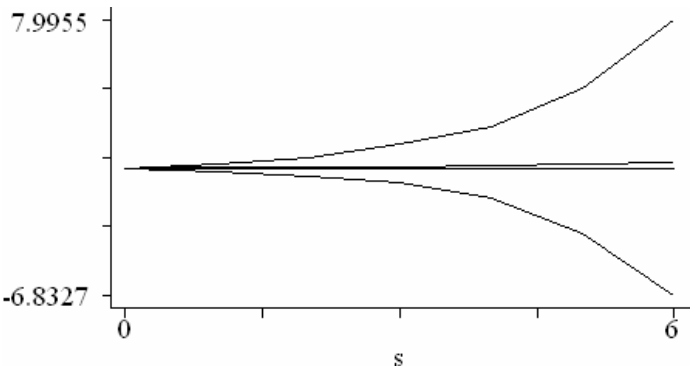
Response of FLEX1 to MISM2 shock



Response of MISM2 to FLEX1 shock



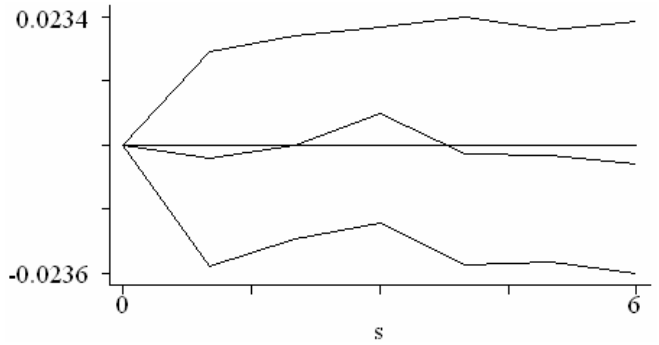
Response of FLEX2 to MISM2 shock



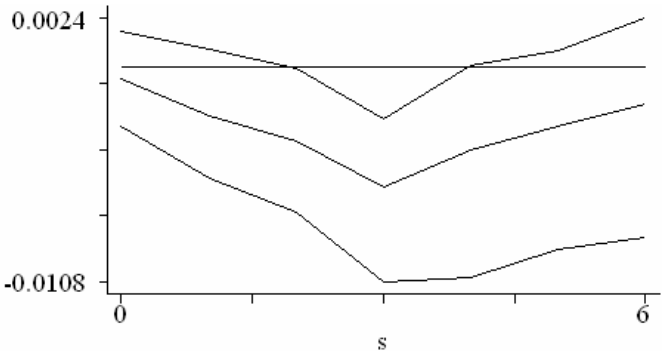
Response of MISM2 to FLEX2 shock

The panel VAR also includes FinanDevelop, CALiberaliz, TradeOpen, and Inflation. Errors are 5 percent on each side generated by Monte-Carlo with 200 repetitions. The number of lags for FLEX1 is 3, and that for FLEX2 is 2.

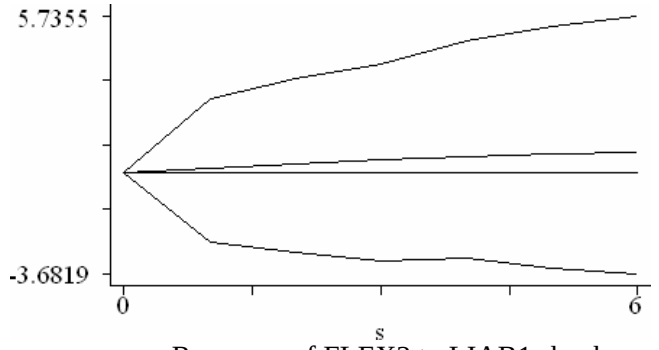
Figure 2.6 Impulse-response functions for total mismatches and exchange rate flexibility (no contemporaneous effects from flexibility to mismatches)



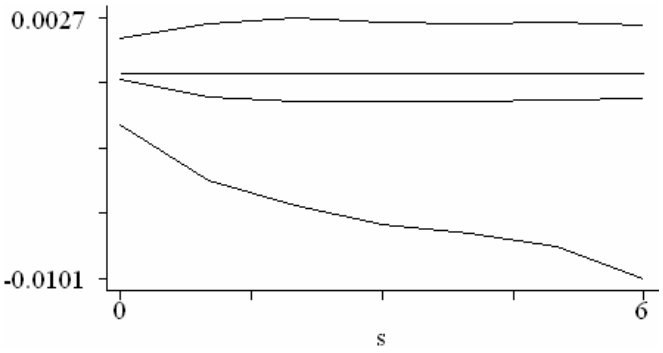
Response of FLEX1 to LIAB1 shock



Response of LIAB1 to FLEX1 shock



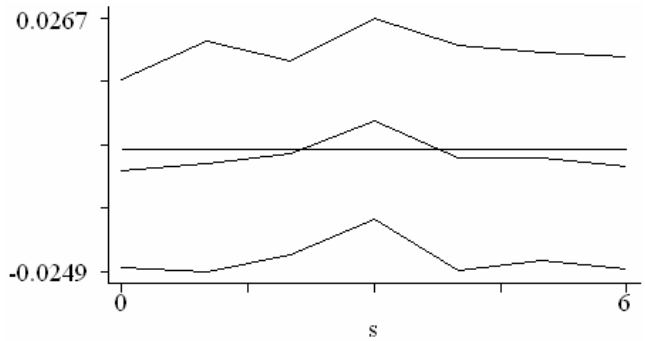
Response of FLEX2 to LIAB1 shock



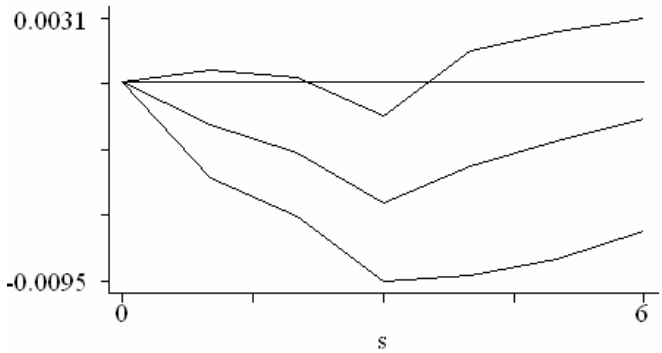
Response of LIAB1 to FLEX2 shock

The panel VAR also includes FinanDevelop, CALiberaliz, TradeOpen, and Inflation. Errors are 5 percent on each side generated by Monte-Carlo with 200 repetitions. The number of lags for FLEX1 is 4, and that for FLEX2 is 1.

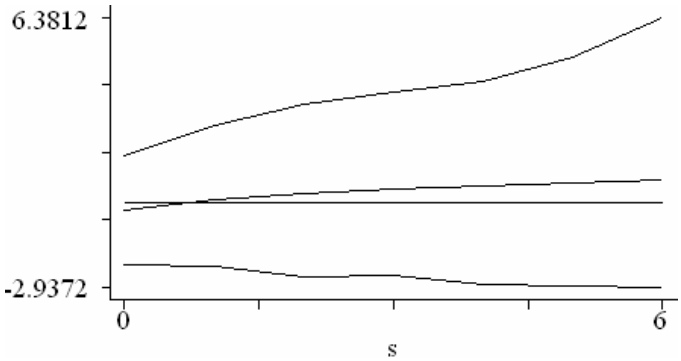
Figure 2.7 Impulse-response functions for external dollar liabilities and exchange rate flexibility (no contemporaneous effects from liabilities to flexibility)



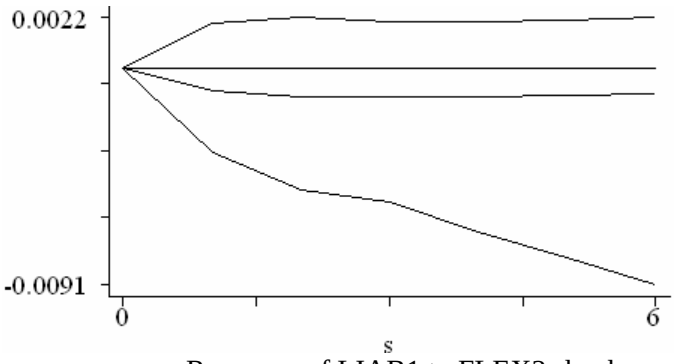
Response of FLEX1 to LIAB1 shocks



Response of LIAB1 to FLEX1 shock



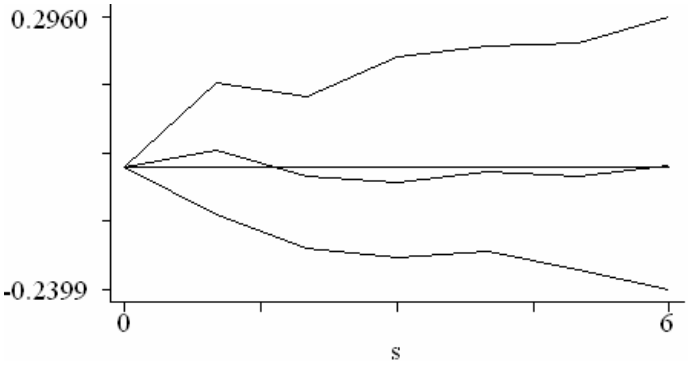
Response of FLEX2 to LIAB1shock



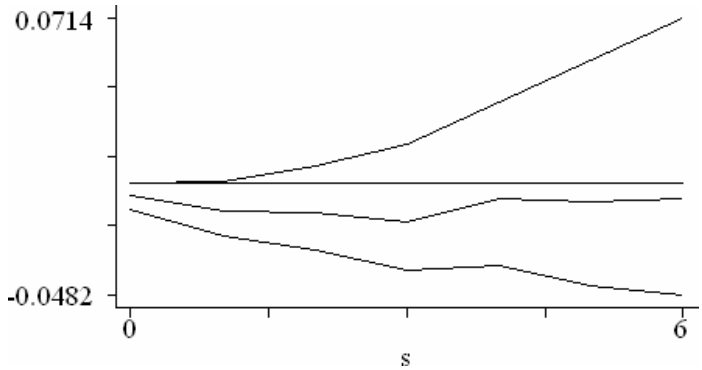
Response of LIAB1 to FLEX2 shock

The panel VAR also includes FinanDevelop, CALiberaliz, TradeOpen, and Inflation. Errors are 5 percent on each side generated by Monte-Carlo with 200 repetitions. The number of lags for FLEX1 is 4, and that for FLEX2 is 1.

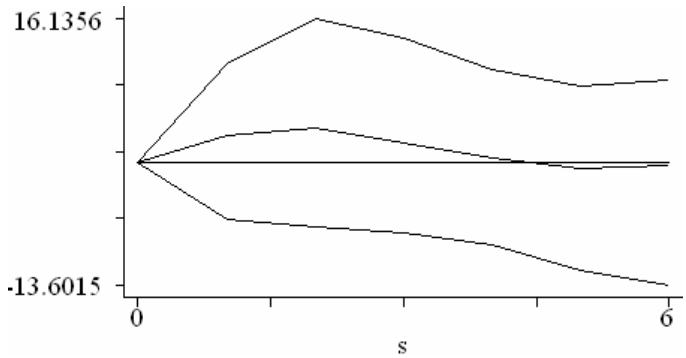
Figure 2.8 Impulse-response functions for external dollar liabilities and exchange rate flexibility (no contemporaneous effects from flexibility to liabilities)



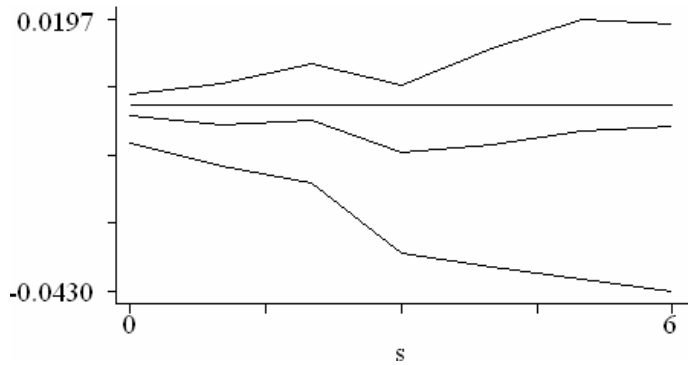
Response of FLEX1 to LIAB2 shock



Response of LIAB2 to FLEX1 shock



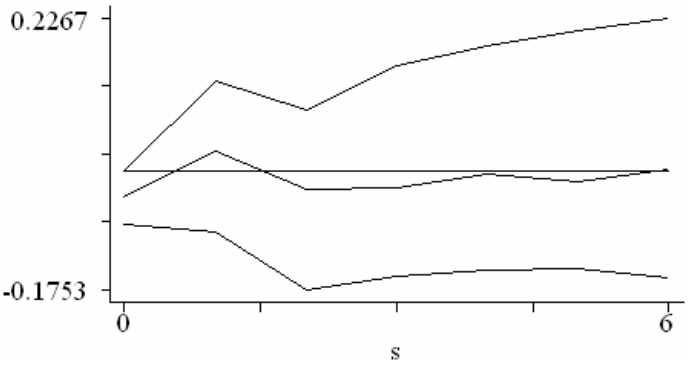
Response of FLEX2 to LIAB2 shock



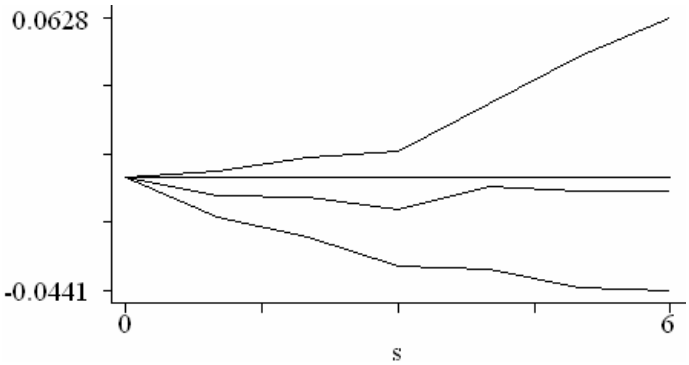
Response of LIAB2 to FLEX2 shock

The 4-lag panel VAR also includes FinanDevelop, CALiberaliz, TradeOpen, and Inflation. Errors are 5 percent on each side generated by Monte-Carlo with 200 repetitions.

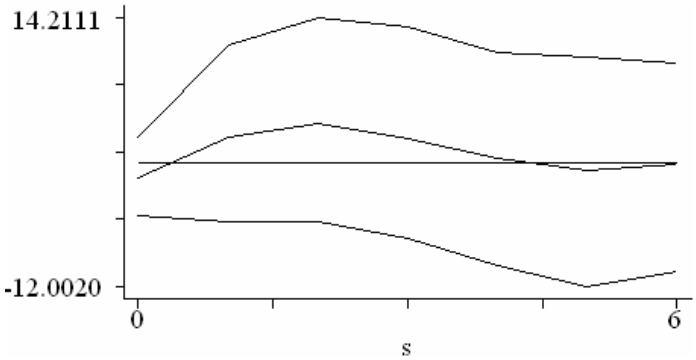
Figure 2.9 Impulse-response functions for total dollar liabilities and exchange rate flexibility (no contemporaneous effects from liabilities to flexibility)



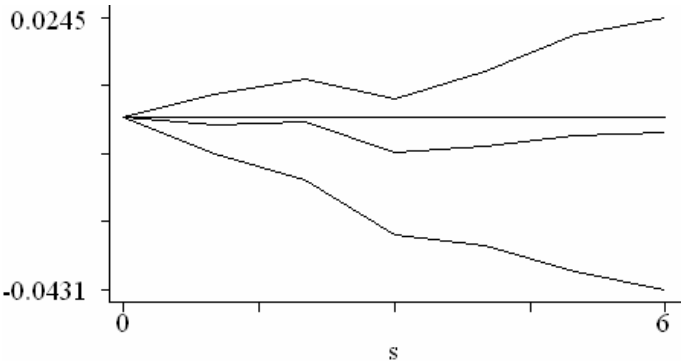
Response of FLEX1 toLIAB2 shock



Response of LIAB2 to FLEX1 shook



Response of FLEX2 to LIAB2 shock



Response of LIAB2 to FLEX2 shock

The 4-lag panel VAR also includes FinanDevelop, CALiberaliz, TradeOpen, and Inflation. Errors are 5 percent on each side generated by Monte-Carlo with 200 repetitions.

Figure 2.10 Impulse-response functions for total dollar liabilities and exchange rate flexibility (no contemporaneous effects from flexibility to liabilities)

Vita

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3. "An Optimal Currency Basket for Emerging Market Economies"

4. "International Linkages of Japanese Bond Markets: An Empirical Analysis", with Bang Jeon and Philip Ji, Chapter 15 of Japanese Fixed Income Markets: Money, Bond and Interest Rate Derivatives, edited by J. Batten, T. Fetherston, and P. Szilagyi. Elsevier-North Holland, October 2006

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