Are the East Asian Currencies Still Misaligned? An Analysis Based on Absolute PPP-Income Relationship Using Panel Data

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Ⅱ　Are the East Asian Currencies Still Misaligned? An Analysis Based on Absolute PPP-Income Relationship Using Panel Data

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Abstract

Over 10 years after the East Asia currency crisis, the degree of exchange rate misalignment is still an issue of contention for East Asian countries. This study evaluates the degrees of currency misalignment of Korea, China, Malaysia, Thailand, the Philippines, and Indonesia by examining absolute purchasing power parity (PPP)-income relationships using panel data. The distinction between local currency misalignments and the US dollar misalignment is stressed. The estimated misalignments in 2007 were 22.4 per cent overvaluation for the Indonesian rupiah, 12.5 per cent overvaluation for the Philippine peso, and 15.6 per cent undervaluation for the Malaysian ringgit.

1　Introduction

Over 10 years after the currency crisis, the degree of exchange rate misalignment is still an issue of contention for East Asian countries. For countries with a free-floating exchange rate, like Japan, South Korea, and the Philippines, the degree of misalignment is important for forecasting future exchange rates. For countries that heavily intervene in the foreign exchange market, like Indonesia, Thailand, Singapore, Cambodia, Laos, Myanmar, and Vietnam, misalignment is an important consideration for intervention, whereas for countries with a fixed or an almost-fixed exchange rate regime, like China, Malaysia, and Brunei, misalignment is a measure of the sustainability of the current exchange rate.

To evaluate the degree of misalignment, we need to know the equilibrium exchange rate based on an exchange rate framework. According to the classification by Cheung et al. (2009), the analysis framework of this study is classified as 'absolute purchasing power parity (PPP)-income relationship 'using panel data. This type of study is relatively new, and few such studies have been conducted thus far compared to the more traditional type of 'relative PPP' analysis using two-country data. The study by Cheung et al. (2007) is an example of this latter type of study. The utilisation of price level data was not common until recently, and time series techniques were used to set the base for exchange rates in most existing studies.

Kawai and Motonishi (2006) evaluated the degree of misalignment for the Chinese yuan using the absolute PPP-income relationship framework. Although their somewhat limited analysis led to certain results regarding exchange rate misalignments, it left room for improvement. For example, their study did not exploit the panel structure of the data-set. They also ignored determinants of the exchange rate other than price levels and per capita income.

Cheung et al. (2007) used the framework closest to the current study. Their study used the absolute PPP-income relationship framework, exploited the panel structure of the data-set, and took into account other determinants of exchange rates, including financial factors. One important thing that the study did not utilise, however, was the co-movement of exchange rates of non- US currencies to the US dollar. By taking this into account, we can obtain not only more accurate estimations but also the decomposition of exchange rate misalignment, that is, decomposition of the exchange rate misalignment of country *i*'s currency to the US dollar into the country *i*'s currency partial misalignment and the US dollar misalignment. We believe that this approach is fruitful in understanding currency misalignments.

It is important to distinguish between the two types of currency misalignment. The existence of the dollar misalignment as opposed to country i's currency partial misalignment implies that the exchange rates among non-US currencies are likely to be unchanged in the adjustment process. In this case, the impact of the adjustment on the international trade of the country is mitigated compared to the adjustment of the country's currency misalignment. Moreover, considering the fact that large amounts of dollar-denominated contracts exist, the value changes in those contracts require attention.

Compared to existing studies, the presentation of the regression results has been improved in this study. The regression framework described above is used not only to evaluate the degree of the exchange rate misalignment, but also to decompose the fitted exchange rates into several components. This decomposition enables us to interpret the past changes in the exchange rates and explore the persistence of the current exchange rates.

The estimation results of the misalignments analysed in this paper are not conclusive, because the standard errors of the regressions are, as those in other studies, not small enough to pin down precisely the degree of misalignment. The results, however, reveal important clues to understanding the exchange rate fluctuations of the six East Asian countries (Korea, China, Malaysia, Thailand, the Philippines, and Indonesia). According to the point estimates of total misalignments in 2007, currencies overvalued to a large degree were the Indonesian rupiah (22.4 per cent) and the Philippine peso (12.5 per cent). The Malaysian ringgit was undervalued (−15.6 per cent). Other currencies were at about their equilibrium levels.

2 Regression Framework

2.1 An Overview

The regression framework used in this paper is based on absolute PPP, modified by taking into account the effects of per capita GDP on the deviation from absolute PPP. It also takes into account the effects of interest rates and current accounts. Several types of studies analyse misalignment[1]. The majority of the existing studies are based on relative PPP. In these studies, price indices are used to take into account the effects of inflation of nominal exchange rates. Because they do not use price level data, it is always necessary to estimate the equilibrium level of exchange rate by averaging out, by setting a base year, or by using the co-integration method. Chinn (2000), for example, simply regressed the real exchange rate on a constant or on a constant and a time trend. Iimi (2006) also estimated the equilibrium level by allowing the constant and the time trend to vary over time. Chinn (2000) and Iimi (2006) incorporated a vector error correction model into their estimation. Yoshikawa (1990) and Miyagawa et al. (2004) set a base year in which the current account was close to zero and the nominal exchange rate was considered to be at the equilibrium level. It is important to note that these methods implicitly assume that the exchange rate

does not depart from its equilibrium level on average over the sample period or in the base year. Under the existence of misalignment from the equilibrium exchange rate over the sample period or mis-specified base year, the estimated equilibrium exchange rate is biased. Therefore, analyses based on relative PPP are not appropriate when long-term misalignment is suspected.

In contrast to these studies, this paper uses an absolute PPP framework. Price level data are estimated using the World Bank's International Comparison Program

(ICP). The strength of using price level data is that this method is immune to long run misalignment of exchange rates, which could be erroneously incorporated into the estimated equilibrium exchange rates in existing studies using relative PPP[2)]. It is impossible for these existing studies to estimate long run misalignment of exchange rates since they utilise only data of price changes. In this sense, the absolute PPP framework used in this paper fully exploits the Balassa-Samuelson effect.

The Balassa—Samuelson model modifies absolute PPP by taking into account the existence of non-tradables[3)]. The most ideal variable for this effect is the price of tradables relative to non-tradables. This variable, however, is not obtainable for many countries. Balassa (1964) pointed out that 'If per capita incomes are taken as representative of levels of productivity, the ratio of purchasing-power parity to the exchange rate will thus be an increasing function of income levels' (p.586). The current study follows this insight of Balassa (1964), and per capita Gross National Income (GNI) is used as the proxy for the Balassa-Samuelson effect.

In recent years, Frankel (2006), Kawai and Motonishi (2006), and Cheung et al. (2007) used the above framework to estimate the equilibrium exchange rate. Frankel (2006) and Kawai and Motonishi (2006) used cross-sectional data for their estimations. Cheung et al. (2007) improved the reliability of their estimations by using panel data.

The current study is closely related to that by Cheung et al. (2007), in that it uses panel data to estimate the equilibrium exchange rate by using the absolute PPP framework modified by the Balassa-Samuelson effect, which is proxied by per capita income. The approach used in this paper, however, differs from other existing studies in three fundamental ways.

First, yearly dummies introduced in the regression of this study play an important role. It is crucial to note that all the exchange rates in this analysis are to the US dollar.

As the dollar appreciates or depreciates against other currencies, all non-US exchange rates change in the same manner. Without yearly dummies, panel analysis cannot exploit this co-movement of exchange rates.

It is meaningful to compare this framework with that of Cheung et al. (2007). Although that study did not introduce yearly dummies, it produced estimates using fixed-effects and random-effects models. The advantage of these methods is that they can capture unobservable country-specific factors. One shortcoming of their methodology is that the model can overlook long-term misalignments, which could be incorporated into country-specific factors by estimation.

By introducing yearly dummies, the current study not only can exploit ex- change rate co-movements but also can evaluate the dollar misalignment separately from the local currency misalignment. The dollar misalignment is the difference between the fitted exchange rate calculated using US sample data, and 1. Detailed explanation of this point is given in the next section.

Second, this study takes into account not only changes in the prices of goods and services but also the effects of financial factors. This means that the empirical framework used in this study allows exchange rates to deviate from the price parity of tradables by the effects of financial factors. Under the assumption that the speed of price adjustment is not fast enough to attain tradable price parity, large flows of funds across borders can keep exchange rates away from the parity rate of tradables. Cheung et al. (2007) tested the significance of some demographic and financial factors. That study, however, did not test the significance of interest rates. Clark and McDonald (1998) and Iimi (2006) estimated equilibrium exchange rates by taking into account various macroeconomic factors that affect exchange rates without using price level data[4)].

Third, we constructed the regression framework in order to be able to de-compose the nominal exchange rate into each determinant, which, we believe, is an intuitively appealing way of presenting the estimation results.

2.2 Determinants of Exchange Rates

The framework used in this study includes the following determinants of nominal exchange rates: the price level, the Balassa-Samuelson effect, the real interest rate, government debt, and net foreign assets. The price level is simply subtracted from the nominal exchange rates to generate the explained variable. The effects of the other components are estimated by regression analysis. The first two terms capture the price parity of tradables. The last three determinants capture financial factors and correspond to the rate of return, risk, and liquidity of financial assets, respectively. A higher real interest rate, a smaller amount of government debt, and a larger amount of net foreign assets are expected to lead to currency appreciation.

Both the treasury bond rate and the private lending rate are used to calculate the real interest rate. Considering the fact that the government debt is used as a risk variable, the treasury bond rate is the first choice for this calculation. The employment of the treasury bond rate, however, reduces the number of observations significantly, which prevents us from analysing some East Asian currencies. Therefore the private lending rate is mainly used in our regression and decomposition analyses.

The choice of the risk variable leaves some room for discussion, especially when the private lending rate is used in the regression. In this case, the more appropriate risk variable is the net foreign assets, which represents the country’s overall repayment capacity. If this is true, the amount of net foreign assets captures not only the liquidity effect but also the risk effect. With this in mind, we estimate both with and without the government debt variable.

An increase in net foreign assets implies that the people in the country hold a greater amount of foreign-currency-denominated assets. Due to the difference in liquidity, they prefer local-currency denominated assets over foreign currency-denominated assets. That leads to an appreciation of the local currency.

2.3 Panel Analysis and decomposition

One of the important features of the regressions of this study is that they en able us to decompose the misalignment of exchange rates between country *i*'s currency and the US dollar into country *i*'s currency misalignment and the US dollar misalignment. Panel analysis with year dummies plays an important role in the decomposition. The procedure of the decomposition is as follows.

The regression equation is

$$\frac{NER_{it}}{PPP_{it}} - 1 = \delta_t D_t + \beta_1 LPCGNI_{it} + \beta_2 RI_{it} + \beta_3 GD_{it} + \beta_4 NFA_{it} + \varepsilon_{it}, \tag{1}$$

where NER_{it} is the nominal exchange rate to the US dollar, PPP_{it} is the relative price level P_{it}/P_{USt}, D_t is the year dummy, $LPCGNI_{it}$ is log per capita GNI, RI_{it} is the real interest rate, GD_{it} is government debt, NFA_{it} is net foreign assets. $LPCGNI_{it}$, RI_{it}, GD_{it}, and NFA_{it} are expressed in terms relative to the United States. Per capita GNI is PPP based, that is, it is converted to the US dollar using the PPP rate. ε_{it} , the error term, is interpreted as the misalignment of country *i*'s currency. More specifically, we call this term 'country *i*'s currency partial misalignment' for the reason mentioned below.

Year *t* dummies capture common exchange rate changes that cannot be explained by the right-hand side macro variables of the sample countries, that is, exchange rate changes due to the dollar misalignments against all the other currencies.

By substituting US data into the equation (1), we have

$$\delta_t = -\varepsilon_{USt} \ . \tag{2}$$

Note that $NER_{USt} = PPP_{USt} = 1$ and $LPCGNI_{USt}$, RI_{it}, GD_{it}, and NFA_{it} are all equal to zero by definition. Because we do not include the benchmark country (United States) data into the regression, this equation requires new interpretation. Note that ε_{USt} is the vertical distance from the regression line to the US observation at time *t*, as opposed to ε_{it} being the vertical distance from the regression line to country *i* observation at time *t*. Therefore, ε_{USt} can be interpreted as the misalignment of the US dollar. Equation (2) shows that the estimated coefficient of the dummy variable for year *t* corresponds to the US dollar misalignment of the year. From (1) and (2), we have

$$\begin{aligned} NER_{it} = PPP_{it}\,[1 &+ \beta_1 LPCGNI_{it} \\ &+ \beta_2 RI_{it} + \beta_3 GD_{it} + \beta_4 NFA_{it} \\ &+ \varepsilon_{it} - \varepsilon_{USt}]. \end{aligned} \tag{3}$$

This equation shows that the nominal exchange rate of country *i* to the dollar is decomposed into seven parts: the PPP rate, the Balassa-Samuelson effect factor, the interest rate factor, the risk factor, the liquidity factor, and $\varepsilon_{it} - \varepsilon_{USt}$.

$\varepsilon_{it} - \varepsilon_{USt}$ corresponds to the component of NER_{it} not explained by explanatory variables. We call this term the *total* misalignment of country *i*'s exchange rate to distinguish it from ε_{it}, the *partial* misalignment of country *i*'s exchange rate. The total misalignment is the partial misalignment minus the US dollar misalignment. The equilibrium exchange rate is defined as

$$ENER_{it} = PPP_{it}\,[1 + \beta_1 LPCGNI_{it} + \beta_2 RI_{it} + \beta_3 GD_{it} + \beta_4 NFA_{it}]. \tag{4}$$

Note that this is different from the fitted nominal exchange rate of the regression. $ENER_{it}$ is the fitted nominal exchange rate plus ε_{USt}.

As we noted in the last subsection, a country's high interest rates, low government debt to GDP ratio, and high net foreign assets to GDP ratio are expected to lead to the appreciation of the country's currency. Thus this theory predicts that β_1, β_2, and β_4 are negative and β_3 is positive.

3 Data

The equation (1) is estimated by using data from 1990 to 2007 for all available countries. Data from the 1980s were not included in the sample period as there were large-scale interventions into currency markets such as Plaza Accord and Louvre Accord during that decade. The data were obtained from the World Development Indicators (WDI) of the World Bank and the International Financial Statistics (IFS) of the International Monetary Fund. Using 1989 to create a lag, 18 years (1990−2007) of data are available for 118 countries.

The ratio of the actual exchange rate to the PPP rate is 'the inverse of PPP conversion factor to official exchange rate ratio' from the WDI. The estimation of the PPP rate is done by the World Bank's International Comparison Program (ICP) in cooperation with other international organisations and participating countries in order to obtain reasonable conversion rates of currencies to compare the per capita GDP between countries. The comparison includes not only consumption goods but also other GDP components.

Per capita GNI data are also obtained from the WDI. The real interest rate (bank lending), defined as the rate charged by banks on loans to prime customers minus the GDP deflator, is obtained from the WDI. The real interest rate of a treasury bill is calculated from the nominal treasury bill rate (IFS) and the GDP deflator. The ratio of government debt to GDP is provided by the WDI. The accumulative current accounts of the past 5 and 10 years are used for net foreign assets. They are calculated from the current account data of the IFS.

To eliminate samples with distorted exchange rates due to government interventions, we employed the Levy-Yeyati—Sturzenegger (LYS) de facto classification of exchange rate regimes data-set. They classified the exchange rate regimes of 180 countries every year for the period 1974–2004 into four categories: flexible, dirty float, crawling peg, and fixed, using a cluster analysis methodology. By using this classification, we can take into account the regime shifts of countries from fixed to float or the other way around. We excluded samples with fixed exchange rate regimes (against the dollar or against a basket of currencies) from the regression analysis, because the exchange rates under this regime do not conform to our regression framework. The exchange rate regimes in and after 2005 are assumed to be unchanged from those of 2004.

It is important to point out that the credibility of our regression results relies on the accuracy of the price level data estimated by the ICP. Bosworth (2004) argued against the utilization of the PPP conversion factor estimated by the ICP, pointing out that the PPP conversion factor for China is unreliable because the nation has never participated in the ICP. China participated in the program recently, and the estimated PPP rate was updated at the latest issue of the ICP data-set. The significant changes in the Chinese price level estimates show that the ICP participation of a country is important for the reliability of the country’s price level data. Thus, we dropped ICP non-participating countries from the sample. Finally, the United States, the benchmark country, was also dropped from the sample.

4　Regression Results

Tables II–1–3 show the regression results. The theory predicts that the effects of the log of per capita GNI, the real interest rate, and the accumulative current account to GDP ratio are negative and the effect of the government debt to GDP ratio is positive.

The coefficient estimates for the government debt to GDP ratio, all insignificant at the 10 per cent level, were omitted from the tables due to space considerations.

Table II−1 shows the result of ordinary least squares (OLS) estimation with yearly dummies. This estimation method can also be interpreted as a time-specific fixed-effects model. The coefficients of yearly dummies correspond to dollar misalignments, as shown by the equation (??). Positive values of the coefficient estimates correspond to dollar overvaluations. The results show significant dollar overvaluations in the late 1990s and early 2000s. The Balassa-Samuelson effect proxied by the log of per capita GNI is significant in all equations. The effects of real interest rates are significant unless the accumulative current account variable is included in the regressions. The treasury bill rate seems to explain exchange rates better than does the bank lending rate. The effects of the accumulative current account do not seem to be robust.

Regression (1) of Table II−1 is limited, with only year dummies and the Balassa-Samuelson effect. This equation is close to the one used by Kawai and Motonishi (2006) and Cheung et al. (2007), except for the inclusion of yearly dummies. Other regressions include one or two financial factors. Although the significance levels of financial variables are mixed, they still seem to have some explanatory power for exchange rates.

To check the robustness of the results, we also estimated the same regression equations using each of the first and second halves of the samples, that is, 1990—1998 and 1999−2007. Tables II−2(a) and II−2(b) show the regression results. The estimates of coefficients of yearly dummies were omitted due to space considerations. The overall results do not largely change from Table II−1. Although the effects of interest rates are large in the second-half sample estimate, this does not largely change the equilibrium exchange rate.

Table II−3 shows the estimation results using WLS (Weighted Least Squares).

Table Ⅱ-1 Estimation Results (OLS)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent Variable	Nominal Exchange Rate/PPP Exchange Rate						
Independent Variables\Model	Ordinary Least Squares						
Year 1990	0.077	0.054	−0.211	−0.049	0.014	−0.307	−0.209
	(0.130)	(0.145)	(0.175)	(0.133)	(0.124)	(0.123)	(0.093)
Year 1991	0.168	0.082	−0.108	0.002	0.041	−0.164	−0.074
	(0.178)	(0.190)	(0.218)	(0.173)	(0.162)	(0.154)	(0.109)
Year 1992	0.001	0.001	−0.144	−0.067	−0.027	−0.163	−0.122
	(0.175)	(0.196)	(0.232)	(0.189)	(0.179)	(0.188)	(0.165)
Year 1993	0.266	0.204	0.167	0.185	0.227	0.200	0.242
	(0.197)	(0.203)	(0.253)	(0.201)	(0.193)	(0.234)	(0.213)
Year 1994	0.390	0.380	0.188	0.351	0.266	0.146	0.178
	(0.179)	(0.208)	(0.252)	(0.203)	(0.186)	(0.211)	(0.191)
Year 1995	0.161	0.080	−0.011	0.032	0.028	−0.022	0.007
	(0.161)	(0.169)	(0.206)	(0.163)	(0.156)	(0.161)	(0.137)
Year 1996	0.200	0.196	0.129	0.100	0.075	0.136	0.108
	(0.163)	(0.178)	(0.225)	(0.177)	(0.167)	(0.192)	(0.169)
Year 1997	0.221	0.147	−0.004	0.072	−0.034	−0.018	−0.103
	(0.156)	(0.173)	(0.218)	(0.166)	(0.163)	(0.181)	(0.160)
Year 1998	0.377	0.293	0.218	0.271	0.115	0.231	0.133
	(0.167)	(0.185)	(0.220)	(0.178)	(0.177)	(0.179)	(0.150)
Year 1999	0.615	0.529	0.340	0.487	0.276	0.352	0.197
	(0.183)	(0.198)	(0.232)	(0.192)	(0.183)	(0.187)	(0.170)
Year 2000	0.594	0.492	0.362	0.457	0.195	0.383	0.182
	(0.177)	(0.191)	(0.235)	(0.185)	(0.167)	(0.196)	(0.165)
Year 2001	0.677	0.565	0.468	0.509	0.332	0.515	0.341
	(0.164)	(0.181)	(0.223)	(0.172)	(0.161)	(0.182)	(0.158)
Year 2002	0.713	0.636	0.427	0.551	0.498	0.490	0.433
	(0.163)	(0.179)	(0.217)	(0.167)	(0.161)	(0.179)	(0.156)
Year 2003	0.568	0.498	0.285	0.454	0.460	0.385	0.390
	(0.153)	(0.167)	(0.206)	(0.158)	(0.151)	(0.166)	(0.140)
Year 2004	0.316	0.301	0.074	0.217	0.232	0.158	0.170
	(0.146)	(0.163)	(0.196)	(0.149)	(0.142)	(0.153)	(0.125)
Year 2005	0.173	0.154	−0.071	0.073	0.099	0.022	0.051
	(0.143)	(0.159)	(0.193)	(0.145)	(0.139)	(0.151)	(0.123)
Year 2006	0.088	0.037	−0.140	−0.042	0.013	−0.038	0.002
	(0.141)	(0.157)	(0.192)	(0.144)	(0.137)	(0.151)	(0.124)
Year 2007	−0.090	−0.140	−0.304	−0.182	−0.153	−0.193	−0.140
	(0.140)	(0.155)	(0.192)	(0.145)	(0.141)	(0.149)	(0.125)
Log of Per Capita GNI	−0.497***	−0.535***	−0.589***	−0.554***	−0.545***	−0.562***	−0.542***
	(0.021)	(0.023)	(0.025)	(0.026)	(0.025)	(0.030)	(0.031)
Real Interest Rate		−0.469*		−0.445	−0.222		
(Bank Lending)		(0.260)		(0.275)	(0.304)		
Real Interest Rate			−0.262***			−0.248***	−0.256***
(Treasury Bill)			(0.062)			(0.045)	(0.048)
Accumulative Current Account				0.081		−0.286	
5 Years/GDP Ratio				(0.131)		(0.179)	
Accumulative Current Account					−0.044		−0.276**
10 Years/GDP Ratio					(0.086)		(0.123)
Adjusted R^2	0.451	0.502	0.639	0.522	0.563	0.657	0.686
Number of Observations	931	806	521	757	697	502	467

Notes: Sample period: 1990−2007.
Standard errors (heteroskedasticity consistent) are in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Figure II‒1 from Kawai and Motonishi (2006) strongly suggests the existence of heteroskedasticity, which is possibly due to the difference in the degree of measurement errors in the explained variable and the misalignment of exchange rates. Under the complicated process of evaluating the prices of various types of goods and calculating the price of a basket of those goods, it is possible that the PPP exchange rate is contaminated with measurement error, especially for countries with weak statistical systems. In this case, the assumption of homoskedastic error term could be too restrictive for the estimation of equation (1). The weighted least squares estimator is more efficient than is the OLS estimator under the existence of heteroskedasticity. We weighted the observations according to per capita GNI under the assumption that the variance of the error term is negatively correlated with the country's per capita GNI.

The WLS estimation results in Table II‒3 show statistically significant differences from those in Table II‒1. Coefficients for yearly dummies and per capita GNI estimated by WLS are smaller than are those by OLS. The smaller yearly dummies' coefficients imply that the estimated dollar misalignments tend to show dollar undervaluation greater than those estimated using OLS. The smaller per capita GNI coefficients imply a larger Balassa-Samuelson effect. Although the WLS depends on the ad-hoc weight of per capita GNI, the difference between the WLS and OLS estimation suggests that the misalignment estimation of this paper is still not conclusive.

The difference between OLS and WLS estimates above is roughly consistent with the income subsample estimation results of Cheung et al. (2007). Their study shows that the Balassa-Samuelson effect is larger for the high-income country group than for the low-income country group. Although the income subsample estimation of their study does not fit the regression framework in this paper because the intercept term has the meaning of dollar misalignment, the high-income country group estimate roughly corresponds to the WLS estimate in this study.

Table Ⅱ-2a Estimation Results 1990–1998 Subsample

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent Variable	Nominal Exchange Rate/PPP Exchange Rate						
Independent Variables\Model	Ordinary Least Squares						
Log of Per Capita GNI	−0.457***	−0.503***	−0.595***	−0.529***	−0.539***	−0.558***	−0.546***
	(0.031)	(0.034)	(0.041)	(0.043)	(0.042)	(0.055)	(0.060)
Real Interest Rate		−0.199*		−0.152	−0.080		
(Bank Lending)		(0.336)		(0.389)	(0.418)		
Real Interest Rate			−0.258***			−0.244***	−0.250***
(Treasury Bill)			(0.059)			(0.040)	(0.045)
Accumulative Current Account				0.096		−0.394	
5 Years/GDP Ratio				(0.203)		(0.314)	
Accumulative Current Account					−0.014		−0.393**
10 Years/GDP Ratio					(0.116)		(0.246)
Adjusted R^2	0.357	0.418	0.593	0.444	0.477	0.624	0.650
Number of Observations	456	378	230	345	320	215	204

Notes: Sample period: 1990–1998.
Standard errors (heteroskedasticity consistent) are in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Table Ⅱ-2b Estimation Results 1999–2007 Subsample

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent Variable	Nominal Exchange Rate/PPP Exchange Rate						
Independent Variables\Model	Ordinary Least Squares						
Log of Per Capita GNI	−0.539***	−0.576***	−0.586***	−0.582***	−0.550***	−0.564***	−0.537***
	(0.028)	(0.030)	(0.030)	(0.030)	(0.027)	(0.032)	(0.030)
Real Interest Rate		−1.049*		−0.923	−0.481		
(Bank Lending)		(0.310)		(0.325)	(0.390)		
Real Interest Rate			−0.389***			−0.422***	−0.378***
(Treasury Bill)			(0.447)			(0.415)	(0.523)
Accumulative Current Account				0.044		−0.233	
5 Years/GDP Ratio				(0.166)		(0.208)	
Accumulative Current Account					−0.108		−0.215**
10 Years/GDP Ratio					(0.111)		(0.122)
Adjusted R^2	0.534	0.566	0.658	0.574	0.630	0.657	0.697
Number of Observations	475	428	291	412	377	287	263

Notes: Sample period: 1999–2007.
Standard errors (heteroskedasticity consistent) are in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Possible measurement errors in the PPP exchange rate can affect the estimation results in a different way, namely through a right-hand-side variable. Note that per capita GNI is converted to the US dollar by the PPP exchange rate. This can cause correlation between per capita GNI and the error term, leading to a biased estimator. Moreover, the utilization of per capita GNI as the proxy for the Balassa-Samuelson

Table Ⅱ-3 Estimation Results (WLS)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent Variable	Nominal Exchange Rate/PPP Exchange Rate						
Independent Variables\Model	Weighted Least Squares						
Year 1990	−0.224	−0.230	−0.256	−0.267	−0.230	−0.292	−0.265
	(0.130)	(0.145)	(0.175)	(0.133)	(0.124)	(0.123)	(0.093)
Year 1991	−0.179	−0.188	−0.214	−0.220	−0.193	−0.245	−0.216
	(0.178)	(0.190)	(0.218)	(0.173)	(0.162)	(0.154)	(0.109)
Year 1992	−0.228	−0.208	−0.248	−0.229	−0.200	−0.266	−0.236
	(0.175)	(0.196)	(0.232)	(0.189)	(0.179)	(0.188)	(0.165)
Year 1993	−0.159	−0.183	−0.221	−0.198	−0.168	−0.217	−0.190
	(0.197)	(0.203)	(0.253)	(0.201)	(0.193)	(0.234)	(0.213)
Year 1994	−0.054	−0.063	−0.137	−0.116	−0.090	−0.194	−0.164
	(0.179)	(0.208)	(0.252)	(0.203)	(0.186)	(0.211)	(0.191)
Year 1995	−0.260	−0.293	−0.271	−0.308	−0.269	−0.302	−0.271
	(0.161)	(0.169)	(0.206)	(0.163)	(0.156)	(0.161)	(0.137)
Year 1996	−0.226	−0.220	−0.231	−0.268	−0.232	−0.255	−0.227
	(0.163)	(0.178)	(0.225)	(0.177)	(0.167)	(0.192)	(0.169)
Year 1997	−0.178	−0.199	−0.201	−0.212	−0.232	−0.193	−0.208
	(0.156)	(0.173)	(0.218)	(0.166)	(0.163)	(0.181)	(0.160)
Year 1998	−0.104	−0.121	−0.111	−0.118	−0.154	−0.102	−0.109
	(0.167)	(0.185)	(0.220)	(0.178)	(0.177)	(0.179)	(0.150)
Year 1999	−0.038	−0.072	−0.111	−0.072	−0.152	−0.099	−0.142
	(0.183)	(0.198)	(0.232)	(0.192)	(0.183)	(0.187)	(0.170)
Year 2000	0.027	−0.049	−0.023	−0.046	−0.137	−0.010	−0.091
	(0.177)	(0.191)	(0.235)	(0.185)	(0.167)	(0.196)	(0.165)
Year 2001	0.133	0.073	0.094	0.038	−0.033	0.108	0.031
	(0.164)	(0.181)	(0.223)	(0.172)	(0.161)	(0.182)	(0.158)
Year 2002	0.143	0.119	0.075	0.108	0.133	0.091	0.108
	(0.163)	(0.179)	(0.217)	(0.167)	(0.161)	(0.179)	(0.156)
Year 2003	−0.020	−0.050	−0.126	−0.068	−0.013	−0.108	−0.055
	(0.153)	(0.167)	(0.206)	(0.158)	(0.151)	(0.166)	(0.140)
Year 2004	−0.203	−0.197	−0.281	−0.234	−0.175	−0.266	−0.212
	(0.146)	(0.163)	(0.196)	(0.149)	(0.142)	(0.153)	(0.125)
Year 2005	−0.289	−0.294	−0.346	−0.327	−0.257	−0.331	−0.272
	(0.143)	(0.159)	(0.193)	(0.145)	(0.139)	(0.151)	(0.123)
Year 2006	−0.327	−0.359	−0.364	−0.387	−0.304	−0.345	−0.284
	(0.141)	(0.157)	(0.192)	(0.144)	(0.137)	(0.151)	(0.124)
Year 2007	−0.426	−0.480	−0.458	−0.476	−0.399	−0.440	−0.376
	(0.140)	(0.155)	(0.192)	(0.145)	(0.141)	(0.149)	(0.125)
Log of Per Capita GNI	−0.811***	−0.855***	−0.834***	−0.851***	−0.799***	−0.820***	−0.773***
	(0.020)	(0.020)	(0.024)	(0.023)	(0.022)	(0.027)	(0.026)
Real Interest Rate		−1.004*		−0.898	−0.578		
(Bank Lending)		(0.156)		(0.163)	(0.158)		
Real Interest Rate			−0.241***			−0.218***	−0.217***
(Treasury Bill)			(0.057)			(0.055)	(0.051)
Accumulative Current Account				0.042		−0.020	
5 Years/GDP Ratio				(0.078)		(0.084)	
Accumulative Current Account					−0.057		−0.079**
10 Years/GDP Ratio					(0.047)		(0.051)
Adjusted R^2	0.665	0.700	0.730	0.712	0.732	0.743	0.758
Number of Observations	931	806	521	757	697	502	467

Notes: Sample period: 1990–2007.
Standard errors (heteroskedasticity consistent) are in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

effect also requires econometric consideration. When per capita GNI is an error-ridden variable of the relative price of non-tradables to tradables, this can lead to dilution bias. As for the real interest rate, the variable is contaminated with unexpected inflation because we substituted the ex-post inflation rate for the unobservable expected inflation rate. The endogeneity of the real interest rate can also emerge from the fact that this is a policy variable.

To partially mitigate these problems, we employed lagged per capita GNI and the real interest rate as the instrumental variables. Because the estimated coefficients do not change significantly from those of OLS, we omitted them.

In summary, the effect of per capita GNI is significant and robust. This is consistent with other existing studies. Estimated coefficients of yearly dummies are significant for some years and capture dollar misalignments. The only financial factor that is significant and robust is the effect of the interest rate. The effects of the government debt and the net foreign asset are not significant. Although these results are robust to changes in the sample period, the estimates of OLS and WLS show quantitatively different results.

5　Misalignments and Decompositions of Exchange Rates

In this section we evaluate the degree of exchange rate misalignment and de-compose the actual exchange rates into several components for six East Asian countries: South Korea, China, Malaysia, Thailand, the Philippines, and Indonesia. Considering the regression results in the last section, yearly dummies and per capita GNI are taken into account as the determinants of real exchange rates. Although overall regression results suggest that treasury bill rate is a better explanatory variable than is bank lending rate, bank lending rate is employed in this section due to missing data regarding treasury bill rates. Therefore, the baseline regression equation used for the evaluation in this section is equation (2) of Table II−1. Although some of the evaluated countries are excluded from the above regressions for some years due to their being classified as countries with fixed exchange rate regimes, we extrapolated the above results of equation (2) of Table II−1.

By assuming $\beta_3 = \beta_4 = 0$ in (3) and (4), we have

$$NER_{it} = PPP_{it}\,[1 + \beta_1 LPCGNI_{it} + \beta_2 RI_{it} + \varepsilon_{it} - \varepsilon_{U\,St}], \qquad (5)$$

$$ENER_{it} = PPP_{it}\,[1 + \beta_1 LPCGNI_{it} + \beta_2 RI_{it}]. \qquad (6)$$

Thus, the nominal exchange rates are decomposed into five parts. The last two terms are the country *i*'s currency partial misalignment and the US dollar misalignment. The two components add up to the total misalignment of the country *i*'s currency, the difference between the actual rates and the equilibrium rates. Figures labeled with subscript 'a' show the actual rates, the equilibrium rates, the country i's currency partial misalignment, and the US dollar misalignment.

The first three terms in the right-hand side of this equation represent the equilibrium exchange rate of this paper. It has three components: PPP rates, Balassa-Samuelson effects, and real interest rates. Figures labeled with subscript 'b' show the actual rates, the equilibrium rates, and the three components of the equilibrium exchange rate. The three components add up to the equilibrium rate.

Considering the fact that most East Asian economies hit by the currency crisis fall in the middle-income range, OLS regression results are employed to evaluate the degree of misalignment and to decompose the misalignment into several factors. Both the OLS and WLS results are used only for South Korea.

The estimated total misalignments show that in 2007, largely overvalued currencies were the Indonesian rupiah (22.4 per cent) and the Philippine peso (12.5 per cent).

The estimated partial misalignments of these currencies was, however, about a half and two-thirds of the total misalignments, respectively, and they are well within one standard error. Other currencies were at their equilibrium level or undervalued (Malaysian ringgit: −15.6 per cent). These figures show that currency overvaluation was not prevalent among the six East Asian countries in 2007.

The graphs of US dollar misalignment show that its overvaluation in the early 2000s subsided from 2002 to 2007. On the other hand, the partial misalignments of currencies of the six countries other than Indonesia countered the US dollar changes, rendering total misalignments unchanged. In contrast to this, the Indonesian rupiah partial misalignment moved in the direction of over-valuation, and this change combined with the US dollar misalignment change in the direction of undervaluation led to the 2007 overvaluation of the rupiah.

The figures also show that the effects of real interest rate are negligible compared to the effects of the PPP rate, the Balassa-Samuelson effect, and currency misalignments. Thus, the short-term exchange rate changes are captured by the misalignments of the US dollar and the local currencies.

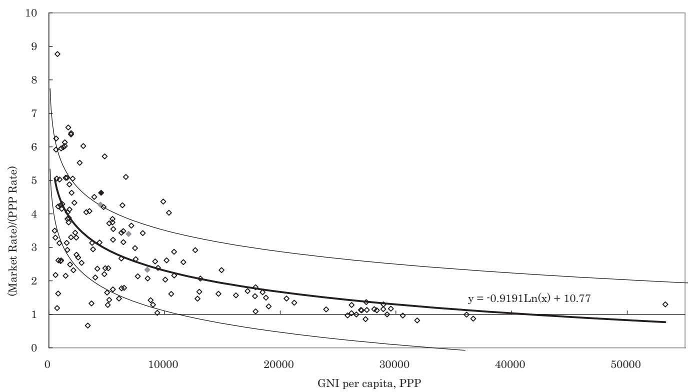

Figure Ⅱ-1　Per Capita GNI and Exchange Rate Disparity from the PPP Rate 2002

In the following subsections, we look more closely at misalignments and decompositions for each East Asian country.

5.1 South Korea

Figures II-2a and II-2b show the misalignments and decompositions of the Korean won rate. In 1996, a year before the Asian currency crisis, the total misalignment of the won was a 24.1 per cent overvaluation. In 1998, it was undervalued by 20.7 per

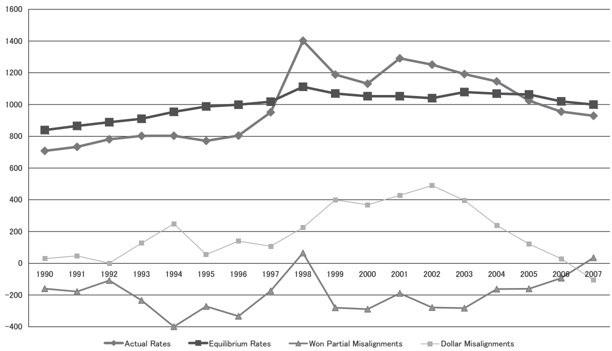

Figure Ⅱ-2a SOUTH KOREA: Won and Dollar Misalignments

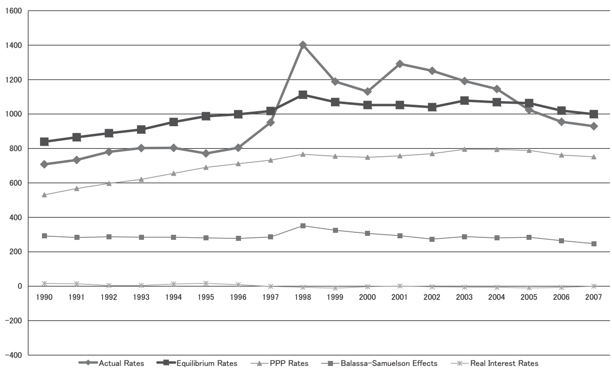

Figure Ⅱ-2b SOUTH KOREA: Decomposition of Equilibrium Rates cent. These figures seem to imply overshooting of the won exchange rate at the time of the currency crisis. In contrast to these figures, the partial misalignment of the won was a 41.4 per cent overvaluation in 1996 and a 4.6 per cent undervaluation in 1998. These figures suggest that the changes in exchange rate at the time of the currency crisis were more an adjustment than an overshooting.

After the currency crisis, the won was undervalued in terms of total misalignment. Note that this was due to overvaluation of the US dollar. The won was overvalued in terms of partial misalignment from 1999 to 2006. In 2007, the won was overvalued by 7.5 per cent in terms of total misalignment. Figure II-2b shows that price level changes chipped away at the value of the won in the sample period, with part of the effect being negated by the Balassa-Samuelson effect.

Figures II-8a and II-8b show the misalignments and decompositions based on the WLS estimates, which put more weight on high per capita GNI countries. The overall tendency of the US dollar and the won overvaluation in Figures II-8a and II-8b subside in Figures II-8a and II-8b. Although the total misalignments show more won overvaluation than do those in Figures II-2a and II-2b, the won was undervalued by about 15.3 per cent in terms of partial misalignment in 2007. This was due to the dominance of the US dollar undervaluation in 2007.

5.2 China

Figures II-3a and II-3b show the misalignments and decompositions of the Chinese yuan. As expected, the Balassa—Samuelson effect largely fills the gap between the PPP rate and the actual rate. Somewhat surprisingly, the estimated equilibrium exchange rate is very close to the actual exchange rate for the entire sample period. Even at the time of 1993—1994 yuan devaluation, the equilibrium exchange rate tracks the actual rate reasonably well. This is due to the fact that price level changes explain the devaluation[5)].

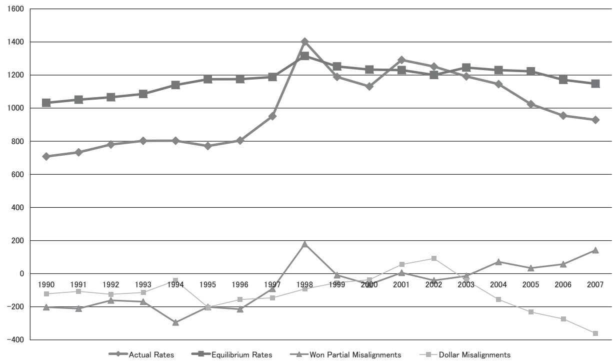

Figure Ⅱ-8a　SOUTH KOREA: Won and Dollar Misalignments Based on WLS Estimates

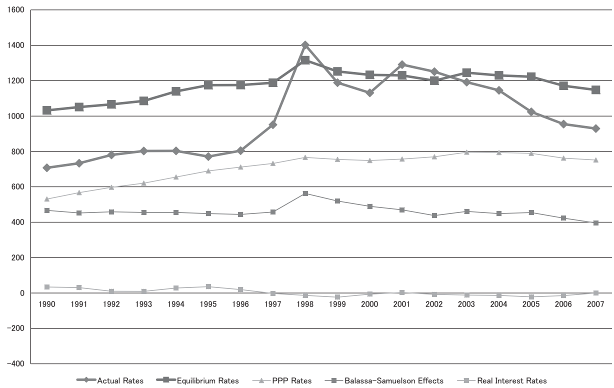

Figure Ⅱ-8b　SOUTH KOREA: Decomposition of Equilibrium Rates Based on WLS Estimates

The total misalignment of the US dollar and the yuan was very close to 0 in 2007, which is inconsistent with Cheung et al. (2007), but is consistent with Cheung et al. (2009). As we noted in the data section, Chinese historical price level data were updated in the latest issue of the ICP data-set. Therefore, ICP data-set version has a significant impact on the evaluation of the yuan misalignment evaluation. This seems to explain the difference of estimated Chinese yuan misalignment between the past and

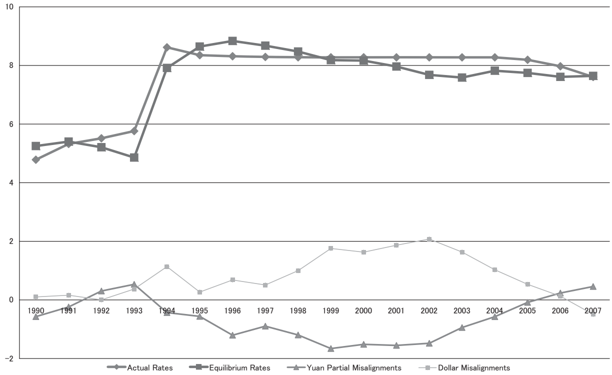

Figure Ⅱ−3a　CHINA: Yuan and Dollar Misalignments

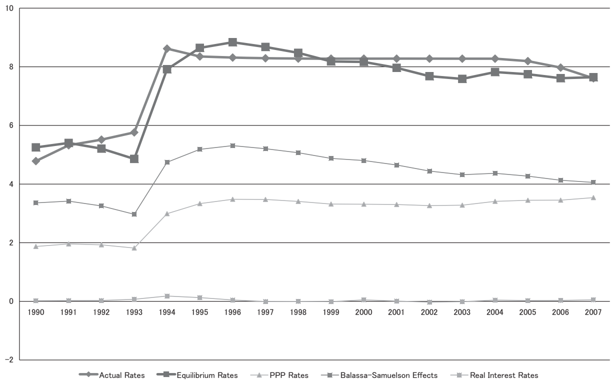

Figure Ⅱ−3b　CHINA: Decomposition of Equilibrium Rates

the current studies.

5.3　ASEAN Countries

Figures II−4a and II−4b to II−7a and II−7b show the misalignments and decompositions of the exchange rates of the currencies of Malaysia, Thailand, the Philippines, and Indonesia.

Figure II−4a shows that the Malaysian ringgit was at its equilibrium level in the 1990s and was undervalued during the 2000s. Before the currency crisis, the ringgit was at about its equilibrium level. The devaluation due to the currency crisis led to the total undervaluation of 28.4 per cent in 1998. Although the total undervaluation decreased in recent years, it was still undervalued by 15.6 per cent in 2007. The undervaluation in terms of partial misalignment is, however, about 1.5 times larger

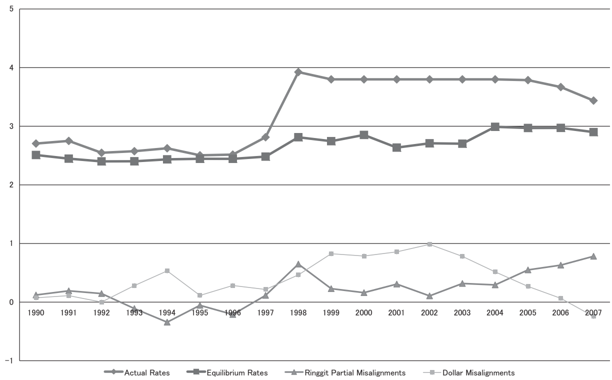

Figure Ⅱ−4a MALAYSIA: Ringgit and Dollar Misalignments

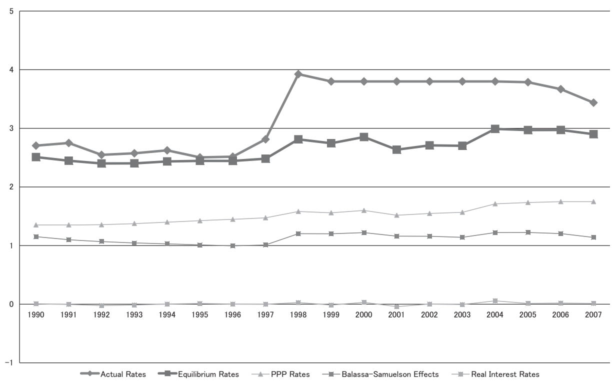

Figure Ⅱ−4b MALAYSIA: Decomposition of Equilibrium Rates than that.

Figure II-5a shows that the Thai baht was overvalued in the total misalignment before the currency crisis and was undervalued after the crisis. As in the case for the Korean won, however, this does not necessarily mean that overshooting occurred at that time. In terms of misalignment, baht overvaluation disappeared due to exchange rate changes during the period 1996-1998. Therefore, the devaluation of Thai baht at

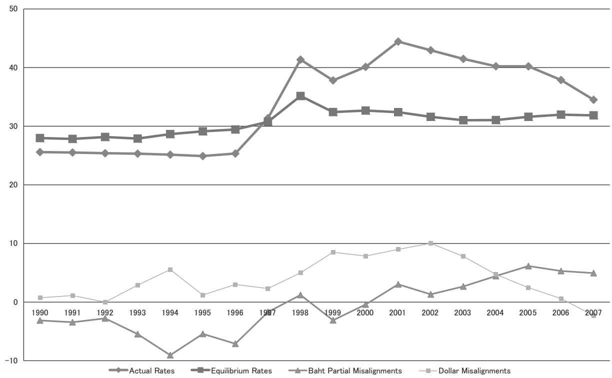

Figure Ⅱ-5a THAILAND: Baht and Dollar Misalignments

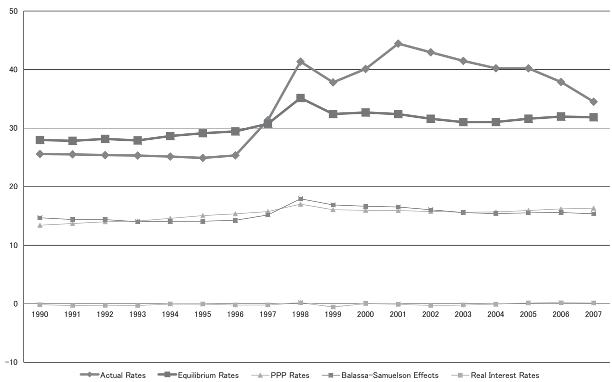

Figure Ⅱ-5b THAILAND: Decomposition of Equilibrium Rates

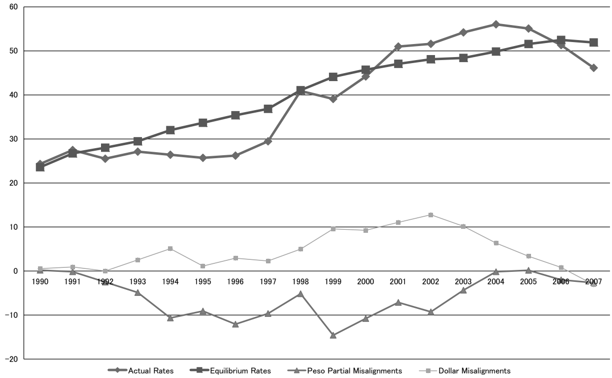

Figure Ⅱ-6a　PHILIPPINES: Peso and Dollar Misalignments

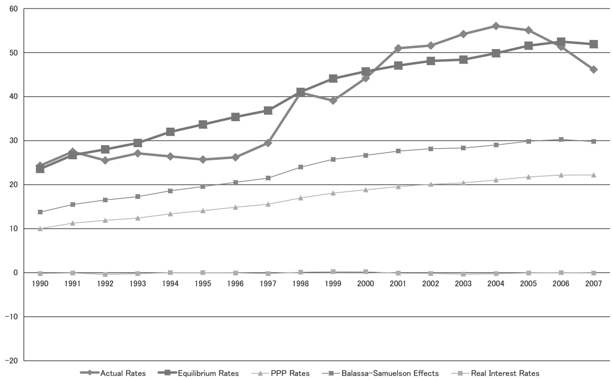

Figure Ⅱ-6b　PHILIPPINES: Decomposition of Equilibrium Rates

the time of the currency crisis can be interpreted as an adjustment rather than an overshooting. Although the degree of the total undervaluation decreased in recent years, the baht was still undervalued by 7.7 per cent in 2007. In terms of partial misalignment, the graph shows a long trend toward undervaluation since 1999. The degree of partial undervaluation in 2007 is about double the size of the total undervaluation.

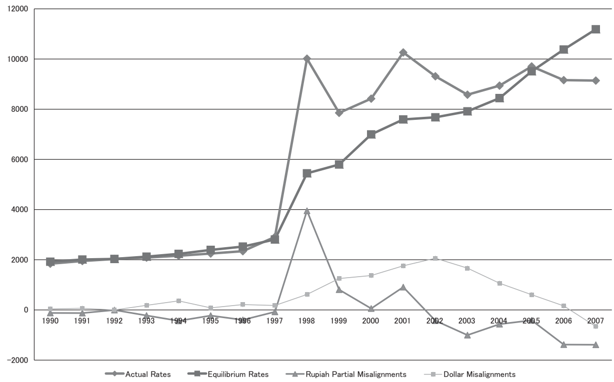

Figure Ⅱ−7a　INDONESIA: Rupiah and Dollar Misalignments

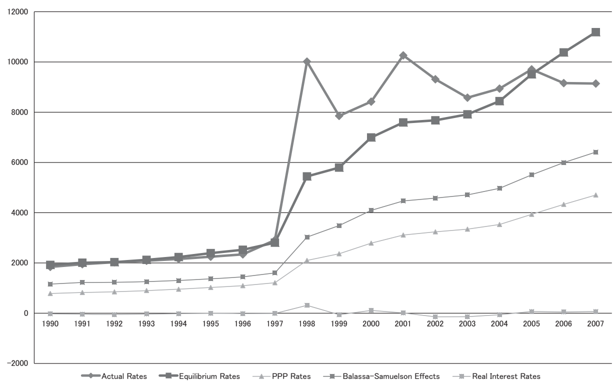

Figure Ⅱ−7b　INDONESIA: Decomposition of Equilibrium Rates

Figure II−6a shows that the Philippine peso was at about its equilibrium level in the sample period, except for the pre-crisis period overvaluation. Overvaluation of the Philippine peso in terms of partial misalignment was, however, over one standard error range in the years of 1994, 1996, and 1999. The depreciation at the time of the currency crisis can be interpreted as the adjustment to the equilibrium level in terms of the partial misalignment. In recent years, the decrease in the US dollar overvaluation and the Philippine peso overvaluation led to the 12.5 per cent overvaluation in terms of total misalignment in 2007.

Figure II−7a is strikingly different from Figures II−4a, II−5a, and II−6a. Before the currency crisis, the Indonesian rupiah was at about its equilibrium level in terms of total misalignments. The rupiah depreciation at the time of the crisis reflected a sudden undervaluation in terms of both total and rupiah misalignments. The undervaluation of the rupiah in terms of partial misalignment in 1998 was well over a 1.96 standard error range. After the crisis, however, rupiah undervaluation disappeared quickly. This change, accompanied by the decrease in the US dollar overvaluation, led to a 22.4 per cent overvaluation in total misalignment in 2007. About two-thirds of the overvaluation was due to rupiah overvaluation in terms of partial misalignment.

6 Conclusions

Under the expectation of more financial cooperation and integration among Asian countries, it is very important to expand research on exchange rate misalignment of these countries. This study estimates the degree of exchange rate misalignments of many countries at the same time by using a common frame-work of exchange rate and appropriate econometric models and employs the regression result to decompose the nominal exchange rate to the dollar.

The regression results find relatively large misalignments in 2007 for the Indonesian rupiah, Philippine peso, and Malaysian ringgit. The currencies of Korea, China, and Thailand were at about their equilibrium levels in the same year. This study stresses the difference between the local currency misalignment and US dollar misalignment. It is important to focus on the local currency misalignment to interpret changes in the exchange rate at the time of the currency crisis. This gives us a different interpretation of the currency crisis compared to focusing only on the total misalignments.

That said, this paper's findings must be interpreted cautiously. In this pa- per, all exchange rates are expressed to the dollar. An alternative way is to calculate misalignments against a basket of currencies, AMU (Asian Monetary Unit) for example[6]. Although this alternative analysis makes it easier for us to interpret estimated misalignments, it seems to make the estimation framework very complicated. Note that estimated misalignments in this study can be interpreted as effective exchange rate misalignments because it distinguishes the country *i*'s currency partial misalignment against the dollar and the US dollar misalignment against many other currencies.

As in other existing studies, the estimation result is not precise enough to counter other estimates of misalignments. Moreover, it is important to note that the reliability of our regression results is dependent on the accuracy of price level data estimated by the ICP.

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Notes

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1) Cheung et al. (2009) shows a typ ology of these approaches.

2) For more about the shortcomings of the relative PPP approach and the advantages of the absolute PPP approach, see Ahlers and Hinkle (1999).

3) A more direct way is to utilise the tradables price. However, good cross-country tradables price data are not available. For more about the Balassa-Samuelson model, see Motonishi (2002).

4) This line of research is called the behavioural equilibrium exchange rate (BEER) approach.

5) Note that all the components in the graphs are affected by the PPP rate because they are presented in nominal terms.

6) AMU is calculated by RIETI Faculty Fellow OGAWA Eiji and SHIMIZU Junko (http://www.rieti.go.jp/users/amu/en/index.html).

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