Equilibrium Exchange Rates in Asian Currencies*

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Abstract

This paper measured the equilibrium exchange rate in Asian currencies (baht, new Taiwan dollar, won, yen, and yuan) and the U.S. dollar. We compared the equilibrium exchange rate reflecting economic fundamentals with the actual exchange rate, checked which factor affects the movement equilibrium exchange rates.

The depreciations of baht, new Taiwan dollar, won, and yuan have moved along the movement of EER based on Yoshikawa (1990) of these currencies. As for Korea and China, rapid increases of labor productivity in these countries have restrained the excessive depreciation of won and yuan. However, considering capital input, actual won and yuan rates were undervalued to yen in 2000. In addition, considering multilateral trade, effective exchange rate of yen was undervalued to effective equilibrium exchange rate in 2000.

Keywords: Asian currency crisis, Equilibrium exchange rate, Hollowing out of industry, Productivity differences, Purchasing power parity

JEL classification: F31, F40, L60, O53

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1. **Introduction**

Since the collapse of the asset bubble in the beginning of the 1990s, the Japanese economy has been suffered from long-term economic stagnation. During the same decade, the other Asian countries attained high growth rate, though Asian currency crisis in 1997-98 disturbed a part of the countries. Observing such contrast, some economists have pointed out that “hollowing out of the Japanese industries” induced by the rapid development in the other Asian countries was one of the causes in the long-term stagnation of the Japanese economy because Japanese firms moved to the other Asian area where the production cost was lower than Japan.

Discussing about “hollowing effect of industries”, we have to consider whether the present exchange rate is a proper index to measure international competitiveness of industries. In the first half of the 1980s, the Japanese export to the U.S. grew sharply, causing trade frictions. Calculating equilibrium exchange rate (hereafter EER) which we will discuss below, Yoshikawa (1990) explained that the sharp increase of the Japanese export was caused by the overvaluation of the U.S. dollar. At that time, the U.S. economy was suffered from “hollowing effect of industries” and lost international competitiveness. In that sense, the U.S. economy in the first half of the 80s gives important lessons for our understanding the Japanese economy in the 90s.

Now, not only we focus on the exchange rate against the U.S. dollar, but also the exchange rates against the other Asian countries because Asian countries have become a big trade partner. Especially, the growing presence and current account surplus of the Chinese economy has influenced the world economy. Many countries pay attention to the U.S. dollar peg system of yuan, and are interested in the long-run equilibrium rate when China moves to more flexible exchange rate system. Furthermore, many Asian countries take positive attitudes toward Free Trade Area (hereafter FTA). However, if home currency is overvalued than EER, FTA is likely to be disadvantageous for industries in the home country. Then, we need the measurement of EER to understand effects of FTA on international competitiveness of industries.

To understand the above topics in an academic field, we will measure EERs of five Asian countries (China, Japan, Korea, Taiwan, Thailand) and U.S. and consider international competitiveness among those countries. The reasons why we select these countries are as follows. Firstly, unlike Singapore and Hong Kong, these countries have relatively similar industrial structures. Secondly, these countries have had close trade relationships.1 Thirdly, in these countries statistical data which we require for measurement of EER is available.

Our paper is constructed as follows. In the next section, we measure EER among five Asian countries and the U.S., using the concept of Yoshikawa (1990).2 In Section3, we examine which

1 Proportion of trade volume to the U.S. and four Asian countries to the total volume in Japan expanded from 16% to 25% in 1990.
factor affects the movement of EER. Especially, we focus on the effects of productivity differences between two countries on the movement on EER. In Section 4 we will propose alternative measures of EER. First, we discard the assumption that cost of capital equates internationally and add capital service as a new factor of production. Second, concerning EER of won, we consider the intermediate input from the service sector. Third, because the original concept of EER is based on bilateral trade, we will measure effective EER based on multilateral trade. In the last section, we summarize our results and state some remarks for future studies.

2 The Measurement of EER Based on Yoshikawa (1990)

2.1 The Concept of EER

EER is a kind of purchasing power parity (hereafter PPP). While the definition of PPP assumes that price including not only tradable goods but also non-tradable goods converged to a constant value between a home country and a foreign country, EER proposed by Yoshikawa (1990) is the exchange rate which equalizes the price of tradable goods between a home country and a foreign country. In the tradable goods sector, he assumed that both labor and raw material are production factors. If the fixed input coefficients are assumed for simplification, the tradable goods price ($P$) of a home country can be expressed as follows,

$$P = aW + bP_m$$  \hspace{1cm} (1)

where $a$, $b$ are labor input coefficient (reciprocal of labor productivity), and raw material input coefficient (reciprocal of raw material productivity), respectively. $W$ and $P_m$ denote nominal wage and material price, respectively. If the “law of one price in the international market” holds for the tradable goods price $P$ and the imported raw material price $P_m$ through the nominal exchange rate $e$, we can rewrite (1) as follows.

$$eP^* = aW + b(eP^*_m)$$  \hspace{1cm} (2)

Here $P^*$ and $P^*_m$ are the prices of tradable goods and raw material evaluated in a foreign currency, respectively.

Similarly, the price of tradable goods in a foreign country is formulated by (3).

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3 Chipman (1971) showed that fixed production factor ratio was selected in the trade model which allowed that production factors are substitutable in the production function.
From (2) and (3), we obtain EER as follows,

\[
P^* = a^* W^* + b^* P_m^*
\]

(3)

From (2) and (3), we obtain EER as follows,

\[
e = \left( \frac{W}{W^*} \right) \left[ \frac{a^*}{a^* + b^* \left( \frac{P_m^*}{P^*} \right)} \right] \left[ 1 - b^* \left( \frac{P_m^*}{P^*} \right) \right]
\]

(4)

The formula (4) shows that EER is influenced by the nominal wage ratio \((W/W^*)\), labor input coefficient \((a, a^*)\), raw material input coefficient \((b, b^*)\), and (the reciprocal of) the terms of trade \((P_m^*/P^*)\). From (4), the rise (fall) of the nominal wage in home country or the fall (rise) of productivity in labor or the raw material input in home country makes depreciation (appreciation) in home currency, and the rise (fall) of the terms of trade makes home currency appreciated (depreciated).

2.2 Calculating EER

As we stated in the introduction, we calculate EER in China, Japan, Korea, Taiwan, Thailand, and the U.S. based on (4). The series of EER is from 1980 to 2000 except for China (from 1985 to 2000), which is due to the availability of the data.

The first step of the measurement of EER is to determine a base year. We set a base year when current account is balanced. In a base year, EER is equal to actual nominal exchange rate. Because Asian countries which we examine industrialized during the 1990s, we select the base year in the decade. We calculate the three-year moving average of the current account of each country to smooth effects of business cycles, and pick up a year with the smallest value as a base year of a country.

The next step is to calculate EER series based on (4). Because each factor in (4) is measured at different term, we make their indices which are 100 at the base year and construct EER series. Concerning the construction of labor and raw material coefficients in tradable goods, we choose eight manufacturing industries (fibers, chemical, primary metals, metal products, general machinery, electrical machinery, transportation equipment, and precision instrument) which dominate trade volume in each country. Both of labor input coefficient and raw material input coefficient of each industry are a weighted average by the export share of the above industries.\(^4\) We transform the

\(^4\) See the data appendix for the estimation method of each coefficient and data sources.
calculated index series into EER in terms of currency by multiplying the indexed EER by nominal exchange rate at the base year.

The results of calculation and actual exchange rates are summarized in Table 1. The data which is used for the calculation is summarized in Appendix.

(Insert Table 1)

2.3 Evaluation of EER

2.3.1 EER concerning Korean won rate

Concerning won/yen rate, won/U.S. dollar rate, and won/yuan rate, actual exchange rate and EER had same trend in the first half of the 1990s. Won has depreciated during for about fifteen years in both rates. This implies that the movements of actual won rate has reflected real phase in Korea, Japan, the U.S. and China.

The large gap between two rates generated in the period of Asian currency crisis in 1997, 98. In won/yen rate, the gap contracted after the crisis and the actual rate converged to EER in 2000. However, in won/ U.S. dollar rate and won/yuan rate, the gap remained in 2000. The actual won was 22% undervalued against equilibrium won/U.S. dollar rate and 91% undervalued against equilibrium won/yuan rate.

2.3.2 EER concerning China yuan rate

Both actual rate and EER in yuan/yen rate had depreciated until 1993. After 1994 when yuan rate was pegged to U.S. dollar, the movement of actual yuan/yen rate was parallel to that of actual U.S. dollar/yen rate. Then, the actual yuan rate undervalued than equilibrium yuan rate when yen appreciated against U.S. dollar in the mid 1990s. Conversely, the actual yuan rate overvalued than equilibrium yuan rate when yen depreciated against U.S. dollar in 1997-98 when Japan suffered from the collapse of the financial system. However, both rate converged in 2000.

Concerning yuan/U.S. dollar rate, the gap between actual rate and EER has widened since 1994 when the peg of yuan began. Basically, actual yuan rate is overvalued than equilibrium yuan rate. In 2000, the gap was about 20%.

2.3.3 EER concerning other currencies

There is no big gap between the actual exchange rate and EER of Taiwan dollar/yen in the first

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5 In the recent works concerning the exchange rate of yuan, Akama, Mifune, and Noro (2002) measured purchasing power parity (PPP) between China and Japan setting the base year 1993. They concluded that the gap between the actual rate and PPP was not large. By estimating export and import function, Hirose and Morito (2003) measured EER which equilibrate trade balance. In their work, yuan is undervalued against yen or US dollar. Examining the gap between EER and actual rate in machine products which is a main tradable goods for Japan, Japan Center for Economic Research (2004) also showed that yuan is undervalued against yen.
half of the 90s. Although the actual exchange rate of new Taiwan dollar tended to be overvalued in the second half of the 90s, the gap between actual rate and EER which widened in the period of Asian Currency crisis was reduced as the actual exchange rate depreciated after the crisis. The actual exchange rate and EER of new Taiwan dollar/U.S. dollar were similar movements from the first half of the 1990s to 1998. Therefore, we consider that the depreciation of the new Taiwan dollar/U.S. dollar after the Asian currency crisis was not explained by economic fundamentals.

The actual baht rates against yen are overvalued to EER in the mid 1990s. On the other hand, comparing to U.S. dollar, the actual baht is overvalued to EER in 1998 and 1999, and these turned on the same level in 2000. Therefore, we consider that the large depreciation of baht against yen and U.S. dollar in the Asian currency crisis reflected economic fundamentals.

3 Sources of the movement of EER: Factor Prices and Productivity Differences

As we observed in the last section, some actual exchange rates had same trends as EERs. This implies that actual exchange rate is affected by economic fundamentals such as the movement of productivity and wage rate. Conversely, in the case that there is a gap between two rates, actual exchange rate does not reflect economic fundamentals and it generates biases in international competitiveness. In this section, we check which factor affects EER like Yoshikawa (1990) and Miyagawa and Toya (1999). We check it to compare EER with several simulated exchange rates (hereafter SER). SER is constructed by fixed one factor which consists of EER at the base year. For example, if SER of which a labor coefficient is fixed at the base year is undervalued against EER, we can understand that the increase in labor productivity makes EER appreciated. Our comparisons between EER and SER are summarized in Table 2.

(Insert Table 2)

3.1 Comparison between EER and SER of Korea won

In Table 2-1, Table 2-2 and Table 2-3, simulation results concerning won rate are summarized. In won/yen rate, the table shows that the movement of EER is in line with that of PPP measured at the wages. The result contrasts with the case of EER of yen/U.S. dollar studied by Yoshikawa (1990) which showed the gap between EER and PPP was very large. However, the result does not mean that productivity differences between Korea and Japan played no role on the movement EER. When the Korea labor input coefficient \( a \) was set constant, SER of won in 2000 decreased to about one third of EER. The simulation shows that the rise of the Korean labor productivity in this period gave a
large effect on won. However, even if Korean raw material input coefficient $b$ is fixed, there is no significant gap between EER and SER. The result implies that change of Korean raw material input coefficient $b$ has seldom affected EER. When labor input coefficient and raw material input coefficient of Japan are fixed, won in SER is more appreciated than won in EER. As a result, as rapid increase in Korean productivity was offset by increases in Japanese labor and raw material productivity, the movement of EER was explained by that of PPP.

In the case of won/U.S. dollar rate, the results are different from the case of won/yen rate. Like won/yen rate, won in EER and PPP has devaluated together. However, won in PPP was more devaluated than won in EER in 2000. The result of fixing labor productivity in both countries implies that labor productivity differences have made won appreciated more than the won/yen case.

### 3.2 Comparison between EER and SER of Chinese yuan

In the case of yuan, PPP was more depreciated than EER in both yuan/yen and yuan/U.S. dollar. This implies that Chinese wage growth was faster than those in Japan and the U.S.. However, the rapid growth of Chinese labor productivity restrained the devaluation of yuan/yen rate and yuan/U.S. dollar rate. If the Chinese labor productivity was fixed at 1993, yuan/yen rate and yuan/U.S. dollar rate dropped at one third of EER in 2000.

On the other hand, the Chinese raw material productivity has not affected EER of yuan so much. However, raw material productivity in Japan and the U.S. affected EER of yuan. The raw material productivity growth in both countries contributed to the appreciation in their currencies.

### 3.3 Comparison between EER and SER of other currencies

Table 2-6 and Table 2-7 show the source of EER movements in new Taiwan dollar. EER in new Taiwan dollar moved with PPP like Korean won. The large increase of the labor productivity in Taiwan was offset by the increase of labor and the raw material productivities in Japan or the U.S. until Asian currency crisis. After the crisis, EER of new Taiwan dollar appreciated because the productivity gap in labor and raw material has contracted.

In Table 2-8 and Table 2-9, the movement of PPP in Thailand baht was different from those in Korean won, Chinese yuan, and new Taiwan dollar. It was overvalued against EER, though it has depreciated during 20 years. The result implies another factor induced more depreciation than that of PPP. Our simulation results show that the devaluation of EER was affected by the productivity growth in labor and raw material in Japan and the U.S., while the productivity growth in Thailand did not play an important role on EER.
4 Alternative Measurements in EER

The concept of EER examined by Yoshikawa (1990) is based on several assumptions. We check the above results by changing these assumptions. In addition to the basic model, we will consider the following three cases; a difference in cost of capital between two countries, adding service input, and effective EER considering multilateral trade.

4.1 A difference in Cost of Capital

In the basic model, we do not consider capital service input on product activities, because costs of capital in two countries are equalized in the long run due to the perfect international capital flow and the difference in capital coefficients in two countries were assumed not to affect EER so much. However, as Feldstein and Horioka (1980) shown, it is hard to say that domestic investment behavior is affected by free international capital movement. In addition, China has still maintained the restraint of capital inflow and outflow. Statistical data also shows that the capital coefficient (efficiency of capital) indicates the upward trend from the 1970s in Japan, while it has been stable in the U.S., and the gap between the two coefficients have widened recently.

Therefore, we remove the assumption of the equalization of the costs of capital due to the free international movement, and measure an alternative EER which includes capital service as a factor of production. When capital is included, the tradable goods price in home country can be expressed as follows.

\[ P = aW + bP_m + cR \] (5)

Here \( c \) is capital coefficient and \( R \) is cost of capital. Similarly the tradable goods price of foreign country is defined by

\[ P^* = a^*W^* + b^*P^*_m + c^*R^* \] (6)

From (5) and (6), the equilibrium exchange rate including capital service as input is

\[ e_k = \left( \frac{W}{W^*} \right) \left[ \frac{1}{1 - b\left( P^*_m / P^* \right)} \right] \left[ \frac{1}{d^* + b^*\left( P^*_m / W^* \right) + c^*q^*} \right] \] (7)

In (7), \( q \) indicates the factor price ratio (cost of capital (\( R \)) / wage (\( W \))). From equation (7), the
relative rise (fall) of capital coefficient and cost of capital depreciate (appreciate) domestic currency in EER.

To construct an alternative measure of EER, we need the data of capital coefficient and cost of capital. However, it is difficult to use these data in the case of China. Hence we can calculate $c_q$ based on the following equation in all countries and areas.

$$c_q = \frac{K}{Y} \frac{R}{W} = \frac{UCC}{W}$$  \hspace{1cm} (8)

We pick up the portion of the operating surplus from Input-Output Table, computed the unit capital cost ($UCC$), and measured $e_k$. The details of data are stated in Appendix.

The results of the measurement in EER concerning China, Korea and Japan are described in Figure 1 and Figure 2. In these figures, we show the series of actual exchange rate and EER in the basic case for reference.

(Insert Figure 1 and 2)

In Figure 1, the gap between EER including capital service and actual exchange rate was larger than that in the basic case after the Asian currency crisis. Then yen was 25% overvalued against won in 2000. Why was actual yen rate overvalued against won though the capital cost decreased by the zero interest rate policy after the middle of the 90s in Japan? First, due to the deflation in Japan, real capital cost was not so low in the late 1990s and unit capital cost has cheaper than in South Korea. Second, due to the rapid increase in wages in Korea, the ratio of cost of capital to wage ($q$) is lower than that in Japan.

Next, we check the movements of EER in yuan/yen. Although the gap between EER including capital service and actual exchange rate spread in the mid 1990s when yen appreciated, the gap has converged recently. The recent movement reflects the rapid capital accumulation accompanying Chinese economic development.

4.2 Considering Service Input

International competitiveness of tradable goods is affected by not only productivity differences of labor or raw materials but also by the price in non-tradable goods. In the 1990s, many economists pointed out that Japanese international competitiveness was deteriorated by high price of

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6 Considering capital service input, we also measure EER of other cases (for example, the case of won/US dollar and yuan/U.S. dollar). If the reader is interested in EER series in the other cases, we can send the results in other cases.

7 Concerning won/U.S. dollar rate, the gap between EER considering capital service input and the actual rate tended to converge.
non-tradable sector. By focusing on the service sector, we check the effects of non-tradable sector on the movement of EER.

We assume that production factor in the service sector is only labor, because the production technology of service sector can be considered as labor intensive. Suppose that the inter-sectoral movement of labor is free and the wage rate is equalized in each industry. Then modified EER \((e_s)\) can be written as follows.

\[
e_s = \left( \frac{W}{W^*} \right) \left[ \frac{(a + gh)g}{a^* + b^* (P_m^*/P^*)} \right] \]

In (9), \(g\) is an input coefficient to the tradable sector from the service sector and \(h\) is the labor input coefficient in the service sector. If \(g\) and \(h\) in a home country rise in (9), a home currency in EER will depreciate and vice versa.

Due to the availability of the data in the service sector, we can measure only EER of won/yen rate. According to Figure 3, won in EER considering the input from the service sector was more depreciated than won in the basic EER. While the actual won rate was undervalued in 2000 with comparison to the basic EER, it was overvalued with comparison to EER considering the input from the service sector. We think that in addition to the lower productivity of Korean service sector, the increase of inputs from service sector in Korea in the 1990s made EER with service sector more depreciated. The low productivity in the service sector was pointed out not only in Korea but also in Japan. That is, if the tradable goods sector attained higher productivity than non-tradable goods sector, Balassa/Samuelson effect will work. This Balassa/Samuelson effect induced the appreciation of the actual won. As a result, Korea as well as Japan may be suffered from the price differential between the domestic and overseas markets.

(Insert Figure 3)

4.3 Measuring the effective equilibrium exchange rate

We have defined EER as the exchange rate where international competitiveness is equalized in the bilateral trade. However, in the real world, goods trade is carried out among many countries and bilateral competitiveness does not equalize in the log run. If we remove the assumption that goods are traded between two countries, the long-term bilateral exchange rate may not revise the trade balance disequilibrium. Even if the actual exchange rate against specific currency converges to EER,

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8 We also measured EER with service input concerning won/U.S. dollar rate. We can send this series upon the request from the reader.
the actual exchange rate against another currency may diverge from another EER. Here we attempt to calculate weighted average of EER constructed between two countries by trade weight, as the effective equilibrium exchange rate. The steps to calculate effective EER are as follows.

1. We use the basic type of EER in each currency to construct the effective EER, due to the data availability.
2. Each EER is indexed. The base year is 1990 and we set the index value in 1990 at 100.9
3. We provide two types of the trade weight. One is the fixed weight in 1990, the other is the flexible weight using annual trade weight. Since we construct Japanese effective equilibrium exchange rate, the data source is *Foreign Trade Outlook* of the Ministry of Finance, Government of Japan.10
4. Effective equilibrium exchange rate is constructed as the weight averaged series of each EER.

Our effective EER is not constructed by covering all trade partners in Japan. However, the trade volume (export + import volume) with China, Korea, Taiwan, Thailand and the U.S. dominated 43.6% of the whole trade volume in Japan in 1990. We think that this proportion has increased recently and it is enough to calculate effective EER.

The series of the effective EER of Japan is described in Figure 4. In Figure 4, not only the effective EER of Japan, but also the nominal effective exchange rate of Japan using the same trade weight at our measurement of effective EER, and the nominal effective exchange rate of IMF statistics (*International Financial Statistics*) are showed. When yen appreciates, the effective EER shows a higher index value in Figure 4.

(Insert Figure 4)

The nominal effective exchange rate calculated by the trade weight to the U.S. and Asian countries and the nominal effective exchange rate of IMF statistics had the similar trend. Hence, we focus on the movement of effective EER and nominal effective exchange rate which we calculated.

Since the actual yen rate appreciated against U.S. dollar in the first half of the 1990s, the nominal rate became overvalued greatly to the effective EER. However, in the period of the crisis in the Japanese financial system in 1997-98, yen was depreciated against U.S. dollar and yuan which was pegged to U.S. dollar. Then, the gap between the nominal rate and the effective EER contracted.

9 The year which recorded the lowest current account/GDP ratio depends on the country. However, we set 1990 the base year when Japan recorded the lowest current account/GDP ratio because we measure effective EER of yen.
10 Trade weight is endogenous in the sense that it is affected by exchange rate. So, we measure the effective EER with fixed trade weight in addition to the effective EER with variable trade weight.
nominal rate has become overvalued again to the effective EER since 1999, because actual yen/U.S.
dollar rate became overvalued to EER in yen/U.S. dollar rate, and actual yen rates are almost equal
to EER of China yuan, Korea won, and new Taiwan dollar. In 2000, the nominal rate is overvalued
about 23% (fixed weight), 17% (flexible weight), compared with the effective EER. In the bilateral
trade case in China, Korea, and Taiwan, the gaps between nominal rate and EER are not so large.
However, under the assumption of multilateral trade, yen needs to depreciate about 17 to 23%.

5 Conclusions and Future Research Topics

International competitiveness in Japanese industries has paid attention to because it is one of the
crucial factors of the long-term stagnation in the Japanese economy and the deterioration of
international competitiveness in Japanese industries caused low productivity growth. The
measurement of international competitiveness depends on whether the actual exchange rate reflects
economic fundamentals such as factor prices and productivity differences. Especially, the topic
concerning exchange rate among Asian countries reflecting appropriate international
competitiveness has become more important, due to the large current surplus of China and FTA
boom in Asian countries.

Concerning the above topics, we provide equilibrium exchange rate as a candidate of an exchange
rate which reflects economic fundamentals and measure it among five Asian countries and the U.S..
Our results of the measurement are summarized as follows.

(1) Korea: There was little gap between EER of won/yen rate in the basic case and the actual
exchange rate till the Asian currency crisis. Although the Asian currency crisis extended the
gap, it disappeared again in 2000. On the other hand, in the case of won/U.S. dollar, the gap
between two rates after the Asian currency crisis remained till 2000, and U.S. dollar has
overvalued a little to won.

(2) China: Since the middle of 90s, the actual yuan rate against yen has been overvalued to EER,
while it against U.S. dollar has been undervalued to EER. However, in 2000, actual exchange
rate and EER of yuan/ yen are almost on the same level.

(3) Taiwan: Although the gap between EER and the actual exchange rate of new Taiwan dollar/
yen generated temporarily in the period of Asian currency crisis, the gap almost disappeared.
However, in the case of new Taiwan dollar/U.S. dollar rate, the actual new Taiwan dollar rate is
somewhat overvalued in 2000.

(4) Thailand: in the case of baht/yen rate, the gap between EER and actual rate has spread after the
Asian currency crisis, and the actual baht rate is overvalued in 2000. On the other hand, in the
case of baht/U.S. dollar rate, there is no divergence is between two rates in spite of the Asian currency crisis.

(5) Checking the sources of the movement in EER, we found that nominal wage rates and productivity differences between two countries played important roles on the movement in EER. In the case of won, EER moved along PPP measured by wage rates in two countries. Labor productivity growth in Korea was offset by labor and raw material growth in the other countries. In the case of yuan, rapid labor productivity growth restrained the devaluation of yuan induced by rapid wage growth in China.

(6) Considering the difference in costs of capital between two countries, actual won rate and actual yuan rate tended to be undervalued to EER in 2000.

(7) Measuring EER with the input from the service sector which is likely to affect the international competitiveness of the tradable goods, won depreciated against yen. This implies the price differential between the domestic and overseas markets inherent in Korea.

(8) Assuming multilateral trade, we construct effective EER. As for comparison of the effective EER and the actual effective exchange rate, the actual effective rate of yen overvalued from 17 to 23% to the effective EER in 2000.

Our analysis offers a useful index about the level of an exchange rate desirable in the long run. The index is also useful for judging the validity of the intervention towards the international financial market by monetary authority. Furthermore, using the gap between actual rate and EER, the government can check whether FTA with a specific foreign country is advantageous for a home country.

We can carry out the following extension to improve our analysis. Firstly, when we make the EER considering capital service input, we used the operating surplus as the data of unit capital cost, but it reflects the accurate cost of capital partly. By estimating the capital stock of major trading partners of Japan, it would be possible to construct more accurate EER with capital service input. Secondly, we have assumed that the industrial structures of home and foreign countries were same. However, the change of the industrial structure in the Asian countries is rapid, and they are in various development stages. It will be necessary to analyze how EER is affected from the different development stages or industrial structures. Finally, the gap between an actual exchange rate and EER affects several international economic variables such as the trade structure in two countries, foreign direct investment behavior, and international capital movement. We will check the relations of EER to these variables.
Appendix Estimation method of the data

The following variables are used in our calculation of equilibrium exchange rate.

(1) Labor input coefficient
(2) Raw material input coefficient
(3) Service input coefficient
(4) Unit capital cost
(5) Nominal wage
(6) Raw material price
(7) Export price
(8) Export share.

The sample period of all variables is from 1980 to 2000, except China (from 1985 to 2000) due to availability of the data. We describe the estimation method of the variables (1) – (8).

(1) Labor input coefficient:  \[ a = \sum_i \sigma_i a_i \]

The labor input coefficient of the manufacturing industry is used the weighted average of the labor input coefficient \( a_i \) in each sector which calculated by having divided the number of workers by real production. The weight used for the calculation is the export share in each sector (\( \sigma_i \): we discuss in detail later). The sectors we used are fibers, chemical, primary metals, metal products, general machinery, electrical machinery, transportation equipment, and precision instrument.

And, about Korea, in order to take service input into consideration, the labor input coefficient of Japanese and Korean service industry is needed. Because the labor input coefficient of service industry (\( h \)) in Japan, and Korea did not have detailed data for every sector like manufacturing industry, we made the labor input coefficient by means of dividing the number of workers of total service industry by the real value added of total service industry.

(2) Raw material input coefficient:  \[ h = \sum_i \sigma_i \left[ b_{1,i} + b_{1,\text{PETRO}} \times b_{\text{PETRO},i} \right] \]

a. First, the direct input coefficient is calculated by (Input of each manufacturing sector from the mining) / (Production of each manufacturing sector) (\( b_{1,i} \)).

b. Second, the indirect input coefficient which is calculated by multiplying the input coefficient: (Input of each manufacturing sector from petroleum and coal products) / (Production of each manufacturing sector), by the input coefficient: (Input of petroleum and coal products sector...
from the mining) / (Production of petroleum and coal products sector) \( (b_{i,\text{PETRO}} \times b_{\text{PETRO},i}) \).

They are weighted by export share like as labor input coefficient. When the data is not available in annual, we estimate it by linear interpolation.

(3) Service input coefficient: \( g = \sum \sigma_i g_i \)

Weighted average of the input coefficient (Input of each manufacturing sector from service industry) / (Production in each manufacturing sector) by export share. When the data is not available in annual, we estimate it by linear interpolation.

(4) Unit capital cost: \( UCC = \sum \sigma_i UCC_i \)

Although it is desirable to use the operating surplus of Input-Output Table as for the unit cost of capital in the manufacturing industry, we can not get Input-Output-Table every year. Then, we use Survey of Manufacturing data, and calculate the value (Nominal value added – Compensation of employee) / (Real production) and weighted average it by export share in each sector.

(5) Nominal wage: \( W \)

Average of the nominal wage of manufacturing industry. When only the wage level is able to be used, we make the index series for the value of 2000 is 100.

(6) Raw material price: \( P_m \)

The import price index (if not available, producer price index or wholesale price index) of petroleum and coal product.

(7) Export Price: \( P \)

The export price index (if not available, producer price index or wholesale price index) of manufacturing industry.

(8) Export share: \( \sigma_i = X_i / \sum_i X_i \)

Export share is the value which divided the export value (the same sector as a labor input coefficient \( X_i \)) of each sector by total export value of each sector \( \sum_i X_i \).

When we estimate the equilibrium exchange rate for any two nations, we use the same export share.
(home country) to both countries as weight, in order to average the labor input and raw-material input coefficient of each sector. Thereby, it is expectable to remove the influence of the difference of export (industry) structure for two countries.

The export share of Japan is taken from the Annual Report on National Accounts (ESRI, Cabinet Office). The export share of each country other than Japan till 1996 was obtained from *Gaikoku Boueki to Keizai Hatten (Foreign trade and economic development)* (Asia information center, Takushoku University, 2000, in Japanese), and since 1997 we can get the export share data from ITC's (International Trade Centre) Web Site (http://www.intracen.org/tradstat/welcome.htm).
### Appendix Table: Data Sources

<table>
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<tr>
<th>Japan</th>
<th>U.S. (See Note1)</th>
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Note 1: Each abbreviation means the following.
- **GDP**: Gross Domestic Product by Industry.
- **GOIPD**: Gross Output for Double-Deflated Industry.
- **PEP**: Persons Engaged in Production.
- **GOC**: Gross Output for Double-Deflated Industry.
- **COMP**: Compensation of Employees.
- **FTE**: Full-Time Equivalent Employees.

References


Table 1 Equilibrium Exchange Rate

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(Reference)
### Table 2-1 Hypothetical Korea-Japan Equilibrium Rates (Base Year: 1990)

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<td>0.114</td>
<td>0.039</td>
<td>0.026</td>
<td></td>
</tr>
<tr>
<td>1990</td>
<td>0.177</td>
<td>0.105</td>
<td>0.104</td>
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<tr>
<td>1995</td>
<td>0.265</td>
<td>0.288</td>
<td>0.288</td>
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<tr>
<td>2000</td>
<td>0.373</td>
<td>0.444</td>
<td>0.443</td>
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</tr>
</tbody>
</table>

### Table 2-9 Hypothetical Thailand-U.S. Equilibrium Rates (Base Year: 1993)

<table>
<thead>
<tr>
<th>Actual Rate</th>
<th>EER</th>
<th>Constant Thailand $a$</th>
<th>Constant U.S. $a$</th>
<th>Wage-based PPP</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980</td>
<td>20.48</td>
<td>2.77</td>
<td>1.82</td>
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<tr>
<td>1985</td>
<td>27.16</td>
<td>6.25</td>
<td>4.14</td>
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<tr>
<td>1990</td>
<td>25.59</td>
<td>13.43</td>
<td>12.96</td>
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<tr>
<td>1995</td>
<td>24.92</td>
<td>28.32</td>
<td>31.63</td>
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<tr>
<td>2000</td>
<td>40.16</td>
<td>41.88</td>
<td>49.41</td>
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</tr>
</tbody>
</table>
Figure 1  Korea-Japan Equilibrium Exchange Rate (Won/Yen)
Base Year: 1990
Figure 2  China-Japan Equilibrium Exchange Rate  (Yuan/Yen)
Base Year: 1993

Actural Rate
Equilibirum Rate
including Capital Input
Figure 3  Korea-Japan Equilibrium Exchange Rate (Won/Yen)
Base Year: 1990

- Actual Rate
- Equilibrium Rate
- including Service Input
Figure 4  Effective Equilibrium Exchange Rate
(1990=100)