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Abstract

In this paper, we investigate the actual exchange rate policy conducted by the Chinese government after the Chinese exchange rate system reform on July 21, 2005. Also, we investigate long-run effect (Balassa-Samuelson effect) on the Chinese yuan. We found that the Chinese government had a statistically significant, but small change in exchange rate policy during our sample period to January 25, 2006. It is not identified that the Chinese monetary authority is adopting the currency basket system because the change is too small in the economic sense. On one hand, higher growth rate of productivity will appreciate the Chinese yuan in terms of the US dollar and the Japanese yen while higher growth rates of productivity in Chinese tradable good sector tend to give the Balassa-Samuleson effect, that is undervaluation bias, to the Chinese yuan.

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Introduction

The Chinese government announced its change in exchange rate system from the dollar peg system into a managed floating exchange rate system "with reference to" a currency basket on July 21, 2005[1]. The exchange rate system reform has been regarded as a historical regime switching in China. This Chinese government decision has preferable effects on neighboring countries in choosing exchange rate system or exchange rate policy because the monetary authorities face coordination failure in choosing their exchange rate policies (Ogawa and Ito (2002), Ogawa (2002)). The evidence is that the Malaysian government has changed its exchange rate system from the dollar peg system into a currency basket system on the same day when the Chinese government did so. Solving the coordination failure might prevent misalignments among East Asian currencies and, in turn, lead to a coordination of exchange rate policies in the future (Ogawa (2004)).

In this paper, we investigate how the Chinese government has been conducting its actual exchange rate policy under the managed floating exchange rate system "with reference to" a currency basket after it announced its changing exchange rate policy to a currency basket system. Also, we take into account productivity to estimate its long-run effects (Balassa-Samuelson effect) on the Chinese yuan.

As our analytical results by using daily data of exchange rates till January 25, 2006, we found that the Chinese government has made a little change in exchange rate policy that is statistically significant. However, it is not identified that the Chinese monetary authority is adopting the currency basket system because the change is too small. On one hand, higher growth rate of productivity in China will appreciate the Chinese yuan vis-à-vis both the US dollar and the Japanese yen while higher growth rates of productivity in Chinese tradable good sector tend to give the Balassa-Samuleson effect, that is depreciating bias, to the Chinese yuan.

This paper includes the following contents. In the next section, we explain about the currency basket system that the Chinese government has adopted on July 21, 2005. In the third section, we use both the Frankel and Wei's method and the Kalman filter method to estimate linkages of the Chinese yuan with the US dollar as well as the Japanese yen, the euro, and the Korea won. The analytical results show how the Chinese government has been adopting its actual exchange rate policy. In the fourth section, we consider the long-run effects on the Chinese yuan from a viewpoint of the Balassa-Samuelson effect. We use recent data on productivity to estimate the long-run trend exchange rates of the Chinese yuan vis-à-vis the US dollar and the Japanese yen.

The Currency Basket System in China

(1) Recent Movements of Effective Exchange Rates of the Chinese Yuan

The Chinese yuan was kept to fix to the US dollar under the dollar peg system before July 21,

[1] The Chinese government has adopted a managed floating exchange rate system not only "with reference to" a currency basket but also with a band (plus and minus 0.3% around the base rate). It could adjust the exchange rate by crawling the base rate. It would be a kind of BBC rule (Williamson (2000)).

2005. On one hand, it was fluctuating against other major trade partners' currencies. After the announcement of Chinese exchange rate system reform, it is a little fluctuating against the US dollar as well as other major trade partners' currencies. Accordingly, a value of the Chinese yuan in terms of trade partners' currencies, that is effective exchange rate, has been fluctuating over time.

A nominal effective exchange rate (NEER) of the Chinese yuan is calculated based on its trade weights with nine trade partners that include the United States, European Union, Hong Kong, Japan, Korea, United Kingdom, Singapore, Russia, and Australia. A real effective exchange rate (REER) is a measure of effective exchange rate adjusted for inflation differentials between China and its trading partners. Both the nominal and real effective exchange rates are set a unity as of January 3, 2005.

In figure 1, we find increases in nominal effective exchange rate from July 21 to the end of 2005, which shows that a value of the Chinese yuan in terms of the nominal effective exchange rate was appreciating after the announcement of the Chinese exchange rate system reform. However, there are decreases in nominal effective exchange rate in 2006. The value of the Chinese yuan in terms of nominal effective exchange rate has been depreciating in 2006.

On one hand, we find decreases in real effective exchange rate, which shows that values of the Chinese yuan in terms of the real effective exchange rates are fluctuating around a constant level after July 21, 2005. It is pointed out that the value of the Chinese yuan in terms of nominal effective exchange rate is appreciating while its value in terms of real effective exchange rate are fluctuating around a constant level even after the announcement of the Chinese exchange rate system reform.

(2) Managed floating exchange rate system with reference to a currency basket

The Chinese government has shifted its exchange rate system into the managed floating exchange rate system with reference to a currency basket. We consider what meanings are included in the managed floating exchange rate system with reference to a currency basket that has been adopted by the Chinese government.

At first, we should identify a "fixed exchange rate system" and a "managed floating exchange rate system". Under the "fixed exchange rate system", the monetary authorities in advance have to pre-announce their target foreign currencies, that is, composition and shares of currency basket, and their target level of exchange rates. According to the pre-announced rule, the monetary authorities have to intervene in the foreign exchange market to fix the exchange rate to the pre-announced target rate. On one hand, under the "managed floating exchange rate system", they do not need to pre-announce their exchange rate policy rule in advance. Even though the monetary authorities have an intention to peg their home currency to the US dollar under the managed floating exchange rate system, they do not need to make their exchange rate policy clear in advance. Accordingly, fixed exchange rate system has transparency and accountability while managed floating exchange rate system has not so clear transparency and accountability.[2]

[2] See Frankel, Schmukler, and Serven (2000).

Next, we can compare "with reference to a currency basket" and "peg to a currency basket" under the managed floating exchange rate system that the Chinese monetary authorities are adopting. Under the "managed floating exchange rate system", the monetary authorities do not pre-announce their exchange rate policy rule in advance. Their exchange rate policy rule is not at all clear in advance although they announce their adoption of the "peg to a currency basket" under the "managed floating exchange rate system." The "peg to a currency basket" should correspond to the "fixed exchange rate system" from a viewpoint of transparency and accountability. Accordingly, we should compare "reference to a currency basket" under the managed floating exchange rate system and "peg to a currency basket" under the fixed exchange rate system.

The "reference to a currency basket" under the managed floating exchange rate system and also the "peg to a currency basket" under the managed floating exchange rate system have weaker transparency and accountability compared with "peg to a currency basket" under the fixed exchanger rate system. Under the weak transparency and accountability of exchanger rate policy rule, the monetary authority may be easy to conduct unclear exchange rate policy and make even manipulation of the exchange rate. Unclear exchange rate policy and possibility of making manipulation in exchange rate policy would decrease credibility of the monetary authorities. Under such a situation, the monetary authorities cannot enjoy honey moon effects (Krugman(1991)) that market participants follow the monetary authorities' intention of exchange rate policy.

On the other hand, under imperfect or asymmetric information on the monetary authorities' exchange rate policy, their intervention in the foreign exchange market might have stronger effect on exchange rates because the monetary authorities give surprise to market participants in a situation of asymmetric information between the monetary authorities and private sectors.

(3) Composition of currency basket for China

There are many different ways of putting currencies into the basket, and there also many different ways of calculating the weights of each currency. We consider which is the best way for China.

Ways of putting currencies into the basket depend on the monetary authorities' objective in exchange rate policy[3]. If the monetary authorities have an objective to stabilize trade balance[4], they should put currencies of trade partners for the objective. In terms of trade volume, that is the sum of exports and imports, Chinese economy has about 15% of its total trade volume with each of the United States, the EU, and Japan. It implies 70%:15%:15% for the US dollar, the euro, and the Japanese yen in the currency basket if currencies of the rest of world have close linkages with the US dollar. Moreover, Ito, Ogawa, and Sasaki (1998) pointed out that we should take into account elasticity of exchange rates in terms of exports and imports. It is more complicated to take into account the elasticity, but the method is more adequate for stabilizing its trade balance. China should adopt the method above mentioned because for the moment trade balance is more important

[3] See Ogawa, Ito, and Sasaki (2004).

[4] The currency basket system can contribute to stabilization of capital flows (Ogawa and Sun (2001)).

for the Chinese government's exchange rate policy and the Chinese government keeps regulating capital transactions by capital controls.

(4) Determination of a currency basket for the appreciating Chinese yuan

We investigate how to determine composition of the currency basket or the weights, given the allowed revaluation or appreciation of the Chinese yuan. If the value of the currency basket should be adjusted daily, how can this practice reconcile with the requirement that the price of the basket is the real effective exchange rate of the currency and should be kept stable? Given the limit of revaluation (0.3%), what should the monetary authority do about the basket formula (price index, weights and so on) for the next day?

Assume that the Chinese government adopts a currency basket system where it targets a currency basket composed of the US dollar and the Japanese yen for simplicity. We should suppose the following three simple cases: the first case where only the yuan/yen rate changes due to a change of the yen/dollar rate, the second case where only the yuan/dollar rate changes with offsetting change in the yen/dollar rate and, in turn, unchanged the yuan/yen rate, and the third case where both the yuan/dollar rate and the yuan/yen rate change in the same direction due to stronger demand for the Chinese yuan against both the US dollar and the Japanese yen without any changes in the yen/dollar rate.

We assume that Chinese currency basket is composed of the US dollar and the Japanese yen and that its weights on the both currencies are 50% and 50%.

$$basket = \begin{cases} 50\% \times yuan/dollar \\ 50\% \times yuan/yen = 50\% \times (yuan/dollar) \times (dollar/yen) \end{cases}$$

We can rewrite the yuan/yen into (yuan/dollar)*(dollar/yen).

In the first case, only change in the dollar/yen leads to changes in only the yuan/yen. The monetary authorities can conduct a partial intervention in the yuan/dollar in order to keep the exchange rate of the Chinese yuan in terms of the basket at the target level although the intervention changes its composition of the currency basket compared with the target composition.

In the second case, the Chinese yuan has appreciated against the US dollar while the US dollar depreciated against the Japanese yen. Accordingly, the yuan/yen rate is unchanged. The monetary authorities can conduct a partial intervention in the yuan/dollar in order to keep the exchange rate of the Chinese yuan in terms of the currency basket at the target level although the intervention changes its composition of the currency basket compared with the target composition.

In the third case, the Chinese yuan has appreciated against both the US dollar and the Japanese yen while there are no changes in the dollar/yen rate. In this case, the monetary authorities have faced not any changes in basket composition but only appreciation of the Chinese yuan against the basket. Accordingly, the monetary authorities should conduct a full intervention in the yuan/dollar in order to keep the exchange rate of the Chinese yuan in terms of the basket as well as its composition of the currency basket at target one.

We can suppose the case where the yuan-dollar rate has changed due to change of the dollar-yen rate is a mixture of the first and second cases. Accordingly, even in the supposed case, the monetary authorities can conduct a partial intervention in the yuan/dollar in order to keep the exchange rate of the Chinese yuan in terms of the currency basket at the target level although the intervention changes its composition of the currency basket compared with the target composition.

The second case where only the Chinese yuan has appreciated against the US dollar and the Japanese yen corresponds to the above third case. In this case, the monetary authorities should conduct a full intervention in foreign exchange markets in order to keep the exchange rate of the Chinese yuan in term of the currency basket. However, it is pointed out that the Chinese yuan is still undervalued against the US dollar and the Japanese yen. In this situation, the monetary authorities should not conduct the full intervention to keep the exchange rate of the Chinese yuan in terms of the currency basket. They should leave appreciation of the Chinese yuan against the currency basket. The monetary authorities can leave the appreciation of the Chinese yuan against the currency basket by only 0.3% in a day. If the monetary authorities kept changing its central parity by 0.3% for 10 days, the Chinese yuan would appreciate in terms of the basket by 3% compared with the current level.

Actual Exchange Rate Policy after the Chinese Exchange Rate Policy Reform

(1) Estimation by using Frankel and Wei's Method

An empirical analysis is conducted to investigate whether Chinese monetary authorities have really adopted a currency basket system. For the purpose, the empirical analytical method of Frankel and Wei (1994) is used to analyze the linkages of the Chinese yuan to four currencies; the US dollar, the Japanese yen, the euro, and the Korean won[5]. According to Frankel and Wei (1994), the Swiss franc is used as a numeraire in denomination of exchange rates. Daily data of exchange rates are used to regress log differences of the Chinese yuan (in terms of the Swiss franc) on log differences of the four currencies (in terms of the Swiss franc) for each quarterly sub-sample period in the sample period.

$$\Delta \log e^{RMB/SFR} = a_0 + a_1 \Delta \log e^{USD/SFR} + a_2 \Delta \log e^{JPY/SFR} + a_3 \Delta \log e^{euro/SFR} + a_4 \Delta \log e^{WON/SFR} + \varepsilon_t \quad (1)$$

where $e^{RMB/SFR}$: exchange rate of the Chinese yuan in terms of the Swiss franc, $e^{USD/SFR}$: exchange rate of the US dollar in terms of the Swiss franc, $e^{JPY/SFR}$: exchange rate of the Japanese yen in terms of the Swiss franc, $e^{EURO/SFR}$: exchange rate of the euro in terms of the Swiss franc,

[5] The governor of the People's Bank of China referred that the Chinese monetary authorities target the four currencies as components of the currency basket.

$e^{WON/SFR}$: exchange rate of the Korean won in terms of the Swiss franc.

Daily data of exchange rate are used for the empirical analysis. The data are collected from the Datastream. Its sample period covers from January 3, 2005 to January 25, 2006.

Table 1 shows results of the regression analysis. It is proved that the coefficient on the US dollar is nearly equal to a unity even after the exchange rate system reform. The coefficient on the US dollar decreased a little immediately after the exchange rate system reform although it still remained at quite a high level. However, it has increased to a unity in the recent month.

On one hand, coefficients on the Japanese yen, the euro, and the Korean won are very small and statistically insignificant in many cases. The weights on three currencies increased a little after the exchange rate system reform although these are statistically insignificant.

We also estimated following regression equation that excludes the term of the Korean won.

$$\Delta \log e^{RMB/SFR} = a_0 + a_1 \Delta \log e^{USD/SFR} + a_2 \Delta \log e^{JPY/SFR} + a_3 \Delta \log e^{euro/SFR} + \varepsilon_t \qquad (2)$$

Table 2 shows results. Also in the case of the regression analysis without the Korean won as explanatory variable, the coefficient on the US dollar is nearly to equal to a unity even after the exchange rate system reform.

Tables 3-1 to 3-3 show the correlation matrix of the movements of five currencies during all the sample period, before and after the revaluation of the Chinese yuan. The correlation coefficient between the movements of the Chinese yuan and the US dollar was unity before the exchange rate system reform. However, it slightly decreases after the reform although it still remains at nearly unity.

(2) Estimation by using the Kalman Filter Method

We use the Kalman filter method to conduct the estimation of coefficients on the US dollar and the other three currencies[6]. The Kalman filter method is used to estimate time-varying coefficients. The regression equation is the following one:

$$\Delta \log e^{RMB/SFR} = a_0 + a_1 \Delta \log e^{USD/SFR} + a_2 \Delta \log e^{JPY/SFR} + a_3 \Delta \log e^{euro/SFR} + a_4 \Delta \log e^{WON/SFR} + \varepsilon_t \qquad (3)$$

$$a_{0,t} = a_{0,t-1} + \eta_{0,t} \qquad (4a)$$

$$a_{1,t} = a_{1,t-1} + \eta_{1,t} \qquad (4b)$$

$$a_{2,t} = a_{2,t-1} + \eta_{2,t} \qquad (4c)$$

$$a_{3,t} = a_{3,t-1} + \eta_{3,t} \qquad (4d)$$

[6] McKinnon (2002) used the Kalman filter method to conduct similar estimation of East Asian currencies.

$$a_{4,t} = a_{4,t-1} + \eta_{4,t} \qquad (4e)$$

Equation (3) is the same as the OLS estimation, but coefficients are assumed to vary over time. The transition equations of coefficients are given by equations (4a), (4b), (4c), (4d), and (4e).

Figures 1 shows time-varying evolution of the coefficients. The solid line shows an estimate of the coefficient while the dotted lines represent plus or minus two times the standard errors around the estimate.

The coefficient on the US dollar was nearly equal to a unity before the exchange rate system reform. On the day of the exchange rate system reform, it has abruptly decreased from a unity to 0.91. It is regarded that the change is statistically significant because the change is larger than two times the standard error. However, the change is very small in the economic meanings compared with other East Asian countries (Ogawa(2004)). After the day of the exchange rate system reform, it has been a little increasing toward a unity. The increases in the standard errors after the reform imply that the Chinese yuan has less stable linkages with the US dollar compared to the period before the exchange rate system reform.

The coefficients on the Japanese yen and the euro were nearly equal to zero before the exchange rate system reform. They have risen on the day of the exchange rate system reform. Especially the coefficient on the Japanese yen has statistically significant change on the day. Also standard errors of those coefficients increased on the day. However, the coefficients on the Japanese yen and the euro have been a little decreasing since the day of the exchange rate system reform.

We also estimated following regression equation that excludes the term of the Korean won.

$$\Delta \log e^{RMB/SFR} = a_0 + a_1 \Delta \log e^{USD/SFR} + a_2 \Delta \log e^{JPY/SFR} + a_3 \Delta \log e^{euro/SFR} + \varepsilon_t \qquad (5)$$

$$a_{0,t} = a_{0,t-1} + \eta_{0,t} \qquad (6a)$$

$$a_{1,t} = a_{1,t-1} + \eta_{1,t} \qquad (6b)$$

$$a_{2,t} = a_{2,t-1} + \eta_{2,t} \qquad (6c)$$

$$a_{3,t} = a_{3,t-1} + \eta_{3,t} \qquad (6d)$$

Figure 2 shows results. The result s are similar with the results in the case of regression analysis with the Korean won as an explanatory variable as shown in the figures.

Balassa-Samuelson Effect on the Chinese yuan

From a long-run viewpoint, we consider a possible trend path of the Chinese yuan in the future. We take account of growth rates of productivity when we consider Balassa-Samuelson effects on the Chinese yuan.

According to the Balassa-Samuelson hypothesis, it is assumed that productivity in tradable good sectors such as manufacturing sectors is increasing faster than that in non-tradable good sectors such as service sectors. In the situation of higher growth rate of productivity in the tradable good sectors, firms in the tradable good sectors can increase wage rate of labors who they employ, given that the firms are price-taker of the tradable goods in the world markets under a small open economy assumption. The increase in wage rate in the tradable good sectors affects on wage rate in the non-tradable good sectors under an assumption of labor mobility across the sectors. Firms in the non-tradable good sectors have to respond to the increase in wage rate by increasing their product prices in order to keep their profits. Accordingly, the general price index such as Consumer Price Index (CPI) which includes prices of non-tradable goods as well as tradable goods rises although prices of tradable goods are kept at unchanged level. A Purchasing Power Parity (PPP) calculated based on the CPI tends to be undervalued for the countries with higher growth of productivity. That is why their currency should be revalued compared with the PPP based on the CPI.

A simple model to explain the Balassa-Samuelson effect is described as follows. It is assumed that both domestic and foreign economies have a tradable good sector (T) and a non-tradable good sector (N). The domestic economy is assumed to be too small to have any effects on the foreign economy. It is assumed that workers can freely move between the tradable and the non-tradable good sectors in each of the economies while workers cannot move across the border between the two economies. Accordingly, a nominal wage rate (W) should be equalized between the tradable and the non-tradable good sectors. For simplicity, each price of the tradable (P_T) and the non-tradable goods (P_N) is assumed to be equal to the nominal wage rate divided by labor productivity (α_T and α_N for productivities of the tradable and the non-tradable good sectors, respectively). The law of one price is assumed to hold for the tradable goods as a result of international commodity arbitrage.

The prices of the tradable (P_T) and the non-tradable goods (P_N) in the domestic economy are represented as follows:

$$P_T = \frac{W}{\alpha_T} \qquad (7)$$

$$P_N = \frac{W}{\alpha_N} \qquad (8)$$

The prices of the tradable (P_T^*) and the non-tradable goods (P_N^*) in the foreign economy are represented as follows:

$$P_T^* = \frac{W^*}{\alpha_T^*} \qquad (9)$$

$$P_N^* = \frac{W^*}{\alpha_N^*} \qquad (10)$$

From the law of one price for the tradable goods, prices are equalized between home and foreign tradable goods as follows:

$$P_T = SP_T^* \qquad (11)$$

From equations (5), (7), and (9), we obtain the following equation:

$$S = \frac{W}{W^*}\frac{\alpha_T^*}{\alpha_T} \qquad (12a)$$

We can represent equation (11a) in terms of rate of change as follows:

$$\dot{S} = \left(\dot{W} - \dot{W}^*\right) + \left(\dot{\alpha}_T^* - \dot{\alpha}_T\right) \qquad (12b)$$

Equation (12b) means that higher growth rate of productivity should appreciate home currency. Higher growth rate of productivity should lead to decrease in prices of traded goods. In fact, prices of manufacturing products in China are cheaper than those in the rest of world, especially in developed countries. The decrease in relative prices of tradable goods in China in terms of those in developed countries should appreciate the Chinese yuan. In the long run, as the Chinese economy accumulates capital stocks and progress technology by transferring technology by FDI from developed countries, productivity of labor in Chinese economy will increase. Accordingly, revaluation of the Chinese yuan will be necessary in the long run.

Table 3 shows that growth rates of productivities of tradable goods sector in China, the United States, Japan, and Korea are 8.08%, 2.39%, 2.36%, and 5.08%, respectively.[7] On one hand, rates of change in nominal wage rate in tradable goods sector in China, the United States, Japan, and Korea are 6.74%, 1.48%, -0.24%, and 8.90% respectively. Given an assumption that their productivities keep growing at the current speeds, it is estimated that only growth rate of productivity will contribute to appreciation of the Chinese yuan about 5.7% p.a. against both the US dollar and the

[7] To calculate productivity, we defined tradable goods and non-tradable goods as following: for China and the United States, tradable goods are defined as products of primary industry and secondary industry excluding construction. Primary industry refers to agriculture, forestry, animal husbandry and fishery. Secondary industry refers to mining and quarrying, manufacturing, production and supply of electricity, water and gas, and construction. Non-tradable goods are defined as products of construction and tertiary industry. Tertiary industry refers to all other economic activities not included in primary or secondary industry. For Japan and Korea, tradable goods are defined as products of primary industry and secondary industry excluding construction and electricity, gas and water supply. Non-tradable goods are defined as products of construction, electricity, gas and water supply and tertiary industry. However, we define mining and manufacturing as tradable goods and other industry excluding primary industry as non-tradable goods for Japan and Korea when we calculate nominal wage growth as following because of the current data constraints.

Japanese yen. It is estimated that only growth rate of productivity will contribute to appreciation of the Chinese yuan about 3.0% p.a. against the Korean won. However, after taking into account increase in nominal wage rates, the Chinese yuan will appreciate by about 0.4% p.a. against the US dollar and depreciate by about 1.3% p.a. against the Japanese yen. It will appreciate by about 5.2% against the Korean won.

General price levels are weighted averages of tradable good price and non-tradable good price as follows:

$$S = P_T^{\omega_T} P_N^{\omega_N} \quad (13)$$

$$S^* = P_T^{*\omega_T^*} P_N^{*\omega_N^*} \quad (14)$$

When purchasing power parity (S^{PPP}) is defined as ratio of the general price levels in the domestic and the foreign economies, we can induce the following equation:

$$\log S^{PPP} = \log\left(\frac{P}{P^*}\right) = \log S + \omega_N\left(\log\alpha_T - \log\alpha_N\right) - \omega_N^*\left(\log\alpha_T^* - \log\alpha_N^*\right) \quad (15)$$

where S^{PPP}: purchasing power parity based on CPI, S: exchange rate for balancing trade balances, α_T: productivity in tradable goods sector, α_N: productivity in non-tradable goods sector, ω_T: share of tradable goods in CPI, ω_N: share of non-tradable goods in CPI, P_T: price of tradable goods, P_N: price of non-tradable goods, an asterisk (*) represents foreign variables.

We rewrite equation (15) in terms of rate of change as follows:

$$\dot{S}^{PPP} = \dot{S} + \omega_N\left(\dot{\alpha}_T - \dot{\alpha}_N\right) - \omega_N^*\left(\dot{\alpha}_T^* - \dot{\alpha}_N^*\right) \quad (16)$$

In the long run, the monetary authorities should adjust their target level and target composition of currency basket according to growth rate of productivities that bring about deviation between true equilibrium exchange rate and the PPP based on CPIs. Especially, we should take into account not only domestic productivity growth but also foreign productivity growth. If the monetary authorities put both the US dollar, the Japanese yen, the euro, and the Korean won into their currency basket under the currency basket system, they take into account not only productivity growth rate in China but also those in the United States, Japan, the euro area, and Korea according to equation (16).

On the other hand, it is recognized that wage rates in the tradable and non-tradable goods sectors are kept at lower levels because of a plentiful of potential unemployment in rural area in China. The unchanged wage rate in the non-tradable good sector is completely different from the assumption of

the Balassa-Samuelson hypothesis.

According to equation (16), it is estimated that the PPP of the Chinese yuan would be undervalued by about 1.6% p.a. against the US dollar, by about 0.8% against the Japanese yen, and by about 0.2% p.a. against the Korean won compared with the exchange rate ($\dot{S}$ in equation (16)) that is realized under the law of one price.

Conclusion

In this paper, we identified the actual exchange rate policy conducted by the Chinese government after the Chinese exchange rate system reform. Also, we consider long-run effect (Balassa-Samuelson effect) on the Chinese yuan. We found that the Chinese government has a statistically significant but little change in exchange rate policy by using data till January 25, 2006. It is not identified that the Chinese monetary authority is adopting the currency basket system because the change is too small in the economic sense. On one hand, higher growth rate of productivity will appreciate the Chinese yuan in terms of the US dollar and the Japanese yen while higher growth rates of productivity in Chinese tradable good sector tend to give the Balassa-Samuleson effect, that is depreciating bias, to the Chinese yuan.

What should be the next stage of China's reform of exchange rate regime? At the first step, the monetary authorities should seriously consider how to implement the current manage floating exchange rate system with reference to the currency basket and very small band. It is not necessary that the monetary authorities should pre-announce all of their exchange rate policy rules under the managed floating exchange rate system. However, the monetary authorities should have ex-post transparency and accountability for their exchange rate policy. They should consider about ex-post announcement of their intervention in foreign exchange markets like the Japanese Ministry of Finance.

At the next step, the monetary authorities should widen the band in order to make exchange rates of the Chinese yuan against each components of the currency basket. And at the third step, they should go toward floating exchange rate system while they prepare for deregulating capital control such as forward and future foreign exchange transactions, interest rate swap, and domestic firms' borrowing foreign currencies and foreign firms' borrowing the Chinese yuan not only inside Chine but also outside China and offshore markets.

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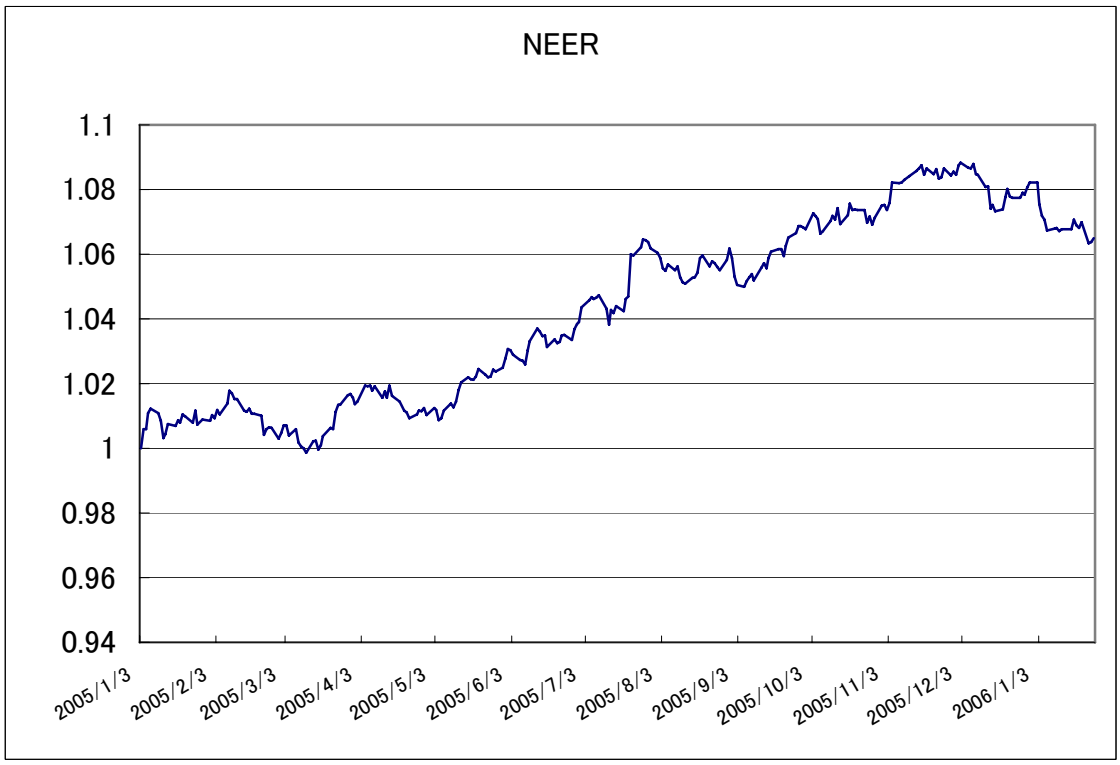
Figure 1: Effective exchange rates of the Chinese yuan



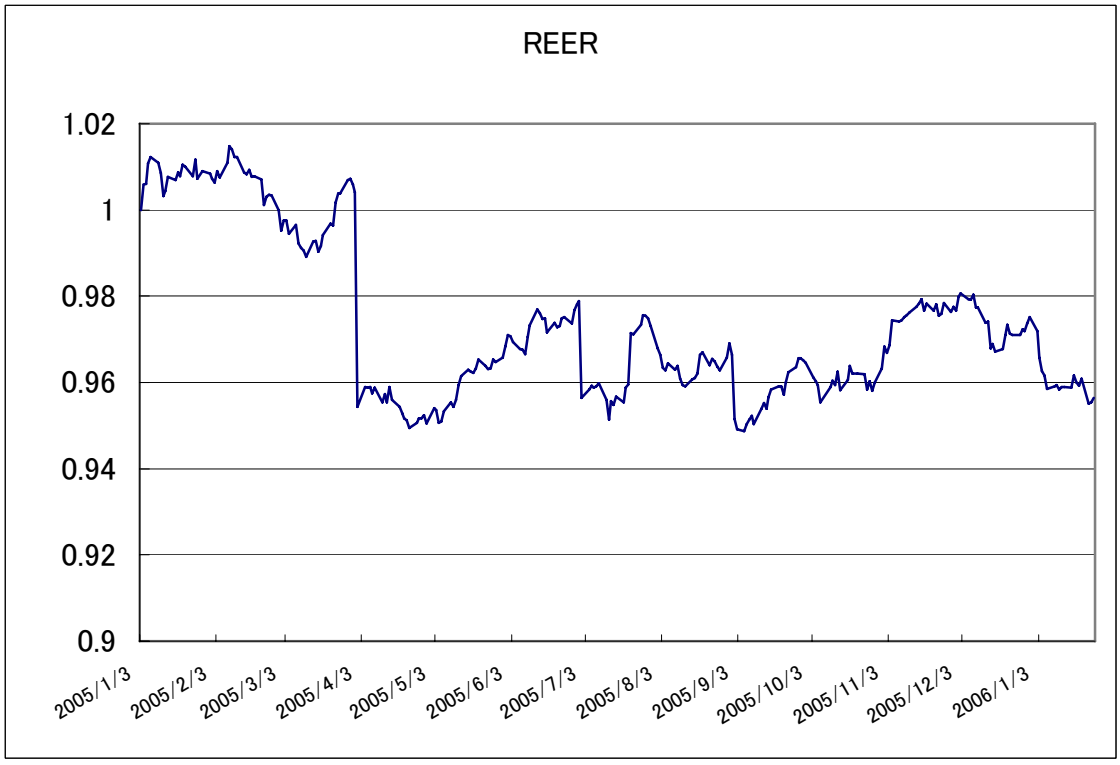


Table 1. Results of Estimation by using Frankel and Wei (1994) method (including the Korean Won)

Period	Constant	Japanese Yen		US Dollar		Euro		South Korean Won		Adj.Rsquared	D.W.Stat
2005/1/3-2005/3/31	0.0000	0.0002		0.9998	***	0.0001		-0.0003		1.0000	2.9634
S.D.	0.0000	0.0008		0.0009		0.0023		0.0007			
2005/4/1-2005/6/30	0.0000	-0.0001		0.9998	***	-0.0044	*	0.0001		1.0000	2.7789
S.D.	0.0000	0.0010		0.0011		0.0024		0.0010			
2005/7/1-2005/7/20	0.0000	0.0005		1.0016	***	-0.0043		-0.0031		1.0000	2.2144
S.D.	0.0000	0.0022		0.0016		0.0056		0.0015			
2005/7/22-2005/9/30	-0.0001	-0.0002		0.9582	***	-0.0222		0.0438	***	0.9976	2.2495
S.D.	0.0000	0.0103		0.0150		0.0358		0.0150			
2005/10/1-2005/12/30	0.0000	-0.0116	**	0.9842	***	-0.0037		0.0231	***	0.9991	2.5034
S.D.	0.0000	0.0058		0.0074		0.0166		0.0076			
2006/1/2-2006/1/25	-0.0001	-0.0040		1.0044	***	-0.0231		0.0220	*	0.9982	2.4166
S.D.	0.0001	0.0174		0.0210		0.0709		0.0113			

1)Daily foreign exchange rate data are from Datastream.

2)Estimated coefficients (standard errors) are calculated by OLS of Frankel and Wei Model.

3)***, ** and * indicate that the estimated coefficients are statistically significant at the 1%, 5% and 10% levels, respectively.

Table 2. Results of Estimation by using Frankel and Wei (1994) method (the without Korean Won)

Period	Constant	Japanese Yen	US Dollar		Euro		Adj.Rsquared	D.W.Stat
2005/1/3-2005/3/31	0.0000	0.0001	0.9995	***	0.0003		1.0000	2.9766
S.D.	0.0000	0.0007	0.0007		0.0023			
2005/4/1-2005/6/30	0.0000	-0.0001	0.9998	***	-0.0044	*	1.0000	2.7840
S.D.	0.0000	0.0009	0.0009		0.0023			
2005/7/1-2005/7/20	0.0000	0.0006	1.0004	***	-0.0082		1.0000	2.7680
S.D.	0.0000	0.0025	0.0017		0.0060			
2005/7/22-2005/9/30	0.0000	0.0075	0.9899	***	-0.0180		0.9972	2.3559
S.D.	0.0000	0.0108	0.0112		0.0387			
2005/10/1-2005/12/30	0.0000	-0.0073	1.0019	***	0.0045		0.9989	2.2308
S.D.	0.0000	0.0060	0.0049		0.0175			
2006/1/2-2006/1/25	-0.0001	0.0031	1.0251	***	-0.0470		0.9978	2.3195
S.D.	0.0001	0.0186	0.0199		0.0765			

1)Daily foreign exchange rate data are from Datastream.

2)Estimated coefficients (standard errors) are calculated by OLS of Frankel and Wei Model.

3)***, ** and * indicate that the estimated coefficients are statistically significant at the 1%, 5% and 10% levels, respectively.

Table 3-1 Correlations Matrix of the Movements of Five Currencies (all the period: January 3, 2005 to January 25, 2006)

	Chinese Yuan	US Dollar	Japanese Yen	Euro	Korean Won
Chinese Yuan	1				
US Dollar	0.98055	1			
Japanese Yen	0.54703	0.50515	1		
Euro	0.51269	0.51975	0.25561	1	
Korean Won	0.76883	0.77151	0.51042	0.4159	1

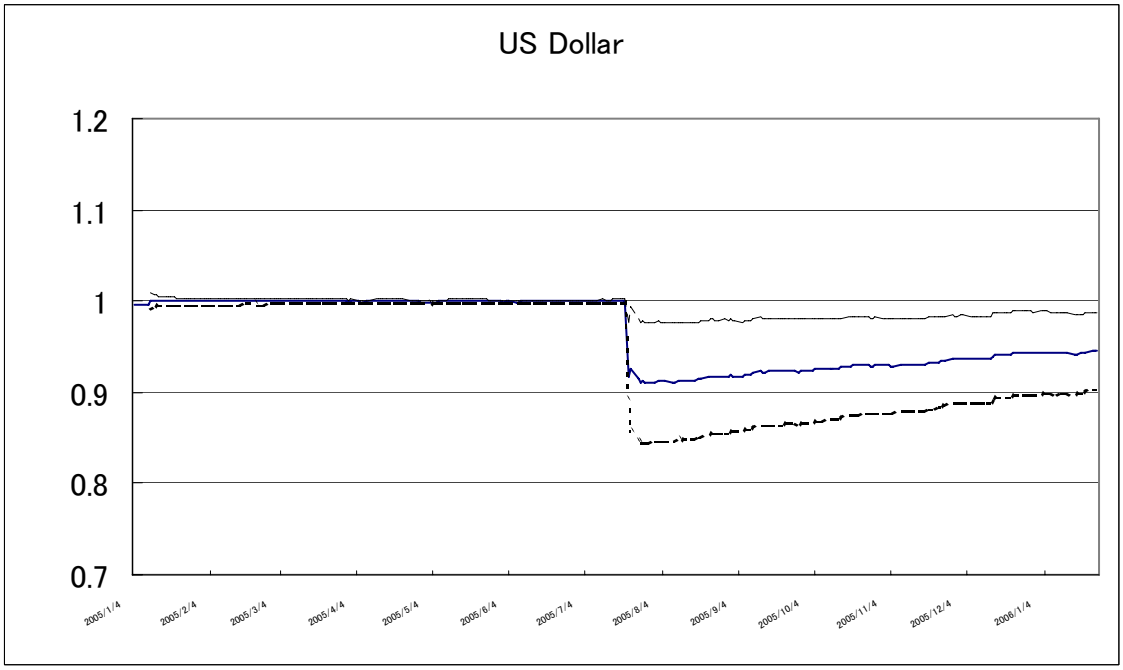
Table 3-2 Correlation Matrix of the Movements of Five Currencies (before the revaluation: January 3, 2005 to July 20, 2005)

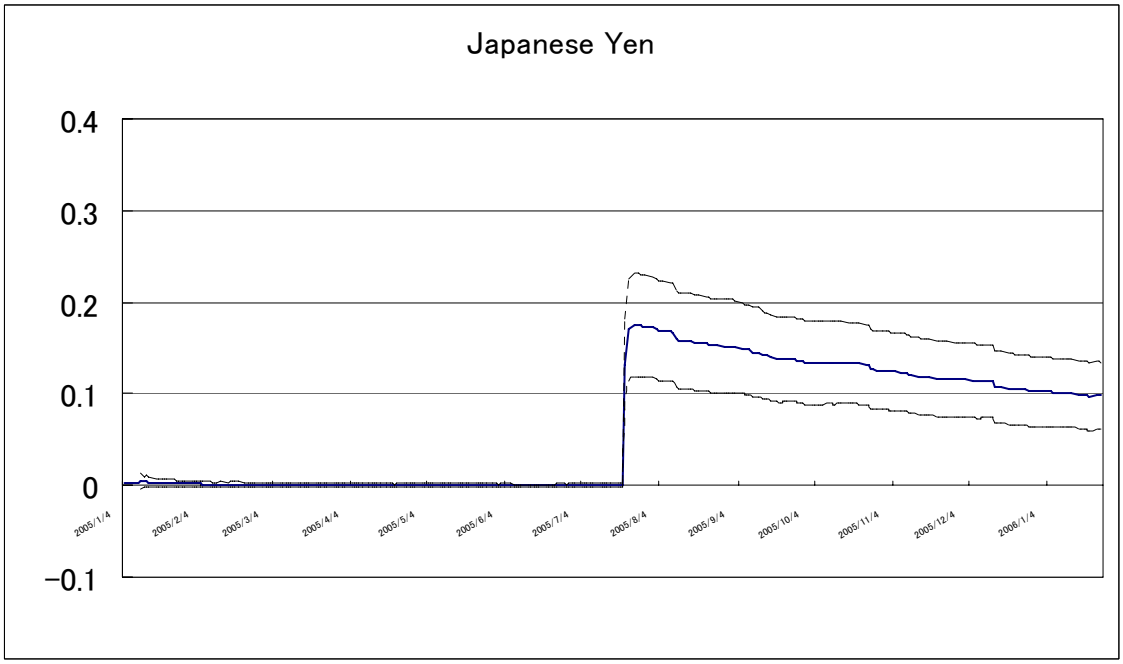
	Chinese Yuan	US Dollar	Japanese Yen	Euro	Korean Won
Chinese Yuan	1				
US Dollar	0.99999	1			
Japanese Yen	0.53297	0.5329	1		
Euro	0.53867	0.53921	0.23469	1	
Korean Won	0.753	0.7533	0.51697	0.40154	1

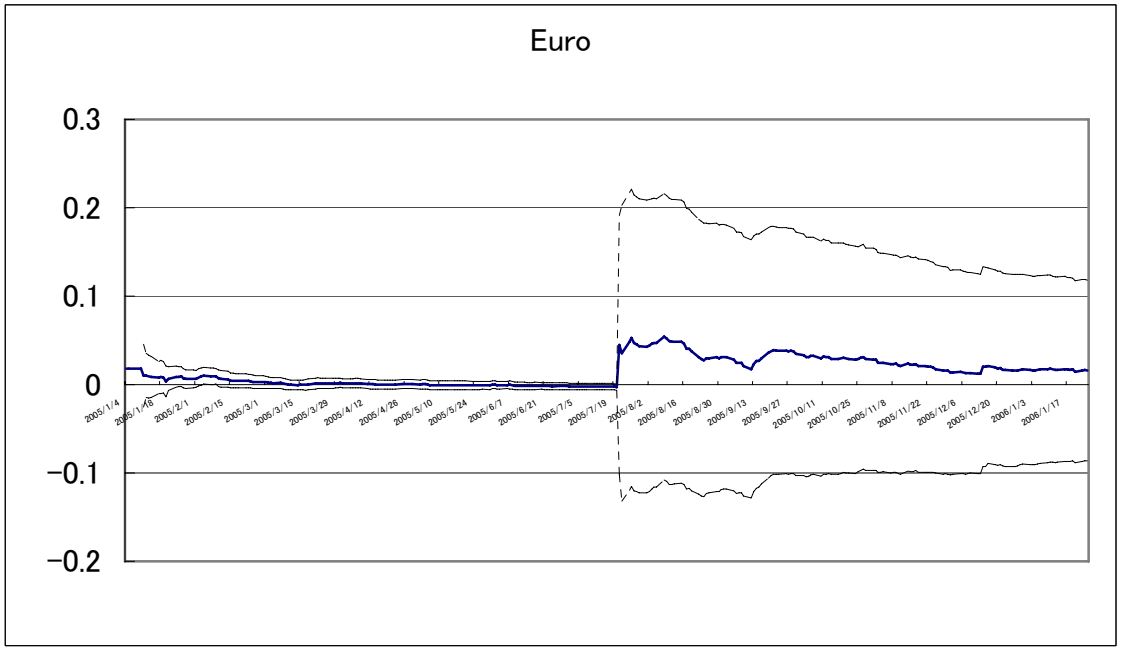
Table 3-3 Correlation Matrix of the Movements of Five Currencies (after the revaluation: July 22, 2005 to January 25, 2006)

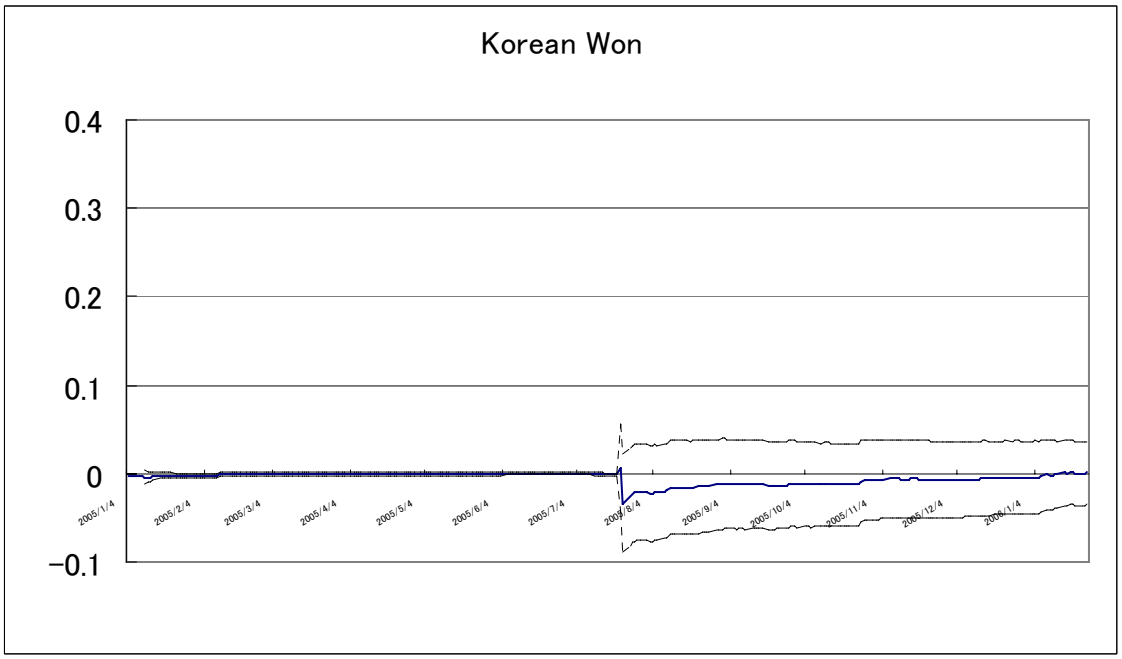
	Chinese Yuan	US Dollar	Japanese Yen	Euro	Korean Won
Chinese Yuan	1				
US Dollar	0.9991	1			
Japanese Yen	0.54883	0.54912	1		
Euro	0.49334	0.49549	0.30956	1	
Korean Won	0.81506	0.8064	0.55861	0.42979	1

Figure 2: Results of Estimation by using Kalman Filter Method (model including Korean Won)





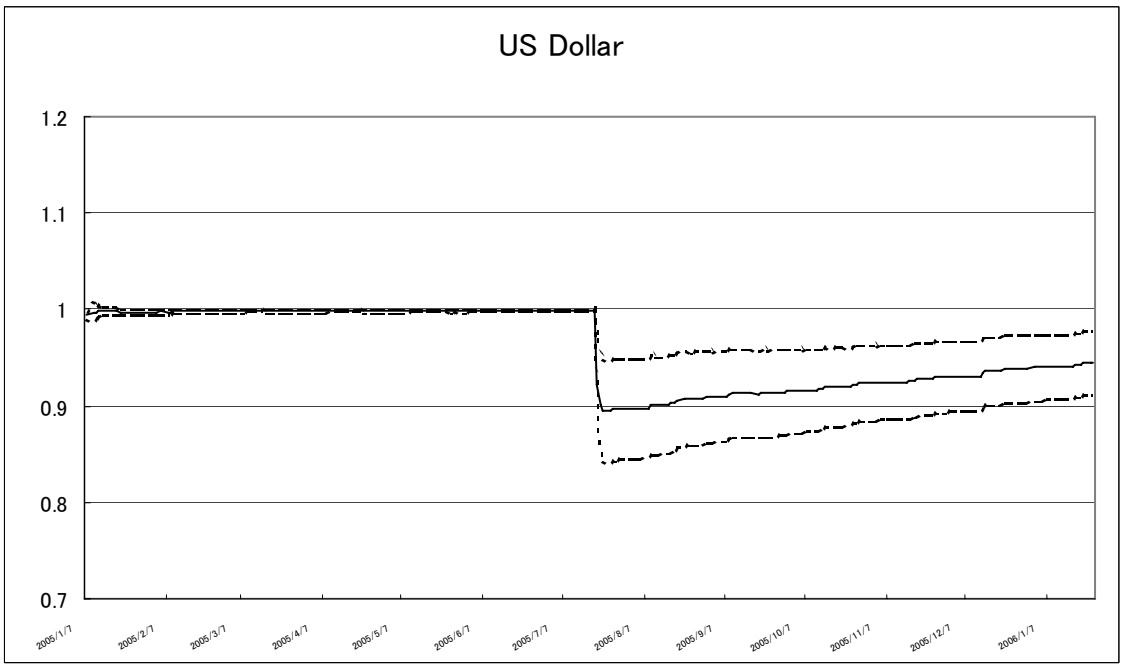


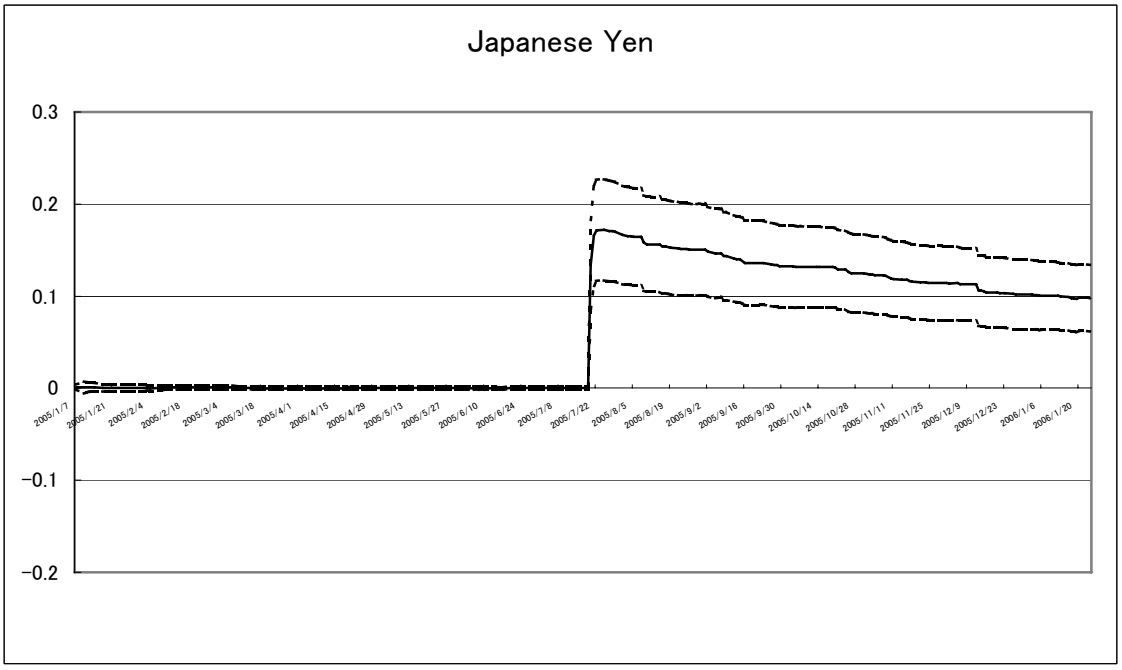


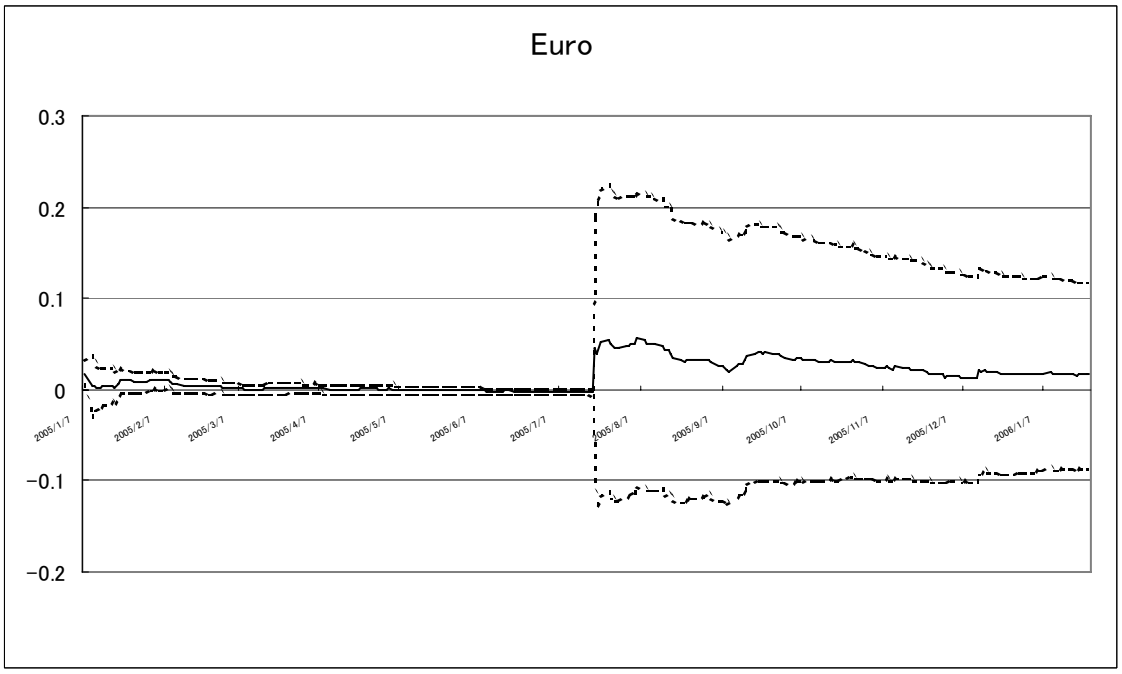
1) Solid lines indicate weights on each of the currencies

2) Dotted lines indicate $\pm 2\sigma$ (where σ =standard error) lines.

Figure 3: Results of Estimation by using Kalman Filter Method (model without Korean Won)







1) Solid lines indicate weights on each of the currencies

2) Dotted lines indicate $\pm 2\sigma$ (where σ =standard error) lines.

Table 3: Growth Rate of Productivity and Rate of Change in Nominal Wage
(Average in a period from 2000 to 2003*)

	China		United States		Japan		Korea	
	Tradable	Non-tradable	Tradable	Non-tradable	Tradable	Non-tradable	Tradable	Non-tradable
Share of Goods	59.57%	40.43%	25.39%	74.61%	7.77%	92.23%	19.96%	80.04%
Growth rate of Productivity	8.08%	4.17%	2.39%	2.39%	2.36%	1.50%	5.08%	3.39%
Rate of change in nominal wage rate	6.74%	8.55%	1.48%	5.89%	-0.24%	0.29%	8.90%	10.44%

Effects on Chinese yuan			
	vis-à-vis US dollar	vis-à-vis Japanese yen	vis-à-vis Korean won
Productivity effect	5.7% p.a. of appreciation	5.7% p.a. of appreciation	3.0% p.a. of appreciation
Productivity + wage effects	0.4% p.a. of appreciation	1.3% p.a. of depreciation	5.2% p.a. of appreciation
Balassa-Samuelson effect	1.6% p.a. of undervaluation	0.8% p.a. of undervaluation	0.2% p.a. of undervaluation

We defined real production divided by employment as productivity here. GDP deflator is used to deflate nominal variables to real variables.

* As for China, average in a period from 2000 to 2002 because of data constraints. As for nominal wage rate in the United States, average in a period from 2000 to 2001 because of data constraints. For Japanese and Korean nominal wage rate data, we define products of mining and manufacturing omitting products of agriculture, forestry, hunting and fishing as tradable good sectors. Thus the data is not consistent with the data of productivity growth.

Source: China: China Statistical Yearbook, United States: OECD STAN Data Base, Bureau of Economic Analysis, and Bureau of Labor Statistics, Japan: OECD STAN Data Base and Basic Survey on Wage Structure, Korea: OECD STAN Data Base and Korea Statistical Yearbook.