A Simple Model and Its Application in the Valuation of Five Asian Real Exchange Rates

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ABSTRACT

In the current paper, a new and simple currency valuation model called the ratio model is proposed based on the Penn effect (a systematic deviation of the purchasing power parity (PPP)). The ratio model, which reduces the uncertainty of the econometric specification that many other valuation models have, is used to valuate the bilateral real exchange rates (RERs) of five Asian industrial countries and areas, namely, Japan, Korea, Taiwan, Hong Kong, and Singapore, against the United States. In the early 1950s to 2009, the misalignments from the ratio model of four new industrial countries and areas converged, but those from the PPP model did not, implying the competitiveness of the ratio model against the PPP model both in currency valuation and as a RER anchor. In 2010–2011, based on the two models, the yen was overvalued by approximately 30%, whereas the Singapore dollar was undervalued by approximately 20%. However, the conclusions on the other three RERs were not consistent.

JEL classification: F31; F41

Keywords: Equilibrium exchange rate; Absolute purchasing power parity; Balassa-Samuelson effect; Penn effect

1. Introduction

Currency valuation, the calculation of the equilibrium exchange rate of a currency, has been a popular topic in international finance from the 1910s to the current times (Cassel, 1916a, 1916b; Yeager, 1958; Balassa, 1964; Ohno, 1990; Clark and MacDonald, 1998; Takeuchi, 2003; Chang and Shao, 2004; Frankel, 2005; Barisone et al., 2006; Isard, 2007; Wang et al., 2007; Cheung et al., 2010; Subramanian, 2010; Benassy-Quere et al., 2011; Imam and Minoiu, 2011; Sidek et al., 2011; Alper and Civcir, 2012; Garroway et al., 2012; Lopez-Villavicencio et al., 2012; Sato et al., 2012). Currency valuation models are mainly classified as the absolute or relative purchasing power parity (PPP) (Cassel, 1916a, 1916b; Yeager, 1958; Balassa, 1964; Ohno, 1990; Isard, 2007; Sidek et al., 2011), the Penn effect or Balassa-Samuelson (BS) regression or extended PPP (EPPP) (Takeuchi, 2003; Chang and Shao, 2004; Frankel, 2005; Isard, 2007; Cheung et al., 2010; Subramanian, 2010; Garroway et al., 2012), the behavioral equilibrium exchange rate (BEER) (Clark and MacDonald, 1998; Wang et al., 2007; Benassy-Quere et al., 2011; Imam and Minoiu, 2011; Sidek et al., 2011; Alper and Civcir, 2012; Lopez-Villavicencio et al., 2012), and the macroeconomic balance or fundamental equilibrium exchange rate models (Clark and MacDonald, 1998; Barisone et al., 2006; Isard, 2007; Imam and Minoiu, 2011; Lopez-Villavicencio et al., 2012; Sato et al., 2012).

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In this study, I develop the ratio model based on the Penn effect (or BS regression or EPPP). The model reduces the uncertainty of econometric specification that most other models have. The ratio model is simple, easy to use, and expected to give some meaningful misalignment results. I use the ratio model to calculate the bilateral real exchange rates (RERs) of five Asian industrial countries and areas, namely, Japan, Korea, Taiwan, Hong Kong, and Singapore, against the United States. Japan, Korea, Taiwan, Hong Kong, and Singapore are chosen because of the following. (1) They all experienced rapid economic growth stages, for example, Japan in 1950–1990 and the other four countries and areas from 1960s to the current times (except for some subsequent years after 1997). They are good examples to illustrate and investigate the Penn effect, the basis of the ratio model. (2) Related studies on the valuation of the five currencies are few. However, there are studies on other relevant topics such as the exchange rate appreciation and the BS effect of the same five Asian countries and areas (Ito et al., 1997), the business cycle and the yen/dollar exchange rate fluctuation in East Asia (McKinnon and Schnabl, 2003), and the exchange rate appreciation and economic growth of Taiwan (Xu, 2008). (3) I exclude the Chinese renminbi (RMB) in my research because of the large number of studies on its valuation (Takeuchi, 2003; Chang and Shao, 2004; Frankel, 2005; Wang et al., 2007; Cheung et al., 2010; Subramanian, 2010; Garroway et al., 2012; Lopez-Villavicencio et al., 2012; Sato et al., 2012). Moreover, Understanding the currency valuation of Asian industrial countries and areas will help Chinese policymakers to make decisions in the future, given that China has been learning from its five industrial neighbors in its development.

In Section 2, the ratio model is presented after a brief review on the relevant models. Section 3 gives the applications of the model in the valuation of the five RERs from 1950 to 2009. In Section 4, the model findings in Section 3 are analyzed. In Section 5, the ratio model is compared with the PPP model, and the misalignment differences between the two models are presented. Section 6 gives the five RER misalignments not examined in Section 3 in the period of 2010–2011. Finally, Section 7 concludes.

2. The PPP, Penn effect, and new models

The new model is based on the Penn effect, and the two are extensions of the PPP. Thus, the PPP and Penn effect are discussed first.

2.1. The PPP, Penn effect models, and their faults

In its absolute version, the PPP is a basic model used in assessing a bilateral nominal exchange rate (NER). PPP uses Eq. (1), where P_i is the domestic price level of a country, P^* is the price level of a foreign country (in this paper, the United States), and NER_i is expressed as the national currency units per US dollar. In the PPP model, if the value of *RER* is equal to one, NER will be equal to its PPP rate and will be in equilibrium; otherwise, NER will be over- or undervalued. Alternatively, the PPP model can be viewed as a model used to determine the value of an RER. When the RER value is one, it is in equilibrium; otherwise, RER is over- or undervalued. The misalignment of an RER is obtained by "*RER* -1".[1]

[1] The *RER* (defined in Eq. (1)) also measures the relative price level between two countries in terms of a common currency. Thus, it is also called "the price level of the GDP of one country relative to that of the US" in the Penn World Tables (PWT) database.

$$RER_i = \frac{PPP_i}{NER_i} = \frac{P_i/_{P^*}}{NER_i} = \frac{P_i}{NER_i \times P^*} \quad (1)$$

According to Balassa (1964), PPP is not a proper model to value NER or RER in any case. As Balassa (1964, p.596) states, "By incorporating non-traded goods in the model, the existence of a systematic relationship between purchasing power parities and (nominal) exchange rates is indicated in intercountry as well as in intertemporal comparisons." Based on Balassa's statement, the RERs (defined in Eq. (1)) of high-income countries become higher and those of low-income countries become lower. The "systematic relationship" called in Balassa (1964) is now a well-known empirical regularity (Rogoff, 1996; Takeuchi, 2003; Chang and Shao, 2004; Frankel, 2005; Isard, 2007; Cheung et al, 2010; Garroway et al., 2012), as illustrated in Fig. 1. This regularity is called the BS effect (Chang and Shao, 2004; Frankel, 2005), "Penn effect" (Samuelson, 1994; Isard, 2007; Cheung et al., 2010), "(long-run) deviations from PPP" (Rogoff, 1996), or others. Given that the Penn effect essentially refers to this empirical regularity (Samuelson, 1994) and that the BS effect is only one of its explanations (Rogoff, 1996), with the BS effect being an invalid explanation in some cases (Ito et al, 1997; Isard, 2007), the Penn effect is perhaps the more suitable name. Therefore, in this paper, I call this regularity the Penn effect.

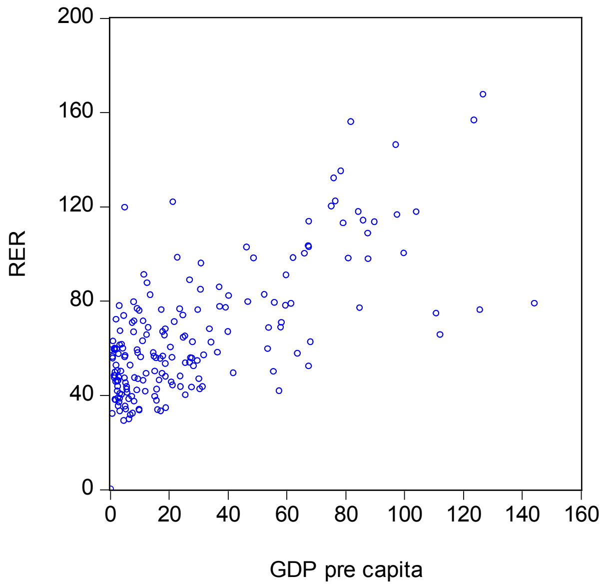

Fig. 1. RERs and income levels of 116 countries and areas in 2009.

Note: RER (defined by Eq. (1)) and GDP per capita (PPP converted) are both normalized, with US = 100.

Source: Alan Heston, Robert Summers and Bettina Aten, Penn World Table (PWT) Version 7.0, Center for International Comparisons of Production, Income and Prices at the University of Pennsylvania, June 2011.

Given the invalidity of the PPP model between the United States and a poor country because of the existence of the Penn effect, in the early 2000s, some economists (Takeuchi, 2003; Chang and Shao, 2004; Frankel, 2005) used the Penn effect model, Eq. (2) or its log-linear form, to obtain the value of the RER of the RMB. In Eq. (2), *RER* is defined by Eq. (1), GDPP (GDP per capita) represents the income level or the economic development stage, and the subscript i denotes the cross-section data dimension. As Eq. (2) regresses the RERs on the income levels, the deviations from the regression line represent the over- or undervaluation of the RERs when the Penn effect is considered. Some recent application examples of this model are given by Isard (2007), Cheung et al. (2010), Subramanian (2010), and Garroway et al. (2012).

$$RER_i = \beta_0 + \beta_1 GDPP_i + u_i \quad (2)$$

However, the Penn effect model has a fault in that different econometric specifications in the model always give different misalignment results (Dunaway et al., 2009; Cheung et al., 2010). The different econometric specifications of the Penn effect model include the following: different function forms (double log or ordinary linear equation), different econometric methods (cross-section or panel data), different proxies for GDPP (PPP converted or current priced), different databases (for a chosen variable proxy, use the PWT, WDI, or WEO to obtain data), and different observations (sample number or period). A different choice of econometric specifications leads to different misalignment results. I used the same database to simulate the result of Frankel's research (2005) and find the following. (1) The double-log function and the 118 sample countries give an RMB undervaluation of 36% in 2000, which is the same as the valuation of Frankel (2005). (2) However, when the number of the sample countries is reduced to 60 and the double-log is left unchanged, the RMB undervaluation changes to 22.4% in the same year. (3) When the double-log changes into an ordinary linear function and the 118 sample countries are left unchanged, the RMB undervaluation changes to 33.3%.

Aside from the Penn effect model, the default also appears in all other models using an econometric method such as the BEER model and the macroeconomic balance model (see Dunawayet al. (2009) and Zhang (2010) for details).

2.2. The simple model (ratio model)

The new model called the ratio model is also based on the Penn effect, but it uses a simple algebraic calculation rather than regression, which is used by the Penn effect model. The model described in Eq. (2) can be called the "regression" Penn effect model, and the model presented in this paper and described in Eq. (3) can be called the "ratio" Penn effect model. I call the "ratio" Penn effect model the "ratio model" to simplify and differentiate the two terms. Using the classification given by Dunaway et al. (2009), the regression and ratio Penn effect models belong to the EPPP, as they are both developed under the line of PPP.

$$Ratio_i = \frac{RER_i}{GDPP_i} \qquad misalignment = Ratio_i - 1 \quad (3)$$

In Eq. (3), RER_i is defined by Eq. (1). $GDPP_i$ is country *i's* per capital GDP relative to that of the United States, and $Ratio_i$ is the ratio of RER_i and $GDPP_i$. The index $Ratio_i$ measures the difference in a country *i's* RER relative to the United States and its GDPP relative to the United States. The misalignment is equal to the value of "$Ratio_i$-1." According to the definition of RER, if the value of $Ratio_i$ is one or if the misalignment is equal to zero, the RER will be equal to the GDPP (both relative to the United States) and will be in equilibrium. If the value of $Ratio_i$ is more than one or if the misalignment is greater than zero, the RER will be greater than the GDPP and will be concluded as overvalued. However, if the value of $Ratio_i$ is less than one or if the misalignment is less than zero, the RER will be undervalued.[2] According to the PWT 7.0, in 2009, the RER and GDPP of Japan (both relative to the United States, where US = 100) are 122.1 and 76.8, respectively. Thus, the $Ratio_i$ is 1.59 (= 122.2/76.8) and the misalignment is 59%, making the yen overvalued.

[2] In the ratio model, each currency's RER should remain at the same level of the country's GDPP (both relative to the US). A poor country's RER should remain as low as its GDPP, and a rich country's RER should remain as high as its GDPP. Otherwise, the RER will be misaligned.

The uncertainty of econometric specification that the (regression) Penn effect model and all other econometric valuation models (e.g., the BEER) have is greatly reduced because the ratio model uses a simple algebraic calculation, not an econometric method. Compared with the Penn effect and BEER models, the ratio model is free from uncertainties in function form, econometric method, and observation. However, the uncertainties in variable proxy and database remain. The Penn effect and BEER models require special software to conduct the econometric analysis. However, for the ratio model, hand computation is enough, making it easier to use. These two advantages of the ratio model are similar to those of the PPP model.

The following are brief discussions on the three closely relevant models, namely, PPP, regression Penn effect, and ratio Penn effect models:

(1) The PPP model is based on the PPP theory that holds only between a rich (similar income level) country and the United States, while the ratio and regression models based on the Penn effect hold between an arbitrary country and the United States. Thus, the ratio and regression Penn effect models extend the application range of the PPP model.

(2) The PPP model estimates the RER value of a country from the price level and does not consider the income level difference of that country with that of the United States. The regression and ratio Penn effect models estimate the RER value based on the income level difference between the country and the United States.

(3) The equilibrium criteria are different among the three models. In the PPP model, whether the RER is in equilibrium is decided by whether the price level of a country is equal to that of the United States (measured in the common US dollar). In the regression Penn effect model, whether the RER is in equilibrium is decided by whether the RER is equal to the average RER of all the countries with same income levels given by a regression. In the ratio Penn effect model, whether the RER is in equilibrium is decided by whether the RER is equal to the GDPP of a country (both relative to the United States, where US = 100).

3. Application of the ratio model

The ratio model is used to valuate the bilateral RERs of the five Asian industrial countries and areas against the United States. The databases of the World Economic Outlook (WEO) of the International Monetary Fund (IMF) and the World Development Indicators (WDI) of the World Economic Outlook (WEO) can supply more updated data. However, the data of WEO or WDI are only available after the year 1980, which is not long enough to illustrate the Penn effect because the five Asian economies took off in the 1950s and 1960s. Thus, the PWT 7.0 is used to supply relevant data from the early 1950s to 2008 or 2009, as shown in Sections 3, 4, and 5.[3] The RER (the variable p in the database) and the GDPP (PPP converted; the variable y in the database) can be directly obtained using the PWT 7.0. In the database, the RER and GDPP are both normalized, with US = 100 in each year. The periods for the different countries and areas obtained in the PWT 7.0 are different. For Japan, Korea, and Taiwan, the period is from early 1950s to 2009. For Hong Kong and Singapore, the period is from 1960 to 2009 and from 1960 to 2008, respectively.

3 The updated data in 2010 to 2011 from the WEO will be used in Section 6.

3.1. Each RER misalignment against the US dollar

The RER misalignment of each currency against the US dollar is obtained by using Eq. (3), which is presented in Fig. 2.

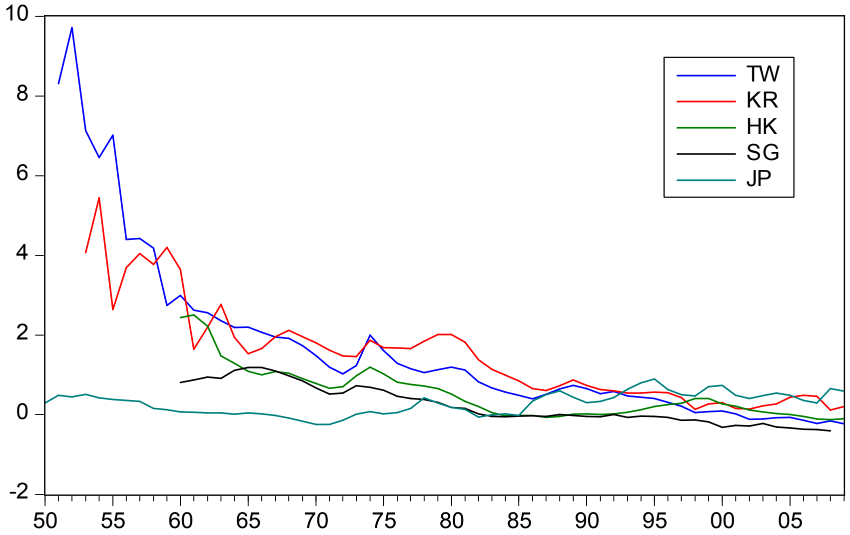

Fig.2. RER misalignment of each currency against the US dollar based on the ratio model.

Note: TW, KR, HK, SG, and JP represent the RER misalignment for Taiwan, Korea, Hong Kong, Singapore, and Japan, respectively.

Source: PWT 7.0 and the author's calculation.

In Fig. 2, the misalignments vary greatly from more than 800% to -40%. To distinguish these misalignments clearly, I classify each currency misalignment into five intervals, namely, highly overvalued, overvalued, near equilibrium, undervalued, and highly undervalued, which are denoted by $\text{Mis} > 50\%, 10\% \leq \text{Mis} \leq 50\%, -10\% < Mis < 10\%, -50\% \leq \text{Mis} \leq -10\%$, and $\text{Mis} < -50\%$, respectively. These interval classifications are listed in Table 1.

Table 1

Each RER misalignment in different intervals from the ratio model

	Taiwan	Korea	Hong Kong	Singapore	Japan
Highly overvalued ($\text{Mis} > 50\%$)	1951–1984 1987–1992	1953–1996	1960–1980	1960–1975	1993–2000* 2008–2009
Overvalued ($10\% \leq \text{Mis} \leq 50\%$)	1985–1986 1993–1997	1997–2009	1981–1982 1994–2002	1976–1981	1950–1959 1977–1981 1986–1992* 2001–2007*
Near equilibrium ($-10\% <\text{Mis}< 10\%$)	1998–2001 2004–2005		1983–1993 2003–2006	1982–1996	1960–1968 1973–1976 1982–1985
Undervalued ($-50\% \leq\text{Mis}\leq -10\%$)	2002–2003 2006–2009		2007–2009	1997–2008	1969–1972
Highly undervalued ($\text{Mis} < -50\%$)					

Note: For Japan, 1986–1992* means 1986–1992 except 1988, when the RER was highly overvalued (by 60.2%); 1993–2000* means 1993–2000 except 1998, when the RER was overvalued (by 46.7%); 2001–2007* means 2001–2007 except 2004, when the RER was highly overvalued (by 53.9%).

In Table 1, the RER of the four new industrial countries and areas are highly overvalued in their early development stage. Concretely, the new Taiwan dollar, Hong Kong dollar, and Singapore dollar are highly overvalued in the periods of 1951–1984, 1960–1980, and 1960–1975, respectively, from the first year recorded to about early 1980s. From 1953 to 1996, the won is highly overvalued until the mid-1990s. The yen is also overvalued (although not highly overvalued) in its early development stage, which is the period of 1950–1959. The data confirm that, in the early development stage of a country or area, the currency of that country is often overvalued to exchange for more foreign currency and buy more foreign goods because of the severe shortage of foreign exchanges at that time, as analyzed by Xu (2000, p. 265) for China before 1985.

However, after the mid-1980s, most misalignments of the four industrial countries and areas enter the range of ±50%. Therefore, after 20 years of fast development and economic reform, these RERs tend to fluctuate around their equilibrium levels.

3.2. RER misalignment against each other

Table 1 gives the misalignment of each currency against the (common) US dollar, from which the misalignment of one currency against the others can be obtained. The calculation of the equation is as follows. Let Mis_A and Mis_B be the misalignments of currency A against the US dollar and that of currency B against the US dollar. Thus, the misalignment of currency A against currency B, as noted by $Mis_{A/B}$, can be obtained by using Eq. (4). $Mis_{A/B}$ can also be directly calculated by using the same idea as in Eq. (3). See the part in the bracket of Eq. (4), where RER_A (RER_B) and $GDPP_A$ ($GDPP_B$) still have the same meanings as those in Eq. (3). The two methods can give the same result, which can be proven if we use a simple algebraic transformation:

$$Mis_{A/B} = \frac{Mis_A - Mis_B}{1 + Mis_B} \left(= \frac{\frac{RER_A}{RER_B}}{\frac{GDPP_A}{GDPP_B}} - 1\right) \tag{4}$$

As shown in Fig. 1, in 2009, the misalignments of the new Taiwan dollar and the yen against the US dollar are -23.1% and 59.1%, respectively. In the same database (PWT 7.0) as that used in Fig. 1, the RERs of the new Taiwan dollar and the yen against the US dollar are 52.0 and 122.1, respectively. The GDPPs of Taiwan and Japan against the United States are 67.7 and 76.8, respectively. Thus, the misalignments of the new Taiwan dollar against the yen are -51.7% (the new Taiwan dollar is undervalued by 51.7% against the yen or the yen is overvalued by the same degree against the new Taiwan dollar) based on Eq. (4) (see Eq. (5)). Using the same method, in 2009, the yen is overvalued by 24.1% against the won and is overvalued by 43.2% against the Hong Kong dollar.[4]

$$Mis_{TW/JP} = \frac{-23.1\% - 59.1\%}{1 + 59.1\%} \left(= \frac{\frac{52.0}{122.1}}{\frac{67.7}{76.8}} - 1\right) = -51.7\% \tag{5}$$

[4]The yen being overvalued against the three other Asian currencies is caused by the slower economic growth (the smaller GDPP) and higher price level (the bigger RER) of Japan relative to the other three. The Japanese economy has been stagnating for almost two decades (Hoshi and Kashyap, 2011, p.2).

4. Analysis of the model finding

Based on Fig. 2, the model finding from the ratio model, two apparent observations are determined and discussed as follows. (1) Some misalignments in the 1950s (and in other years) are unusually large. (2) Some RER misalignments have a downward trend before 1985 (in their first half periods).

4.1. Some unusually large misalignments in the 1950s

In Fig. 1, some misalignments in the 1950s are unusually large. For example, the misalignments of the new Taiwan dollar are 830.4% in 1951 and 971.5% in 1952, and those of the won is 407.3% in 1953 and 544.1% in 1954, which are remarkable. Two reasons can explain this phenomenon.

One reason is that these countries and areas have higher price levels relative to their low incomes at that time. In Table 2, I list down the RER, GDPP, and misalignment changes of Taiwan and Korea, whose characteristics are obvious. As shown in the same table, in each year of the period of 1951–1955, the RER of Taiwan against the United States is greater than 75, but the GDPP of Taiwan is not greater than 10. These two factors lead to the misalignment of more than 600%. In 2001–2005, the RER of Taiwan decreases to less than 60, but the GDPP is greater than 60. Thus, the misalignment changes from highly overvalued in the early 1950s to near equilibrium. Korea also gives similar information. In the early 1950s, RER of Korea is more than three times of its GDPP, giving a misalignment of more than 200%. However, in 2001–2005, the GDPP of Korea is more than 50 and is near its RER level, giving a misalignment of about 25%. In the early 1950s, the RERs of Taiwan and Korea are very high, but their GDPPs are too low, inevitably giving an immense misalignment that will disappear when their GDPPs greatly increase.[5]

Table 2

RER, GDPP, and misalignment changes in Taiwan and Korea in 1951–1955 and 2001–2005

Year	Taiwan			Korea		
	RER	GDPP	Misalignment	RER	GDPP	Misalignment
1951	78.6	8.4	830.4%			
1952	96.3	9.0	971.5%			
1953	76.1	9.4	712.6%	52.4	10.3	407.3%
1954	75.8	10.2	645.5%	70.0	10.9	544.1%
1955	81.3	10.1	701.7%	39.7	10.9	264.0%
2001	61.4	60.1	2.2%	59.3	51.1	16.0%
2002	57.2	64.9	-11.8%	62.0	54.1	14.4%
2003	57.1	64.3	-11.1%	66.2	54.3	21.8%
2004	58.7	63.6	-7.7%	69.7	54.6	27.6%
2005	59.4	63.5	-6.4%	77.2	53.6	44.0%

Note: The RER and GDPP are both normalized, with the US = 100 in each year. This table is taken from and is part of Fig. 1.

Source: PWT 7.0 and the author's calculation.

[5] Taiwan and Korea priced their RERs higher than their income level in their early development stage mainly for import, given their shortage of foreign exchanges at that time, as noted in Section 3.1.

Another reason explaining this phenomenon is the model structure of the ratio model. In the model, the misalignment is mainly obtained from the quotient of the RER and GDPP of a country from which a result of more than 100% can be easily obtained when the difference between RER and GDPP is large. In other words, the ratio model lacks a mechanism that can make its misalignment smaller in whichever case. By contrast, the misalignment of a Peen effect model is obtained from the residual of a regression equation and the regression theory makes the residual value smaller. Therefore, its misalignment is very small and approximately near zero. Similarly, in a time-series BEER model, the misalignment is obtained from the residual of a co-integration regression and is also minimal (Zhang, 2010, p. 15–16).Therefore, the misalignments from a Penn effect or a BEER model are usually less than 50% (in absolute value), and a misalignment of more than 100% is rare. For examples, the RMB misalignment is 5% to 45% in 1980–2003 by using the Penn effect model by Chang and Shao (2004) and is no more than 5% in 1980–2004 by using the BEER model by Wang et al. (2007). The lack of a special mechanism to adjust the misalignment value, which is contained in the Penn effect and BEER models, is another reason for the unusually large misalignment calculated by the ratio model.

4.2. Downward trend of the four RER misalignments before 1985

In Fig. 1, most misalignments (in each RER from the 1950s or 1960s to mid-1980s) have a downward trend. The downward trend appears in the misalignment of the four industrial countries and areas before 1985 but not in that of Japan. All five RER misalignments from 1953 to 1985 are listed in Table 3 to illustrate this point.

Table 3

Five RER misalignments of Asian industrial countries and areas from 1953 to 1985

Year	Taiwan	Korea	Hong Kong	Singapore	Japan
1953	712.6%	407.3%			50.8%
1954	645.5%	544.1%			41.9%
1955	701.7%	264.0%			38.3%
1956	440.2%	369.1%			35.7%
1957	442.8%	404.2%			33.8%
1958	418.2%	377.5%			16.3%
1959	274.4%	420.1%			12.3%
1960	299.5%	364.3%	243.9%	80.4%	7.0%
1961	262.1%	164.3%	250.5%	86.9%	6.0%
1962	256.1%	220.1%	222.3%	94.8%	4.4%
1963	235.6%	276.9%	147.7%	91.4%	5.0%
1964	219.3%	194.4%	128.9%	111.6%	1.5%
1965	220.0%	152.8%	109.3%	118.8%	4.8%
1966	207.1%	166.3%	100.0%	118.4%	2.0%
1967	194.9%	196.2%	108.3%	110.5%	-2.1%
1968	192.0%	211.9%	104.4%	97.5%	-8.3%
1969	173.7%	195.1%	90.5%	84.8%	-16.4%
1970	148.2%	180.9%	78.3%	67.4%	-23.9%
1971	119.5%	162.0%	66.3%	51.4%	-24.4%

Year	Taiwan	Korea	Hong Kong	Singapore	Japan
1972	102.4%	147.7%	70.9%	54.3%	-14.2%
1973	123.5%	146.1%	97.5%	73.2%	1.1%
1974	199.6%	186.5%	119.8%	68.7%	7.7%
1975	160.9%	168.3%	102.4%	61.9%	2.5%
1976	129.1%	167.3%	82.1%	46.6%	5.5%
1977	115.4%	165.9%	75.9%	40.9%	16.3%
1978	105.6%	184.2%	72.6%	38.0%	42.0%
1979	113.3%	201.0%	65.4%	31.1%	29.8%
1980	119.9%	201.1%	51.7%	18.5%	18.2%
1981	112.1%	182.2%	33.6%	16.4%	14.0%
1982	82.2%	138.2%	20.0%	2.1%	-5.9%
1983	67.1%	113.7%	5.5%	-3.7%	-0.2%
1984	56.9%	99.7%	-2.6%	-5.4%	2.0%
1985	48.7%	84.9%	-1.4%	-3.4%	-1.4%

Note: This table is taken from and is a part of Fig. 1.

Source: PWT 7.0 and the author's calculation.

Table 3 shows that the misalignment of the new Taiwan dollar declines from about 700% in the early 1950s to less than 50% in 1985. The misalignment of the Korean won declines from more than 400% in 1953–1954 to 85% in 1985. The misalignment of the Hong Kong dollar declines from about 250% in 1960–1961 to near equilibrium in 1984–1985. The misalignment of the Singapore dollar declines from more than 110% in 1964–1965 to near equilibrium in 1982–1985. In short, the four RER misalignments all exhibit a downward trend before 1985. Why? The answer lies in the changes in the RERs and GDPPs in their respective periods, which can be explained and seen in Table 4.

Table 4

RER and GDPP changes of the four new Asian industrial countries and areas in (or in part of) 1953–1985

	Taiwan				Korea		
	RER	GDPP	Misalignment		RER	GDPP	Misalignment
1953	76.1	9.4	712.6%	1954	70	10.9	544.1%
1985	53	35.6	48.7%	1985	49.5	26.8	84.9%
AGR	-1.1%	4.2%	-8.0%	AGR	-1.1%	2.9%	-5.8%
	Hong Kong				Singapore		
	RER	GDPP	Misalignment		RER	GDPP	Misalignment
1961	70.1	20	250.5%	1965	55.1	25.2	118.8%
1983	62.6	59.4	5.5%	1982	65.4	64.1	2.1%
AGR	-0.5%	5.1%	-15.9%	AGR	1.0%	5.6%	-21.1%

Notes: AGR represents the annual growth rate of a variable in its period. AGR is obtained from $a \cdot (1+AGR)^n = b$, where a and b are values in the first and last years, respectively, and n is the number of years examined.

Source: PWT 7.0 and the author's calculation.

Table 4 shows that the annual growth rates of RERs in Taiwan from 1953 to 1985, in Korea from 1954 to 1985, and in Hong Kong from 1961 to 1983 are -1.1%, -1.1%, and -0.5%, respectively. However, the corresponding annual growth rates of GDPPs in the same periods are 4.2%, 2.9%, and 5.1%, respectively. The decreasing RER (the numerator of *Ratio* in Eq. (3)) and the fast-increasing GDPP (the denominator of *Ratio* in Eq. (3)) make the value of *Ratio* decline gradually, leading to the downward trend of the misalignment in each period. The RER in Singapore appreciates in its period unlike that in the aforementioned three countries and areas. However, the annual growth rate of RER appreciation (1.0%) is much less than that of the GDPP increase (5.6%). As a result, the misalignment in Singapore also declines during its period, although the downward trend is not as obvious as that in the other three countries and areas.

4.3. Misalignment of the yen

Fig. 2 shows that the yen misalignment presents a different situation from the misalignment of the other four countries. (1) All yen misalignments during its entire period (from 1950 to 2009) fluctuate in the range of -25% to 90%, and no unusual value more than 100% appears. (2) The yen misalignment mainly fluctuates around the zero line before 1985, and a downward trend doesn't appear. Let us analyze the reason for this situation in the succeeding paragraphs.

Fig. 3 shows that the yen RER always fluctuates around and near the GDPP before 1985, giving the misalignment a narrow range of -25% to 50%. Moreover, it prevents the downward trend, which has emerged in the other four countries and areas, from appearing. The Plaza Accord takes effect in 1985, and the yen is pressured to appreciate. The RER increases from 81.0 to 173.3 (more than two times) from 1985 to 1995, but the GDPP only increases from 82.2 to 91.4. These increases make the misalignment in this period obviously greater than that before 1985, often overpassing 50%. The difference between the RER and GDPP is maximized in 1995, and the yen is overvalued by 89.6%, reaching the greatest misalignment in the whole period examined. Both the RER and GDPP decline after 1996, but the RER remains slightly greater than the GDPP, leading to the misalignment from 1996 to 2009 to be 30% to 75%.

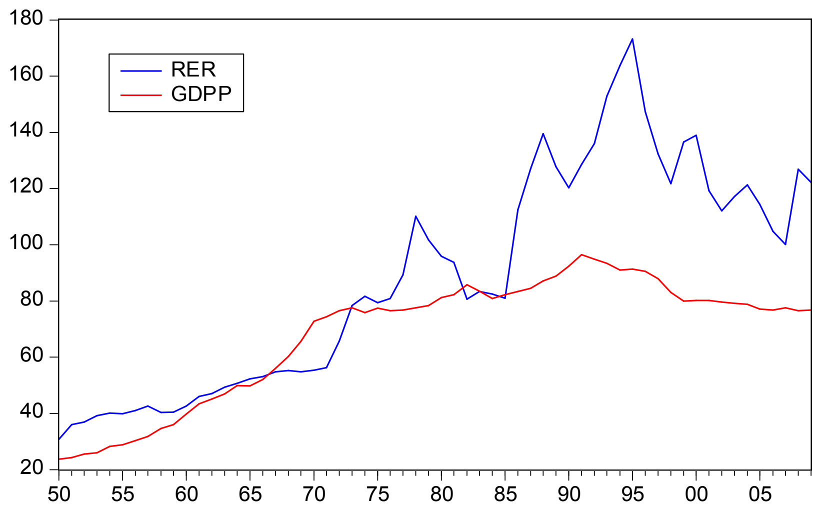

Fig. 3. RER and GDPP (both relative to the United States and the US=100) of Japan from 1950 to 2009.

Why does the yen RER misalignment have a different behavior from the misalignment of the other four? Three main reasons are possible. (1) The yen RER is too high. The RERs are all greater than 100 starting in 1986, with most of them more than 120, indicating that the price level of Japan is more than 120% of that in the United States. The continuous exchange rate appreciation pressure from the United States after the Plaza Accord may be a main factor. However, all other RERs of the four new industrial countries and areas are below 90 except those in Hong Kong from 1993 to 2001 and Singapore in 1996. (2) Japan developed very slowly or even stagnated in many years after 1986, as noted in Section 3.2. Fig. 3 shows that the GDPP decreases rather than increases from 1986 to 2009. By contrast, the GDPPs of the four new industrial countries and areas clearly increase from the mid-1980s to 2009. (3) Japan became an industrial country earlier than the other four countries and areas, and its economy has some special characters. For example, Japan's GDPP reached 50 in 1964. The GDPPs of the other four countries and areas were less than 30 at that time. Hong Kong and Singapore reached a GDPP of 50 in about 1980, whereas Taiwan and Korea reached a GDPP of 50 in the 1990s. The frequent change in government could have had a negative effect on the economy.

5. Combination with the PPP model

After understanding the finding from the ratio model, I now combine it with the PPP model from which the difference between the two model findings can be analyzed and some inspirations can be obtained.

5.1. Difference between the two model findings

Each RER misalignment against the US dollar from the PPP model is obtained by using the method introduced in Section 2.1 (misalignment=RER-1). The result is presented in Fig. 4.

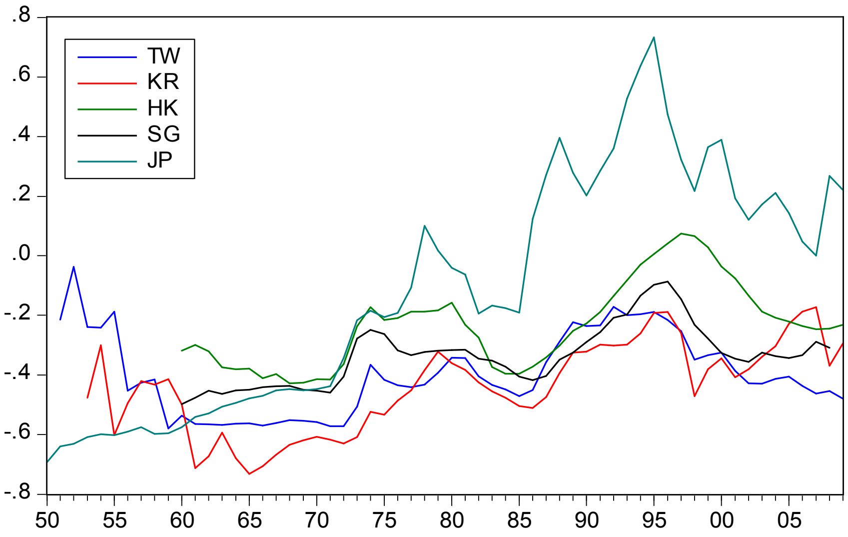

Fig.4. RER misalignment of each currency against the US dollar based on the PPP model.

Note: TW, KR, HK, SG, and JP represent the RER misalignments for Taiwan, Korea, Hong Kong, Singapore, and Japan, respectively.

Source: PWT 7.0 and the author's calculation.

Using the same method as in Section 3.1, I classify each RER misalignment into five intervals. The RER misalignment classification for Fig. 4 is listed in Table 5.

Table 5

Each RER misalignment in different intervals from the PPP model

	Taiwan	Korea	Hong Kong	Singapore	Japan
Highly overvalued ($\text{Mis} > 50\%$)					1993–1995
Overvalued ($10\% \leq \text{Mis} \leq 50\%$)					1986–1992 1996–2009*
Near equilibrium ($-10\% < \text{Mis} < 10\%$)			1993–2001		1978–1981
Undervalued ($-50\% \leq \text{Mis} \leq -10\%$)	1951–1958 1974–2009	1953–1960 1976–2009*	1960–1992 2002–2009	1960–2008*	1964–1977 1982–1985
Highly undervalued ($\text{Mis} < -50\%$)	1959–1973	1961–1975			1950–1963

Note: For Korea, 1976–2009* means 1976–2009 except 1985–1986, when the RER is highly undervalued (by about -51.0%). For Singapore, 1960–2008* means 1960–2008 except 1995–1996, when the RER is near equilibrium (with a misalignment of about -9.0%). For Japan, 1996–2009* means 1996–2009 except 2006–2007, when the RER is near equilibrium (with a misalignment of about 2.5%).

The following differences are observed when comparing the misalignment of the five RERs from the ratio model (Fig. 2 and Table 1) with that from the PPP model (Fig. 4 and Table 5):

1. The difference between the findings of the two models is great for the four new industrial countries and areas before 1985. Most of the RERs are undervalued or highly undervalued in the PPP model. Conversely, most of the RERs in the ratio model are highly overvalued. For example, the RER misalignments of Taiwan and Korea in 1961–1973 are less than -50% in the PPP model but are greater than 100% in the ratio model, giving the difference between the two misalignments in each same year in the period to be greater than 150% (in absolute value). This great difference reflects the ratio model's adjustment in the PPP model. That is, when the PPP model is used and the income level difference is not considered, an RER of a low-income country against the United States is often considered undervalued. However, when the ratio model is used and the income level difference is considered, the RER may be overvalued.

2. The difference between the two model findings is clearly reduced for the four new industrial countries and areas after 1986. For example, the RERs in Taiwan and Hong Kong in 2003–2009 are undervalued in the PPP model. They are also undervalued or near equilibrium in the ratio model. The difference between the two model findings (in absolute value) for Korea is greater than 130% before 1985 but is reduced to less than 120% in 1986–1993 and less than 80% in 1994–2009. The RER of Singapore in 1997–2008 is undervalued whether in the PPP or the ratio model. The GDPPs of the four countries and areas reach a relatively high level after 1986 compared with those before 1985, with most GDPPs being less than 40 before 1985 and greater than 60 after 1986.[6] The reduced gap of the GDPPs between the four countries and areas and the United States reduces the Penn effect, making the difference between the two model findings even smaller after 1986.

[6] The GDPP of Korea is the smallest in the four countries and areas. It is usually less than 20 before 1985 and greater than 40 after 1986. The GDPPs of the other three countries and areas are usually less than 40 before 1985 and greater than 60 after 1986.

A similar phenomenon can also be observed in the five RER misalignments in 2010–2011 (see Table 6 in Section 6). Table 6 shows that the misalignment differences of Japan and Singapore (with their GDPPs near that of the United States) are smaller between the two models and that those of Korea and Taiwan (with GDPPs less than half of that of the United States) are farther between the two models. This finding gives the following impression: the nearer a GDPP is to that of the United States, the smaller the difference between the two model findings. When a GDPP is equal to that of the United States, the denominator of the *Ratio* in Eq. (3) is 1, and the ratio model is reduced to the PPP model.[7]

3. The difference between the two model findings in Japan in 1950–1965 is in the range of 50% to 120%, with a mean of 81.7%. The difference between the two model findings in 1966–2009 is less than 50%, with a mean of 24.5%. For example, the misalignments are -60.2% in 1955 and 14.3% in 2005 in the PPP model and 38.3% in 1955 and 48.4% in 2005 in the ratio model. The difference is reduced from 98.5% in 1955 to 34.1% in 2005. Given that the GDPP increases from less than 50 (mostly less than 40) in 1950–1965 to more than 50 (mostly more than 70) in 1966–2009, the reduced difference between the two model findings in 1950–1965 and in 1966–2009 also reflects the Penn effect and the ratio model's adjustment in the PPP model, although the reduced difference is not as obvious as that in the four new industrial countries and areas.

5.2. Ratio model completing the PPP model

Aside from the differences between the two model findings that demonstrate regularity, the ratio model can also complete the PPP model.

1. The ratio model can complete the PPP model in measuring the currency misalignment.

Just as the Penn effect completes the PPP theory, the ratio model can also complete the PPP model in currency valuation, as discussed to some extent in Section 2.2. The PPP model values an RER from the perspective of two price levels without considering the influence of income level difference between the two countries. Conversely, the Penn effect values an RER with an income level difference. The PPP model only holds well when a GDPP is similar to that of the United States. Conversely, the ratio model, as a corrected version of the PPP model, can be used in any case, especially in cases in which the PPP does not hold well. By combining the two models, we can obtain a more complete misalignment result.

The following are some examples. As shown in Fig. 2 and Fig. 4, the PPP model gives a misalignment of -30.8% for the Singapore dollar in 2008, whereas the ratio model gives a misalignment of -40.6%. As the two models provide the same result (the same misalignment classification), the obtained undervaluation of the Singapore dollar should be more reliable than the one achieved by using only one model. The PPP model gives a misalignment of 26.8% (overvalued) for the yen in the same year, whereas the ratio model gives a misalignment of 65.7% (highly overvalued). Thus, the yen can be overvalued when the income level difference is not considered and highly overvalued when it is considered. The PPP model gives a misalignment of -23.1% (undervalued) for the Hong Kong dollar in 2009, whereas the ratio model gives a misalignment of -9.6% (near equilibrium). Thus, the Hong Kong dollar can be viewed as being

[7] For example, according to the same WEO database, the forecast GDPP of Singapore in 2014 will be 100.4% of that of the US; thus, undoubtedly, the misalignment in the same year in the ratio model (-19.6%) is also almost equal to that in the PPP model (-19.3%).

undervalued when the income level difference is not considered and near equilibrium when it is considered.

2. The ratio model completes the PPP model as an NER anchor.

According to Rogoff (1996, p.647), "While few empirically literate economists take PPP seriously as a short-term proposition, most instinctively believe in some variant of purchasing power parity as an anchor for long-run real exchange rates." Taylor and Taylor (2004, p. 138–140) showed that the bilateral NER between the sterling and the US dollar, whether measured by producer price indices or consumer price indices, moves closely to its PPP rate in a long period (i.e., 1820–2001). However, the validity of the PPP model seems to vary for different countries.

The PPP model does not hold for the RERs of the four new industrial countries and areas in the periods examined. Fig. 4 shows that most of the RER misalignments are less than -20% in their entire periods. The misalignments neither exhibit an upward trend near the equilibrium level (the zero line) nor fluctuate around the equilibrium level. By contrast, each RER misalignment of the four Asian industrial countries and areas from the ratio model exhibits a downward trend in its early period (from the 1950s or 1960s to 1985), and then the misalignment mostly fluctuates in a narrow range of ±50% in 1985–2009, as shown in Fig. 2 and discussed in Section 4.2. In other words, each RER misalignment first declines from high overvaluation to its equilibrium (misalignment=0) and then fluctuates around the equilibrium, which is an obvious convergence phenomenon. This phenomenon indicates that the ratio model can be considered an RER anchor. Furthermore, it seems to be a more suitable RER anchor than the PPP model.

However, in the case of the yen, the PPP model does give some indications as an RER anchor. Fig. 5 shows that the misalignment of the yen from the PPP model fluctuates around the zero line. Meanwhile, the misalignment from the ratio model is also around the zero line, although it fluctuates in an opposite direction from that in the PPP model before 1970. The ratio model can also be considered an RER anchor.

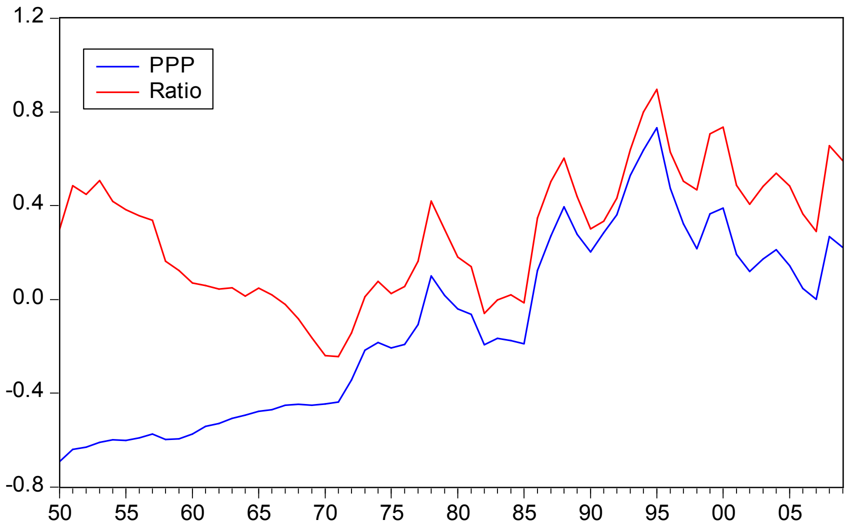

Fig. 5. Misalignments of the yen from the PPP and ratio models in 1950-2009.

In summary, the ratio model seems a more suitable RER anchor than the PPP model for the four new industrial countries and areas. The two models equally serve as RER anchors for the yen.

6. Updated misalignments

In Sections 3, 4, and 5, the five RER misalignments are calculated and analyzed using the PWT 7.0 database, which is only until 2008 or 2009. The WEO database (April 2012) is used to calculate these RER misalignments in 2010–2011 in this section to obtain more updated results.[8] The data in 2010–2011 are actual in the database; the data after 2012 are predicted by the IMF and not used. NER is calculated from two GDPs measured by national price and the US dollar (current price). Then, RER is calculated from NER and PPP according to Eq. (1). The GDPP is measured by the US dollar in its current price, not converted PPP as in the PWT 7.0 used in earlier sections. The RERs and GDPPs are normalized with US=100 to be consistent with Eq. (3).

Both the PPP and ratio models are used to obtain more complete results as analyzed in Section 5.2. The results are presented in Table 6.

Table 6

Five RER misalignments in 2010–2011 in the PPP and ratio models

	Japan		Singapore		Hong Kong		Korea		Taiwan	
RER(US=100)										
2010	125.3		77.4		68.4		69.1		52.2	
2011	132.2		82.5		69.3		71.8		53.3	
GDPP(US=100)										
2010	91.7		93.5		67.3		44.3		39.6	
2011	94.9		101.8		70.4		47.1		41.5	
Misalignment	PPP	Ratio	PPP	Ratio	PPP	Ratio	PPP	Ratio	PPP	Ratio
2010 (%)	25.3	36.6	-22.6	-17.2	-31.6	1.6	-30.9	56.0	-47.8	31.8
2011 (%)	32.2%	39.3	-17.5	-19.0	-30.7	-1.6	-28.2	52.4	-46.7	28.4

Note: "PPP" and "Ratio" refer to the misalignments in the PPP and ratio models, respectively.

Source: WEO database and the author's calculation.

Table 6 shows that the yen is overvalued by about 30% in 2010–2011 whether the PPP or the ratio model is used. The Singapore dollar is undervalued by about 20% in 2010–2011 regardless of which model is used. Therefore, the yen's overvaluation and the Singapore dollar's undervaluation can be confirmed. According to the WEO database, the annual compound GDP (constant price) growth rate of Singapore is 5.1% in 2000–2011, which is greater than that of the other four Asian countries and areas and the United States (from Japan's 0.5% to Korea and Hong Kong's 3.8%). Given this fast economic growth in Singapore, its RER is still undervalued in 2011, although it appreciates by 1.3% per year in the period. The PPP model gives a misalignment of about -30% for the Hong Kong dollar in 2010–2011, but the ratio model gives a misalignment of close to zero. Therefore, the Hong Kong dollar is undervalued by about 30% when the income level difference is not considered but is in equilibrium when it is considered.

The Korean won is undervalued by about 30% in 2010–2011 when the income level difference is not considered but is highly overvalued by about 55% when it is considered. The new Taiwan dollar is undervalued by nearly 50% in 2010–2011 when the income level difference is not considered but is overvalued by about 30% when it is considered. As the GDPPs of Korea and Taiwan are less than 50 in 2010–2011 (much smaller than that of the United States), the PPP

[8] I first considered using the WDI database, but it didn't contain data of Taiwan, thus it was abandoned.

model may not hold.[9] Thus, we can mainly rely on the ratio model and consider that the Korean won is overvalued by about 55% and that the new Taiwan dollar is overvalued by about 30% in 2010 to 2011.

7. Conclusion

A new model (the ratio model), which is based on the Penn effect and extends the traditional PPP model, is developed in this paper. The ratio model is simple to use. It reduces the uncertainty of econometric specification present in the (regression) Penn effect and the BEER models. The misalignments of each RER of the five Asian industrial countries and areas against the United States are investigated by using this model and the PPP model from a long-term (from early 1950s to 2009 and through the PWT database) and an updated (in 2010–2011 and through the WEO database) perspectives. The misalignments of the five RERs and the characteristics of the ratio model are determined from these applications.

The model findings from the PWT database show that some misalignments in the 1950s are incredibly large. The reason for this is the model's particular structure that lacks the mechanism to adjust its misalignment values to make them smaller. This mechanism is included in the Penn effect and the BEER models. Misalignments greater than 50% (in absolute value) can be considered high over- or undervaluation in the ratio model. The misalignments of Taiwan, Korea, Hong Kong, and Singapore all exhibit a downward trend before 1985. After 1985, they fluctuate in a narrow range of ±50%, demonstrating an obvious convergence phenomenon. A similar convergence phenomenon cannot be found in the misalignments of the PPP model. This finding suggests that the ratio model can complete the PPP model as an RER anchor. However, the yen shows a different misalignment from that of the other four counties and areas from the long-term perspective.

The ratio model can also complete the PPP model in currency valuation. The PPP model values an RER without considering the influence of income level difference between two countries, whereas the ratio model considers such income level difference. Based on this idea, I calculate the five RER misalignments in the latest years (2010–2011) in the WEO database. The yen is overvalued by about 30%, and the Singapore dollar is undervalued by about 20% whether the income level is considered or not. The Hong Kong dollar is undervalued by about 30% when the income level difference is not considered and is in equilibrium when it is considered. In the case of Korea and Taiwan, their GDPPs are too small (against that of the United States) for the PPP model to hold. Thus, we can mainly rely on the ratio model. Based on the ratio model, the RERs of Korea and Taiwan are highly overvalued by about 55% and overvalued by about 30%, respectively.

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[9] Note that different databases or dimensions may give different values. Although the PPP-converted GDPPs of Korea and Taiwan from the PWT database used in Sections 3 to 5 are about 60 and 65 in 2008–2009, respectively, their current priced GDPPs from the WEO database used in this section are only about 45 and 40 in 2010–2011, respectively. In addition, no explicit criterion on the validity of the PPP model is set.

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