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Understanding the behavioral equilibrium exchange rate model via its application to the valuation of Chinese renminbi

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Abstract

In this paper, the behavioral equilibrium exchange rate (BEER) model used in a time-series setting is investigated, via its application to the valuation of Chinese renminbi. A classical definition with its generalization is given. The different misalignment results derived from the BEER models are proven to result from the different econometric component choices. It is found that some of the misalignment results are consistent with Chinese economic facts, but some others are not. Finally, four main flaws unavoidable under the BEER model are given and analyzed.

JEL classification: F31; F41

Keywords: Behavioral equilibrium exchange rate; Chinese renminbi

1. Introduction

Estimating the degree of exchange rate misalignment is one of the most important issues in open-economy macroeconomics. The behavioral equilibrium exchange rate (BEER) model is one of the models broadly used for this purpose, for instance by Baffes et al. (1997) and by Clark and MacDonald (1998). In recent years, the BEER model has been again used to calculate the equilibrium value of the Chinese currency, the renminbi (RMB); see Zhang (2001), Funke and Rahn (2005), Goh and Kim (2006), and Wang et al. (2007). In light of the ongoing debate over global current account imbalances and the important role of China in this regard, the studies assessing the valuation of the RMB are certainly relevant. However, the BEER model itself, including its RMB valuation results, needs to be studied at the same time. This has not previously been done. In an approach markedly different from the authors who use the BEER model to calculate the RMB's equilibrium exchange rate, the model itself, via its application to RMB valuation, is studied in this paper. This research is judged to be useful for both the development of exchange rate economics and for understanding the equilibrium value of Chinese RMB.

The remainder of the paper is structured as follows. Section 2 describes the BEER model, classifies its features, and gives two definitions of it. Section 3 lists the concrete econometric components used in some BEER models and their (different) results, which serves as a base for the subsequent analysis in Sections 4 through 6. Section 4 uses a simulation to analyze how the different econometric component choices influence the estimated results. Whether and why the results derived from the BEER models are consistent with Chinese economic facts is analyzed in

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This paper was finished in January 2010. And it should be supplemented by my other relevant papers.

Section 5. The four main faults unavoidable under the BEER model are listed and analyzed in Section 6. Section 7 concludes the study. [2]

2. The BEER model: Description and definitions

2.1. Description

The term behavioral equilibrium exchange rate comes from Clark and MacDonald (1998, p.4), who compare the BEER model with the fundamental equilibrium exchange rate (FEER) model. They specify, "Thus it is useful to compare the FEER approach with one that involves the direct econometric analysis of the behavior of the real effective exchange rate, which can be called the BEER (Behavioral Equilibrium Exchange Rate) approach" (p.4).

According to Clark and MacDonald (1998, p.10), the actual, observed real effective exchange rate, q, is explained in terms of a set of fundamental variables, Z_1 and Z_2, a set of variables that affect the exchange rate only in the short run, T, and a random error ε.

$$q_t = \beta_1' Z_{1t} + \beta_2' Z_{2t} + \tau' T_t + \varepsilon_t \tag{1}$$

In equation (1), Z_1 is a vector of economic fundamentals that are expected to have persistent effects over the long run, Z_2 is a vector of economic fundamentals that affect the exchange rate over the medium term, β_1 and β_2 are vectors of reduced coefficients, T is a vector of transitory factors affecting the exchange rate in the short run, τ is a vector of reduced-form coefficients, and ε is a random disturbance term.[3]

Based on equation (1), the current misalignment, cm_t, and the total misalignment, tm_t, are defined; see equations (2) and (3).

$$cm_t = q_t - \beta_1' Z_{1t} - \beta_2' Z_{2t} = \tau' T_t + \varepsilon_t \tag{2}$$

$$tm_t = q_t - \beta_1' \overline{Z}_{1t} - \beta_2' \overline{Z}_{2t} = \tau' T_t + \varepsilon_t + [\beta_1'(Z_{1t} - \overline{Z}_{1t}) + \beta_2'(Z_{2t} - \overline{Z}_{2t})] \tag{3}$$

In equation (2), the current misalignment, cm_t, is the difference between the actual real exchange rate and the equilibrium real exchange rate given by the current values of all the economic fundamentals. In equation (3), the total misalignment, tm_t, is the difference between the actual real exchange rate and the equilibrium real exchange rate given by the long-run values of the economic fundamentals, which are denoted by $\overline{Z}_{1t}$ and $\overline{Z}_{2t}$. The long-run values, which are also named as sustainable or permanent values, can be obtained by using a filter procedure, such as the Hodrick- Prescott filter. It can be seen that the total misalignment includes two components: the first component is simply the current misalignment given by equation (2), and the other component shows the effect of departures of the current values of economic fundamentals from

[2] At the end of this introduction, several points are worth noting. First, though the BEER model can be (and has also been) used in a panel data setting, what we discuss in this paper is the model as used in a time-series setting, because most applied BEER models in the field of the RMB valuation are of this sort. Second, the characteristics of the model in a time-series setting are more obvious than those in a panel data setting. Third, it will be an easy matter to assess the model in a panel data setting after the time-series setting is discussed.

[3] In applied works, q_t can be other forms of the real exchange rate and may not be a real effective exchange rate, and the difference between Z_1 and Z_2 is also shown to be unclear.

the long-run values. It can also be seen that the difference between the current misalignment and the total misalignment is whether the used values of the economic fundamentals are current values or long-run values.

2.2. A classical definition

In a relevant and further study, Clark and MacDonald (2004) call the model that uses equation (2) to calculate a currency's misalignment the "BEER model", and call the model that uses equation (3) to calculate a currency's misalignment the "permanent equilibrium exchange rate (PEER) model." But the use of the two names is not consistent among economists. For example, Funke and Rahn (2005) indeed use the same names as Clark and MacDonald (2004), but Wang et al. (2007) do not. Wang et al. (2007) use equation (3) (and the Hodrick-Prescott filtered values of economic fundamentals) to calculate the RMB's valuation, but they still call their model the BEER model; if using the definitions by Clark and MacDonald (2004), the model used in Wang et al. (2007) should be termed the PEER model. As the only obvious difference between the BEER and PEER models named by Clark and MacDonald (2004) is the use of either current or long-run values of economic fundamentals, in this study we classify them together under the term BEER model. On the other hand, though the BEER model is often used to calculate equilibrium real exchange rate (Clark and MacDonald, 1998, 2004; Zhang, 2001; Goh and Kim, 2006; Wang et al., 2007), it indeed has been also used to calculate equilibrium nominal exchange rate (Funke and Rahn, 2005). So the forms of exchange rate in the model should include both real and nominal rates.

Combing the classical works of Clark and MacDonald (1998, 2004), Funke and Rahn (2005), and Wang et al. (2007), we give the BEER model, including the so-called PEER model, a formal definition. The BEER model uses a set of economic fundamentals to calculate equilibrium real or nominal exchange rate, using a single equation, unit root, and cointegration analysis method. Its implementation includes three stages: first, choosing a form of exchange rate and a set of economic fundamentals based on relevant economic theory or empirical study; second, performing unit root and cointegration tests for the variables; third, if a cointegration relationship between the exchange rate and its economic fundamentals exists, then the equilibrium exchange rate can be derived from the cointegration equation. It can be seen easily that, under this definition, the PEER models named and used by Clark and MacDonald (2004) and Funke and Rahn (2005) would all be classified as BEER models. That is, the BEER model can be used to calculate either equilibrium real or nominal exchange rate, and either the actual or filtered values of economic fundamentals can be used. Under this definition, the model used by Baffes et al. (1997) is classified as a BEER model, though they (see p.1) call their model a "single- equation approach" or a "single-equation econometric model." Clark and MacDonald (1998, p.9, the last footnote) and Zhang (2001, p.85) all indeed take the model used by Baffes et al. (1997) as the BEER model. Similarly, the Edwards-type model used by Goh and Kim (2006) can also be classified as the BEER model, though they do not give it a concrete name.

The cointegration analysis is an essential part of the BEER model as defined above, because the equilibrium exchange rate is derived from the cointegration equation between the actual (real or nominal) exchange rate and its economic fundamentals. An issue arises, then. If a cointegration analysis method is not used, as Wang (2004), or if both the exchange rate and its economic fundamentals are stationary, which implies that a cointegration analysis cannot be applied, how can we calculate the equilibrium exchange rate? In fact, in these cases, the BEER model as defined above can no longer be applied. But the model used by Wang (2004) resembles the BEER model used by Clark and MacDonald (1998, 2004) and by Zhang (2001) in all points except for whether a nonstationary or stationary time-series method is used. So we generalize the classical definition given above to include the model used by Wang (2004). In order to differentiate, we term the above-defined model the classical BEER model, and its generalization, which will be discussed below, the generalized BEER model.

2.3. A generalized definition

The generalized BEER model is the model that uses a set of economic fundamentals to calculate equilibrium (real or nominal) exchange rate, in which a single-equation, time-series method is used. This definition is still consistent with what is described by Clark and MacDonald (1998) when they state that "the BEER denotes a modeling strategy that attempts to explain the actual behavior of the exchange rate in terms of relevant economic variables" (p.5). They conclude, "To the extent that this particular BEER can explain movements in the actual real effective exchange rate, q, the latter can be said to be in equilibrium in a behavioral sense, i.e., it reflects the economic fundamentals that have found to be related to q in a well-defined statistical sense. The economic fundamentals can be viewed as the factors determining the exchange rate, and the economic behavior generating the observed outcome is consistent with the theory underpinning the model. The systematic relationship between q and its economic fundamentals is the basic equilibrium concept underlying the notion of the BEER" (p.33).

The characteristics of the classical and generalized BEER models are listed in Table 1. From Table 1, we can see that there is only one difference between them, the econometric method. The other four characteristics—explained variable, explanatory variable, data, and direct theoretic basis—are held in common.

Table 1

The characteristics of the classical and generalized BEER models

	The classical BEER model	The generalized BEER model
Explained variable	Real or nominal exchange rate	Real or nominal exchange rate
Explanatory variable	A set of economic fundamentals	A set of economic fundamentals
Econometric method	Single equation, unit root, and cointegration analysis	Single equation, any time-series analysis
Data	One single country's data	One single country's data
Direct theoretic basis	No	No

1. The explained variable can be real or nominal exchange rate, and the exchange rate can be bilateral or multilateral. For example, Zhang (2001), Goh and Kim (2006), and Wang et al. (2007) use the BEER model to calculate bilateral or multilateral real exchange rate; Funke and Rahn (2005) calculate both the equilibrium real effective exchange rate (p.481-484, figures 6 and 8) and the equilibrium nominal bilateral exchange rate (p.483-485, figures 7 and 9). The real exchange rate can be constructed by the relative price of traded to nontraded goods ($E \times P_T^*/P_N$ or $E \times WPI^*/CPI$) or the relative price level of different countries ($P/(E \times P^*)$). For example, Zhang (2001) constructs a bilateral (the US and China) real exchange rate using $E \times WPI^*/CPI$. Funke

and Rahn (2005) and Goh and Kim (2006) both use a trade-weighted real effective exchange rate index, but their construction is different.

2. The explanatory variable is a set of economic fundamentals that are chosen based on relevant economic theory or empirical studies. However, the economic fundamentals used in different studies are shown to be very different. The number of economic fundamentals may range from two to six, and the concrete variables and their proxies may also be different. For example, Zhang (2001) uses investment, government consumption, terms of trade, and the degree of openness; Funke and Rahn (2005) use the productivity levels and net foreign asset position; while Goh and Kim (2006) use government expenditure, the rate of gross fixed capital formation to GDP, capital controls, trade policy, technological progress, and macroeconomic policies.

3. The generalized BEER model uses a single-equation time-series method; a unit root and cointegration analysis, which is an essential component in the classical BEER model, is no longer essential. In the generalized BEER model, any single-equation time-series method, such as an ordinary linear least squares regression, can be used as an alternative choice for a unit root and cointegration analysis. The difference is that when a unit root and cointegration analysis is used, the equilibrium exchange rate is derived from the cointegration relationship; but when another single-equation time-series analysis is used, the equilibrium exchange rate is derived from the corresponding fitted regression equation, which may not be a cointegration one. The generalized dimension allows us to calculate equilibrium exchange rate even when a cointegration relationship does not exist, or when a unit root and cointegration method is not used. Under this dimension, the so-called "extended relative PPP approach" in Wang (2004, p.23-24) and the "(single-country) extended PPP approach" in Dunaway et al. (2006, p.5-6) can both be classified as BEER models, even though they do not consider whether the variables are stationary and cointegrating.

4. Because the single-equation time-series method only uses one single country's data, the equilibrium exchange rate is derived from the country itself. That is, in the (classical or generalized) BEER model, the equilibrium exchange rate, which is derived from the cointegration equation or other fitted regression equation, is decided by the comparison of one country's economic state at some time with that at some other time. The behavior sense implied in the model also stands out from this analysis dimension. The BEER model does not consider other countries at all, so it is very different from the cross-section data model that is used by Frankel (2005) and Chang and Shao (2004) (see Section 7). The cross-section data model used by these authors uses many countries' data and compares the difference between them. So, in appraising a person, the BEER model asks, "After some years, has the person gotten better or worse?" while the cross-section data model asks, "Compared with others, is the person better or worse?"

5. Clark and MacDonald (1998, p.34) say, "More specifically, the BEER approach does not directly involve considerations of internal and external balance, which are identified in the FEER approach as sustainable positions of macroeconomic equilibrium." Égert et al. (2006, p.281) say, "The BEER approach of Clark and MacDonald is not based on any specific exchange rate model." We agree with these authors that there is no direct exchange rate theory for the BEER model. But we cannot say that there is no theoretical basis for the BEER model at all: when choosing the economic fundamentals, the BEER model indeed needs some guidance from relevant economic theories or empirical studies. The Balassa-Samuelson effect, the internal and external balance theory, and other relevant empirical studies are often used in the process of choosing economic fundamentals. The essential thing is that after entering the econometric analysis process, all

relationship between economic fundamentals and their economic theory or empirical study basis is ended, or broken. The equilibrium exchange rate in the BEER model is directly given and decided by the econometric analysis rather than by an economic theory.[4] It is therefore concluded that the BEER model has no direct theoretical basis beyond the indirect theoretical basis for the selection of its economic fundamentals.

3. Different econometric components and results in different studies

In this section, we list some econometric components used in, and results derived by, the BEER models in a number of major studies, to serve as a basis for the analysis in the following sections. Since most journal articles (Zhang, 2001; Funke and Rahn, 2005; Goh and Kim, 2006; Wang et al., 2007) use the classical BEER model to assess the valuation of the RMB, we use this model in our illustrations. The generalized BEER model used by Wang (2004) is also discussed when necessary.

3.1. The different econometric components used in different studies

When using a classical BEER model, three econometric components must be chosen: explanatory variables (economic fundamentals), observations (time periods), and parameter estimation methods. In applied works, the choices for these econometric components are shown to be very different.

First let us examine the choice of explanatory variables (economic fundamentals). Zhang (2001) uses four: investment, government consumption, terms of trade, and degree of openness. Funke and Rahn (2005) use two: productivity levels and net foreign asset position. Goh and Kim (2006) use six: government expenditure, the rate of gross fixed capital formation to GDP, capital controls, trade policy, technological progress, and macroeconomic policies. Finally, Wang et al. (2007) use four: terms of trade, relative price of non-tradable to tradable goods, foreign exchange reserve, and money supply.

Second is the observations or time periods: Zhang (2001) uses the annual data from 1952 to 1997; Goh and Kim (2006) use the annual data from 1978 to 2002; Funke and Rahn (2005) use the quarterly data from 1985:1 to 2002:4; Wang et al. (2007) use the annual data from 1980 to 2004.

Third is the choice of cointegrating parameter estimations. Zhang (2001), Funke and Rahn (2005), and Wang et al. (2007) use the Johansen procedure. However, Goh and Kim (2006) use the Engle-Granger procedure.

The econometric component choice in the generalized BEER model is very similar to that in the classical model. The choice of explanatory variables and observations in the generalized BEER model is completely the same as in the classical model. The only difference is the choice of parameter estimation methods. Since the generalized model does not consider if the (explanatory and explained) variables are stationary and cointegrating, it may use other parameter estimation methods besides the cointegrating parameter estimation method used in the classical model. For example, Wang (2004), in his generalized BEER model, uses a nonlinear least square estimate to derive the values of the parameters.

[4] This is markedly different from the PPP approach, in which the equilibrium exchange rate is decided by macro-economic conditions, rather than mainly relying on an econometric analysis.

3.2. The different results derived from different studies

Because of the different econometric component choices in different studies, we can see that the results derived are also different. The econometric components used and the RMB misalignments derived by four different (classical) BEER models are listed in Table 2.

Table 2

The econometric components used in, and the RMB misalignments derived from, different studies

	Zhang (2001)	Funke and Rahn (2005)	Goh and Kim (2006)	Wang et al. (2007)
Variables	Four	Two	Six	Four
Observations	1952-1997	1985:1-2002:4	1978-2002	1980-2004
Estimations	Johansen	Johansen	Engle-Granger	Johansen
1978	Undervalued		Undervalued	
1979	Undervalued		Undervalued	
1980	Undervalued		Overvalued	Undervalued
1981	Much Undervalued		Undervalued	Undervalued
1982	Overvalued		Equilibrium	Overvalued
1983	Overvalued		Overvalued	Overvalued
1984	Undervalued		Near equilibrium	Overvalued
1985	Much Overvalued		Undervalued	Overvalued
1986	Equilibrium		Much Undervalued	Undervalued
1987	Much Undervalued		Much Undervalued	Undervalued
1988	Undervalued		Much Undervalued	Undervalued
1989	Overvalued		Undervalued	Equilibrium
1990	Undervalued		Equilibrium	Equilibrium
1991	Equilibrium		Equilibrium	Undervalued
1992	Undervalued		Undervalued	Undervalued
1993	Equilibrium		Much Undervalued	Undervalued
1994	Much Undervalued	Over- and Undervalued	Much Undervalued	Undervalued
1995	Undervalued	Over- and Undervalued	Undervalued	Equilibrium
1996	Much Overvalued	Over- and Undervalued	Equilibrium	Overvalued
1997	Equilibrium	Overvalued	Overvalued	Overvalued
1998		Over- and Undervalued	Overvalued	Overvalued
1999		Undervalued	Undervalued	Overvalued
2000		Undervalued	Undervalued	Overvalued
2001		Overvalued	Equilibrium	Overvalued
2002		Over- and Undervalued	Equilibrium	Equilibrium
Range of Misalignment	-400% to 200%	-10% to 5%	-30% to 10%	-5% to 3%

Notes: "Variables" and "Estimations" are the economic fundamentals (of numbers) and cointegrating parameter estimation methods, respectively. The third column uses the current misalignment of Funke and Rahn (2005, p.481, figure 6). The listed RMB misalignments are empirically derived from the relevant studies by the author of the current study.

In Table 2, as Zhang (2001) does not give concrete percentages for the RMB real exchange rate misalignment, we roughly calculate it by using the difference between the actual real exchange rate and its equilibrium value in log form on the basis of his result (figure 1 on p.90). For the others (Funke and Rahn, 2005; Goh and Kim, 2006; Wang et al., 2007), who give concrete percentages for the RMB real exchange rate misalignment, the misalignment and its range can be obtained from relevant figures in the studies. Since the real exchange rates are defined differently in different studies, the positive percentages of RMB misalignment obtained from these studies may represent either over- or undervaluation.

From Table 2 we can see that the results are very different in the four cases. The difference is manifested in two aspects. One is the variation in basic observations of these studies. For example, Zhang (2001), Goh and Kim (2006), and Wang et al. (2007) conclude that the RMB was undervalued, near equilibrium valued, and overvalued, respectively, in 1984. The economists also give different results in 1989. The other is the range of misalignment during the period from 1978 to 2002. Zhang (2001) concludes that the greatest over- and undervaluation of the RMB (in absolute value) is about 400% (in 1996) and 200% (in 1994), respectively. The RMB's misalignment is concluded to be between -10% and 5%, between -30% and 10%, and between -5% and 3% by Funke and Rahn (2005), Goh and Kim (2006), and Wang et al. (2007), respectively.

Given such different results, questions naturally arise. Why do the results differ? Is it due to the variation in choices of econometric components? The answer to the second question is "yes." That is, the different results come from the different econometric component choices of the respective authors, including the explanatory variables (economic fundamentals), observations, and cointegrating parameter estimation methods. This issue will be analyzed in the following section.

4. How does choice of econometric components influence the result?

In this section, the influence of different econometric component choices on BEER model results is simulated, by applying the model to the valuation of the RMB.

4.1. The simulation method

Dunaway et al. (2006) studied the issue of how the econometric choices influence the equilibrium real exchange rate estimates. But for the BEER model, which they term the (single-country) extended PPP approach, they only analyze the sensitivity of the equilibrium real exchange rate estimates to changes in the explanatory variables, and do not analyze the sensitivity of estimate results to changes in the time periods and parameter estimation methods. In this paper we will analyze the sensitivity of the equilibrium real exchange rate estimates to changes in the explanatory variables and in the time periods and parameter estimation methods. In addition, Dunaway et al. (2006) used an out-of-sample forecast to calculate the equilibrium real exchange rate, but we use an in-sample forecast to calculate the equilibrium real exchange rate because most other authors (Zhang, 2001; Wang, 2004; Funke and Rahn, 2005; Goh and Kim, 2006; Wang et al., 2007) use this sort of forecast. Consistent with most authors (Zhang, 2001; Funke and Rahn, 2005; Goh and Kim, 2006; Wang et al., 2007), we simulate the classical model. The conclusions obtained from the classical model can be easily generalized to the generalized model.

Since each of the econometric components (explanatory variables, observations, and parameter estimation methods) can influence the results of the BEER model, each is investigated separately. When investigating one econometric component's influence, the other two are left unchanged. For example, when investigating the influence of explanatory variables, the RMB's valuation is calculated using three, four, and five explanatory variables, whereas the observations and parameter estimation methods are unchanged during the process.

Following the method of the classical BEER models, such as Zhang (2001) and Goh and Kim (2006), the variable space is formulated as:

$$(LNRER, LNGDPP, LNFINVEST, LNGCON, LNOPEN, LNTOT) \quad (4)$$

In Equation (4), LN represents the natural logarithms of the variables. RER is the bilateral China-US real exchange rate. $GDPP$ is real GDP per capital and can be viewed as a proxy for productivity or technological progress. $FINVEST$ is investment represented by gross fixed capital formation, which determines the domestic supply capacity. $GCON$ is government consumption, which captures the effect of fiscal policy. $OPEN$ is degree of openness measured as the ratio of the sum of imports plus exports to GDP and is included to capture the effect of commercial policy. TOT is terms of trade measured as the ratio of Chinese exports to American imports in the U.S. dollar, which is used to represent changes in the international economic environment.[5] A dummy variable will be used in the following econometric analysis, if necessary.

The data for Chinese real exchange rate, real GDP per capital, and degree of openness are taken from the Penn World Tables (PWT), Version 6.2. The real exchange rate uses the price level of gross domestic product, P, defined as the PPP over GDP divided by the nominal exchange rate times 100. Thus, an increase in the real exchange rate implies appreciation of the RMB. The real GDP per capital uses the chain index, RGDPCH. The degree of openness uses the total trade as a percentage of GDP, OPENC, defined as exports plus imports divided by CGDP. (For detailed definitions of the variables, please see the file named append61.pdf at the PWT website.) The data on Chinese exports (F.O.B.) and American imports (C.I.F.) are taken from International Financial Statistics (IFS) Online published by IMF. The data on Chinese gross fixed capital formation and government consumption from 1952 to 1977 are taken form the Scientific Database published by the Institute of Geographical Sciences and Natural Resources Research under the Chinese Academy of Sciences, and the data for the years after 1977 are taken from IFS Online.

As an illustration, we only calculate the RMB's total misalignment, in which the Hodrick-Prescott filter is used. The degree of the total misalignment is measured by the equation "(actual real exchange rate – equilibrium real exchange rate) / equilibrium real exchange rate" that is also used by Frankel (2005). According to the real exchange rate defined above, a value of misalignment less than 0 implies that the RMB is undervalued, whereas a value of misalignment greater than 0 implies that the RMB is overvalued. For example, misalignment=-0.06 means that the RMB is undervalued by 6%, and misalignment=0.08 means that the RMB is overvalued by 8%.

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5 "Terms of trade" is traditionally defined as the ratio of the export price index to the import price index, but this is not available for China. Zhang (2001) uses export growth as the proxy, whereas Goh and Kim (2006) drop it.

This empirical investigation uses the annual data from 1952 to 2004.

The time-series properties of the variables are initially uncovered by the Phillips- Perron unit root tests, which show that each variable is I (1) in each case. The Johansen cointegration test suggests that there are cointegrating vectors among these variables in each case. So the RMB's valuation can be derived in each case. All the econometric proofs in this study are carried out using the Eviews 6.0 software. Some of the typical econometric proofs are provided in the Appendix.

4.2. The influence is simulated

The simulation results of the influence of econometric component choices are listed in Table 3. While investigating the influence of observations, two time periods were used, 1962-2004 and 1952-1994. So the common period is 1962-1994, the results of which are listed, though the time period in the cases of influence of both explanatory variables and parameter estimation methods is 1952-2004.

Table 3

RMB misalignments influenced by different econometric component choices

	Variables change			Observations change		Estimations change	
	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7
Variables	Three	Four	Five	Four	Four	Four	Four
Observations	1952-2004	1952-2004	1952-2004	1962-2004	1952-1994	1952-2004	1952-2004
Estimations	Johansen	Johansen	Johansen	Johansen	Johansen	Johansen	EG
1962	0.195	0.164	0.055	0.277	0.026	0.164	0.127
1963	0.148	0.117	0.022	0.218	-0.008	0.117	0.073
1964	0.170	0.135	0.055	0.226	0.025	0.135	0.070
1965	0.197	0.158	0.093	0.238	0.063	0.158	0.060
1966	0.170	0.126	0.077	0.196	0.045	0.126	-0.012
1967	0.145	0.097	0.064	0.157	0.029	0.097	-0.081
1968	0.123	0.072	0.055	0.123	0.015	0.072	-0.143
1969	0.106	0.054	0.053	0.098	0.006	0.054	-0.189
1970	0.110	0.061	0.074	0.101	0.017	0.061	-0.196
1971	0.072	0.030	0.055	0.068	-0.015	0.030	-0.224
1972	0.147	0.114	0.148	0.153	0.065	0.114	-0.120
1973	0.249	0.224	0.264	0.270	0.172	0.224	0.022
1974	0.177	0.160	0.202	0.216	0.107	0.160	-0.003
1975	0.173	0.158	0.200	0.229	0.113	0.158	0.037
1976	0.063	0.048	0.085	0.138	0.015	0.048	-0.030
1977	0.109	0.091	0.120	0.202	0.077	0.091	0.060
1978	0.218	0.196	0.215	0.330	0.203	0.196	0.213
1979	0.272	0.247	0.256	0.404	0.276	0.247	0.313
1980	0.302	0.277	0.277	0.453	0.325	0.277	0.391
1981	0.161	0.141	0.134	0.330	0.204	0.141	0.297
1982	0.062	0.052	0.044	0.246	0.127	0.052	0.247
1983	0.043	0.049	0.047	0.239	0.132	0.049	0.280

	Variables change			Observations change		Estimations change	
	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7
Variables	Three	Four	Five	Four	Four	Four	Four
Observations	1952-2004	1952-2004	1952-2004	1962-2004	1952-1994	1952-2004	1952-2004
Estimations	Johansen	Johansen	Johansen	Johansen	Johansen	Johansen	EG
1984	-0.102	-0.074	-0.066	0.101	0.014	-0.074	0.190
1985	-0.267	-0.215	-0.192	-0.062	-0.121	-0.215	0.078
1986	-0.394	-0.317	-0.277	-0.193	-0.214	-0.317	-0.002
1987	-0.438	-0.338	-0.279	-0.246	-0.221	-0.338	-0.006
1988	-0.324	-0.203	-0.126	-0.146	-0.067	-0.203	0.137
1989	-0.271	-0.134	-0.041	-0.110	0.026	-0.134	0.205
1990	-0.527	-0.378	-0.272	-0.384	-0.189	-0.378	-0.050
1991	-0.596	-0.441	-0.326	-0.471	-0.218	-0.441	-0.135
1992	-0.535	-0.381	-0.261	-0.429	-0.118	-0.381	-0.109
1993	-0.354	-0.209	-0.089	-0.266	0.100	-0.209	0.021
1994	-0.523	-0.393	-0.278	-0.453	-0.034	-0.393	-0.214

Notes: The values in the table are the RMB misalignments calculated by using relevant econometric components. Values greater or smaller than zero indicate the RMB's over- or undervaluation, respectively. "Three" (explanatory) variables are LNGDPP, LNFINVEST, and LNGCON. "Four" variables are LNGDPP, LNFINVEST, LNGCON, and LNOPEN. "Five" variables are LNGDPP, LNFINVEST, LNGCON, LNOPEN, and LNTOT. "Johansen" and "EG" are the Johansen and Engle-Granger (cointegrating) parameter estimations, respectively.

It can be seen that the influence of (explanatory) variables on the RMB misalignments is great, especially in Cases 1 and 3 and especially from 1987 to 1994. In 1994, for example, the RMB was undervalued by 52.3% in Case 1; undervalued by 39.3% in Case 2; and undervalued by 27.8% in Case 3. The influence of observations is also great. In the 23 years among the total 33 years listed, the RMB misalignments derived from Case 4 are greater or smaller by 10% than those derived from Case 5. In 1962, for example, the RMB was overvalued by 27.7% in Case 4; however, it was overvalued by only 2.6% in Case 5. Similar to the influence of observations, the influence of estimation methods is also great. In 26 years among the total 33 years listed, the RMB misalignments derived from Case 6 are greater or smaller by 10% than those derived from Case 7, and in 14 years the RMB is overvalued (undervalued) according to Case 6 but is undervalued (overvalued) according to Case 7.

If two or three choices among the variables, observations, and parameter estimation methods are different, then great differences can also be expected, such as the RMB misalignments derived from Cases 3 and 7: Case 3 uses five variables and the Johansen (cointegrating) parameter estimation, while Case 7 uses four variables and the Engle-Granger parameter estimation. In 24 years among the total 33 years listed, the RMB's misalignments derived from Case 3 are greater or smaller by 10% than those derived from Case 7.

Therefore, it can be concluded that, at least for China, the result of the BEER model is greatly influenced by the econometric component choice, namely the variables, observations, and parameter estimation methods.[6] If one, two, or three of the choices are different, different results can be expected. The simulation of the application of the BEER model for calculating RMB

[6] The differences in the variables include not only the numbers but also the concrete variables. The influence of (same number but) different concrete variables can be analyzed in a similar way, and is omitted to save space.

misalignment can explain why economists obtain different results as shown in Table 2. In Table 2, the ranges of misalignment derived by Funke and Rahn (2005) and by Wang et al. (2007) are close because their parameter estimation methods are the same, and the observations are also close. Goh and Kim (2006) differ from the other three in parameter estimation method, which is a main cause of the difference between their results and those of the others. Zhang (2001) uses a long period from 1952 to 1997, when the Chinese economic structure and exchange rate regime were both greatly changed, which is a main cause of the difference between his result and those of the others.

5. Is the derived result consistent with economic fact?

Given such varied results by economists in Section 3 and by ourselves in Section 4, a relevant question naturally arises: are the results derived from the various BEER models consistent with economic facts? If a result cannot explain the economic fact reasonably, then it will be of little use for economic and policy analysis and the goal of using the BEER model to assess a currency's valuation cannot be realized.

5.1. Chinese economic facts

In order to analyze if the RMB misalignment derived from the BEER model is consistent with Chinese economic fact, the history of the RMB exchange rate must be known. We only give a simple description of the change in the Chinese exchange rate level here. For other similar descriptions, please see Frankel (2005, p.13-16, p.20-25) and Xu (2000).

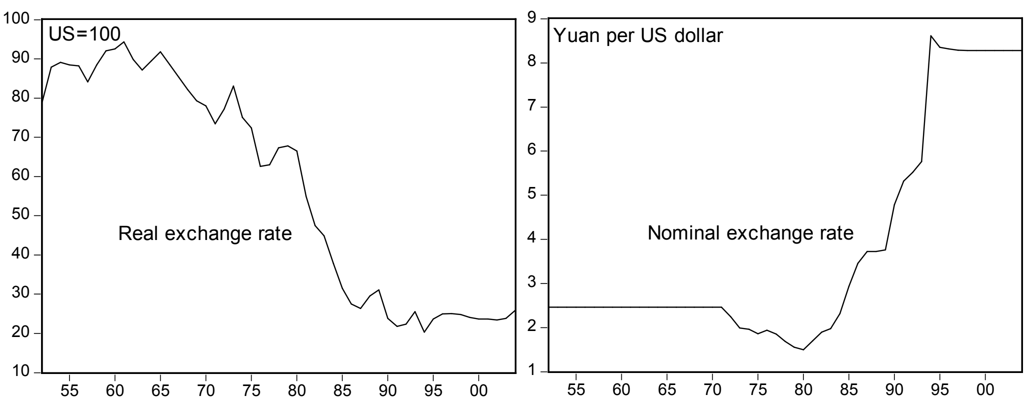

Figure 1. Real and nominal exchange rates of the RMB (1952-2004).

Notes: The real exchange rate is Chinese price level relative to that of the US (US=100) and the nominal exchange rate was a weighted average of the official rate and a parallel rate in its reform period (1978-1994).

Source: Alan Heston, Robert Summers and Bettina Aten, Penn World Table Version 6.2, Center for International Comparisons of Production, Income and Prices at the University of Pennsylvania, September 2006.

Figure 1 shows the concrete changes for the real and nominal exchange rates of the RMB. From 1952 to 1977, the real exchange rate depreciated generally from about 90 to 63, which means that the Chinese price level decreased generally from about 90% of that of the US to 63%. The nominal exchange rate in this period appreciated slightly from 2.5 yuan per US dollar in 1952-1971 to about 2.0 yuan per US dollar in 1972-1977. From 1978 to 1985, the real exchange rate depreciated greatly from 67% of the US level to 32%, and the nominal exchange rate depreciated generally from about 1.7 yuan per US dollar to 2.9 yuan per US dollar. From 1986 to 1994, the real exchange rate depreciated generally from about 30% of the US level to 20%, while the nominal exchange rate depreciated greatly from 3.5 yuan per US dollar to 8.6 yuan per US dollar. From 1995 to 2004, both the real and nominal exchange rates showed little change; the real exchange rate kept at about 25% of the US level, and the nominal exchange rate kept at the level of 8.3 yuan per US dollar.

When combining the two sub-periods, 1978-1985 and 1986-1994, we can reach the following conclusions. The RMB, both in real and nominal terms, was priced (relative to the US) very high in the period of Chinese isolation (1952-1977); it depreciated greatly with the exchange rate reform in the period of Chinese reform and openness (1978-1994); and it was priced very low and changed little from 1995 to 2004 in the period of the fixed exchange rate system.

5.2. The derived result is compared with Chinese economic fact

Though a short-term and small-degree deprecation may not mean that a currency is undervalued, a long-term and high-degree deprecation should be interpreted as a tendency that the currency will change from its original state of being overvalued to being undervalued, or its original degree of undervaluation (overvaluation) will decrease (increase). Whether a result for RMB misalignment is consistent with Chinese economic fact is decided by this criterion, or from this view. Though the real exchange rates used by the economists (Zhang, 2001; Funke and Rahn, 2005; Goh and Kim, 2006; Wang, et al., 2007) are not consistent each other and are not completely same as those we use here, their meanings are generally the same. That is, the real exchange rates are mainly used to measure the RMB's price level differences in different time periods. Therefore the comparison can be made.

If we think that a result for a currency's misalignment may not be precious at each observation and its values at all observations in a period should be treated together, then some results are consistent with economic fact.[7] For example, Zhang (2001, p.90-91) concludes that the real exchange rate of the RMB was overvalued in most years from 1957 to 1977 when it was priced high to be about 60%-90% of the US level, and that it was undervalued (in 12 years) or close to equilibrium (in 4 years) in most years out of the total 20 years from 1978 to 1997 when it depreciated to be mostly 20%-50% of the US level. Other consistent examples can be found in our simulation work in Section 4.2 (Table 3). In Cases 1, 2, and 3, the real exchange rate was consistently overvalued from 1962 to 1983 when it was priced high to be about 45%-90% of the US level, and was consistently undervalued from 1984 to 1994 when it depreciated to be 20%-40% of the US level. Similarly, in Cases 4 and 5, the real exchange rate was almost always overvalued from 1962 to 1984, and was almost always undervalued from 1985 to 1994. But inconsistent examples do exist. For example, according to Wang et al. (2007, p.425, figures 1 and 2), the real exchange rate was always undervalued or near equilibrium from 1986 to 1995 when it was 20%-31% of the US level, but always overvalued from 1996 to 2001 when it was about 25% (roughly the middle value between 20% and 31%) of the US level. Another inconsistent example can be found in our simulation work in Section 4.2. In Case 7 of Table 3, the real exchange rate was consistently undervalued or near equilibrium from 1967 to 1976 when it was priced high to be

[7] We thank an anonymous senior economist for telling us this way to assess a currency misalignment result.

63%-85% of the US level, but was consistently overvalued from 1977 to 1985 when it depreciated to be 32%-68% of the US level.

If, on the other hand, we think that a result for a currency's misalignment should be precious at each observation and that its value at each observation can be treated separately, then the same conclusion just obtained from the last paragraph can be obtained again. That is, there are still some results that are consistent with economic fact and some other results that are not consistent with economic fact. The consistent examples can be also found in our simulation work in Section 4.2 (Table 3). In Cases 1, 2, and 3, the real exchange rate of the RMB was overvalued at each observation from 1962 to 1983 when it was priced high (relative to that of the US), and it was undervalued at each observation from 1984 to 1994 when it was priced low. A similar conclusion can also be found in Case 4. The inconsistent examples can be found in the results obtained by relevant economists (see Table 2 in Section 3.2), because Zhang (2001), Goh and Kim (2006), Wang et al. (2007) all conclude that the real exchange rate was undervalued in some years from 1978 to 1980 when it was highly priced to be about 67% of the US level, and was overvalued in some years from 1995 to 2001 when it depreciated to be about only 25% of the US level. Concretely, Zhang (2001) concludes that the real exchange rate was undervalued from 1978 to 1980 and much overvalued in 1996; Goh and Kim (2006) conclude that the real exchange rate was undervalued in 1978 and 1979 and overvalued in 1997 and 1998; and Wang et al. (2007) conclude that the real exchange rate was undervalued in 1980 and overvalued from 1996 to 2001.

In summary, whichever of the two criteria is used, it seems clear that, for China at least, some results derived from the BEER model are consistent with economic fact, but others are not.

5.3. Possible explanation

From the above sections we know that the results derived from BEER models are not sufficiently satisfying: only some of the results are consistent with economic fact. In other words, it seems to be occasional that a result derived from a BEER model is consistent with economic fact. Why? We conjecture that the inconsistency is, partly or mainly, caused by the unclear relationship between the Chinese exchange rate and its economic fundamentals. From Section 5.1 it can be known that China mainly adopted a fixed exchange rate from 1952 to 2004, because the nominal exchange rate changed little in most of the period (1952-1977 and 1995-2004); it only changed obviously in reform years (1978-1994). Under a fixed exchange rate, the nominal exchange rate, which was fixed and managed by the government, was not affected much by the economic fundamentals; only the price level was affected by the economic fundamentals. As the real exchange rate is made up of the nominal exchange rate and the ratio of the price level between China and the US, and in this equation only the Chinese price level is affected by the economic fundamentals, the real exchange rate, as a whole, may not be obviously affected by the economic fundamentals.

The simple Granger causality tests can, to some extent, prove the not-obvious relationship between the Chinese real exchange rate and its economic fundamentals. The Granger causality between the real exchange rate and its economic fundamentals is listed in Table 4, in which all the variables used are the same as those used in our simulation work in Section 4. It can be seen that, in levels, none of the five economic fundamentals (LNGDPP, LNFINVEST, LNGCON, LNOPEN, and LNTOT) Granger- cause the real exchange rate, while the real exchange rate does

Granger-cause the economic fundamentals, with the LNGDPP and LNTOT at about the 0.10 significance level and the other three fundamentals at the 0.05 significance level. Considering all of the variables to be I (1) and not stationary (see the Appendix A), we also test the causality among them in their first differences in Table 4. In first differences, it can be seen that neither do the economic fundamentals Granger-cause the real exchange rate, nor does the real exchange rate Granger-cause its economic fundamentals. Therefore the weak economic relationship between the Chinese real exchange rate and its economic fundamentals is roughly confirmed.

Table 4

The Granger causality tests for the real exchange rate and its economic fundamentals

Null Hypothesis	In levels		In first differences	
	F-Statistic	Prob.	F-Statistic	Prob.
LNGDPP does not Granger-cause LNRER	0.28	0.76	0.33	0.72
LNRER does not Granger-cause LNGDPP	2.35	0.11	0.52	0.60
LNFINVEST does not Granger-cause LNRER	0.10	0.91	0.21	0.81
LNRER does not Granger-cause LNFINVEST	4.24	0.02	1.09	0.34
LNGCON does not Granger-cause LNRER	0.10	0.91	0.26	0.77
LNRER does not Granger-cause LNGCON	4.57	0.02	0.69	0.51
LNOPEN does not Granger-cause LNRER	1.16	0.32	0.83	0.44
LNRER does not Granger-cause LNOPEN	4.10	0.02	1.13	0.33
LNTOT does not Granger-cause LNRER	1.57	0.22	0.50	0.61
LNRER does not Granger-cause LNTOT	2.42	0.10	0.66	0.52

Note: "LN" represents taking the natural logarithm.

The above discussion can be extended. In theory, the BEER model is more properly used with a flexible exchange rate, in which both the nominal exchange rate and the country's price level (two components of the real exchange rate) are affected by the economic fundamentals. Comparably, it is not suitable for use with a fixed exchange rate, in which the nominal exchange rate is determined by the government and only the country's price level is affected by the economic fundamentals. In this view, it is not recommended that the BEER model be used to assess the valuation of the RMB.

6. Some faults unavoidable in using the BEER model

The BEER model has some advantages which lead to its broad usage. For example, its model construction is simple, it can easily use modern econometric methods, and it can combine relevant economic theory and empirical study to choose economic fundamentals expediently. But it does have some major faults, which cannot be avoided by the model itself. These four main faults are examined next, one by one.

6.1. The appearance in turn of over- and undervaluation

We discuss the current misalignment from a classical BEER model first. From Equation (2) we can see that a currency's current misalignment, cm_t ("$\tau' T_t + \varepsilon_t$"as a whole), is the difference between the actual real exchange rate and its fitted value, and therefore is the residual from

Equation (1). The residual from Equation (1) must be stationary if the cointegration relationship between real exchange rate (q_t) and its economic fundamentals (Z_{1t} and Z_{2t}) holds. The stationary residual means that its negative and positive values lie on two sides around the zero line. In other words, the residual line must cross the zero line once or many times. As a result, positive and negative values must appear in turn. Figure 2 shows such a residual that is derived from our econometric work in Section 4.2 for this use. This property means that the analyzed currency must be over- and undervalued in turn in the whole sample period, no matter what the actual real exchange rate is in the sample period. Furthermore, we cannot obtain a result such that the RMB is all undervalued (or all overvalued) in a whole sample period. The appearance of this phenomenon in the current misalignment from the classical BEER model can be found in Zhang (2001, p.90, figure 1), Funke and Rahn (2005, p.481-483, figures 6 and 7), and Goh and Kim (2006, p.124-125, figures 1 and 2).

Figure 2. A residual from a cointegration equation in the BEER model (1952-2004)

It is necessary to examine possible economic explanations for this phenomenon. In our opinion, there is perhaps no reasonable economic explanation for it at all. Notably, there is no such prior information in the international price level difference model or in the PPP approach, both of which will be discussed in Section 7.

Strictly speaking, it is not sure that the over- and undervaluation must also appear in turn in the total misalignment from a classical BEER model. The reason is that, according to the definition in Equation (3), a filter procedure for the economic fundamentals is used in the total misalignment (tm_t), which causes the total misalignment to be different from the current misalignment and to no longer be the residual from Equation (1). Though over- and undervaluation phenomenon may not appear in the total misalignment, it perhaps often appears because the filtered values (for the economic fundamentals) are roughly equal to the actual ones. In Funke and Rahn (2005, p.484-485, figures 8 and 9) and in Wang et al. (2007, p.425, figures 1 and 2), who both calculate the RMB's total misalignment, we do indeed find the appearance of over- and undervaluation in turn.

Although in the result of the generalized BEER model by Wang (2004, p.24, figure 4.5) we also find the over- and undervaluation phenomenon, the misalignment from the generalized model is not completely similar to that from the classical model. When the economic fundamentals and exchange rate are cointegrating in a generalized BEER model, the (current or total) misalignment is the same as that in a classical model even though a nonstationary time-series method is not used. In this case the appearance in turn of over- and undervaluation can still occur in the current misalignment. But in the case that the economic fundamentals and exchange rate are not cointegrating, the current misalignment may be nonstationary and therefore it is not known if the over- and undervaluation phenomenon appears.

In summary, the phenomenon of in-turn over- and undervaluation must appear in the current misalignment from a classical BEER model, while it may or may not appear in the total misalignment from a classical BEER model and in the misalignment from a generalized BEER model, though it indeed often does.

6.2. The unstable equilibrium relationship

In a BEER model, the equilibrium relationship (the fitted equation) between an actual exchange rate and its economic fundamentals is of primary importance, because the equilibrium exchange rate is obtained from it. But the equilibrium relationship is unstable, which may lead to an unstable and unreliable equilibrium exchange rate.

First, different econometric component (explanatory variable, observation, and parameter estimation method) choices often lead to different equilibrium relationships and therefore different equilibrium exchange rates (see Section 4). For example, in Zhang (2001), the equilibrium relationship and equilibrium exchange rate are decided by four economic fundamentals (investment, government consumption, terms of trade, and degree of openness), a long period from 1952 to 1997, and the Johansen cointegrating parameter estimation; in Funke and Rahn (2005), they are decided by two economic fundamentals (productivity levels and net foreign asset position), a period from the first quarter of 1985 to the fourth quarter of 2002, and the Johansen cointegrating parameter estimation; while in Goh and Kim (2006), they are decided by six economic fundamentals (government expenditure, the rate of gross fixed capital formation to GDP, terms of trade, capital controls, technological progress, and macroeconomic policies), a period from 1978 to 2002, and the Engle-Granger cointegrating parameter estimation. For the various equilibrium relationships and equilibrium exchange rates, we cannot tell which method is better. Since each BEER model may produce such a different equilibrium relationship and equilibrium exchange rate, the equilibrium exchange rate derived is very uncertain.

Second, when used in a developing country like China, the equilibrium relationship between the exchange rate and its economic fundamentals may often change because the economic structure is quickly changing. So an equilibrium relationship that existed in the past may be very different from one that will exist in the future, and the adjustment mechanism cannot play a role. Furthermore, the misalignment obtained by using past data may not be indicative of the currency's future change, and the goal of using the past misalignment to guide the future adjustment of the exchange rate cannot be realized.

6.3. The single-country, time-series analysis method and the theoretic basis

Two other faults are the single-country, time-series analysis method and the theoretic basis, both of which are characteristics of the model and have been analyzed in Section 2.3.

As we know, a traditionally defined exchange rate, the nominal exchange rate or the real exchange rate, is mainly an international comparison concept.[8] Assessing a currency's valuation implies that we want to know whether an exchange rate is priced lower or higher compared with other countries. From this view, the information of other countries relative to the analyzed country must be considered in the model when the model is used to assess a currency's valuation. Because it uses a single-country, time-series analysis method, the BEER model decides whether a currency has equilibrium or not by using data from only one country through a comparison at different times; the equilibrium exchange rate is decided only by the country's economic state, and no information about other countries is considered. Thus, the single-country, time-series dimension of the BEER model seems to be less reasonable than the many-countries, cross-sectional data dimension of the model that is used by Frankel (2005) and by Chang and Shao (2004) (see Section 7).

It is easily seen that lack of a direct theoretical basis is another fault of the BEER model. It has been concluded in Section 2.3 that the BEER model has no direct basis in theory, besides the indirect theoretical basis for the choice of economic fundamentals. In contrast, the PPP approach and the model that is used by Frankel (2005) and by Chang and Shao (2004) have direct theoretical basis.

Should we give up the BEER model and rely on some other model or models, given so many faults in it? We have discussed this issue in another relevant paper.

7. Conclusion

In this paper, the BEER model used in a time-series setting is investigated, via its application to valuation of the Chinese renminbi. The main conclusions are as follows.

Following Égert et al. (2006) and Clark and MacDonald (1998), we classify the BEER model into classical and generalized versions. The classical BEER model is the model that uses a set of economic fundamentals to calculate equilibrium real or nominal exchange rate, in which a single equation, unit root, and cointegration analysis method is used. Most BEER models used in the field of the RMB's valuation are classified as this kind of model. In the generalized BEER model, any time-series analysis method can be used; it is not confined to the use of the unit root and cointegration analysis. Based on these definitions, the extended relative PPP approach (Wang, 2004), the permanent equilibrium exchange rate (PEER) model (Clark and MacDonald, 2004; Funke and Rahn, 2005), and the Edwards-type model (Goh and Kim, 2006) can all be united as the BEER model.

The misalignment results derived by different BEER models are shown to be very different, which is proven to be caused by different econometric component choices. Our simulation for the classical BEER model, which is different from that by Dunaway et al. (2006), shows that different

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[8] Égert et al. (2006, p.260-262) classify real exchange rate into internal real exchange rate and external real exchange rate. Our definition for real exchange rate is the external exchange rate by their terms. They point out that the external real exchange rate is more useful in the analysis of currency valuation.

explanatory variables, observations, and parameter estimation methods may lead to different equilibrium exchange rates.

For the various misalignment results derived from different BEER models, consistency with Chinese economic fact is analyzed. It is shown that some of the misalignment results are consistent with Chinese exchange rate changes, but others are not consistent. This may be, partly or mainly, caused by the unclear relationship between the Chinese exchange rate and its economic fundamentals, which is confirmed by a simple Granger causality test. The fixed exchange rate that China adopted in most sample years may be a deeper cause for this. Furthermore, the BEER model is more properly used in a flexible exchange rate than in a fixed exchange rate; therefore, it is not recommended that the BEER model be used to assess the RMB's valuation.

Finally, there are four main faults that are unavoidable with the BEER model. One is the appearance in turn of over- and undervaluation in the whole sample period. This inevitably happens in the current misalignment from a classical BEER model because of the stationary residual, and often (though not inevitably) happens in the total misalignment from a classical BEER model and in the misalignment from a generalized BEER model. The second fault is the unstable equilibrium relationship (between actual exchange rate and its economic fundamentals) and therefore the unstable equilibrium exchange rate, which may be caused by different econometric component choices and the quickly changing economic structure of a developing country such as China. The third fault is the single-country, time-series analysis method, in which the international comparison dimension demanded by the traditionally defined exchange rate cannot be embodied. The fourth is that the BEER model has no direct theoretical basis besides the indirect basis for its choice of economic fundamentals.

Appendix A. Some econometric proofs

In this appendix, some representative econometric proofs are presented, which are omitted in the text. Other econometric proofs can be obtained by the same method.

Table A.1

Phillips-Perron unit root test for Case 1, Case 2, and Case 3 in Section 4.2

	Test for I(0)		Test for I(1)	
	τ_μ (without trend)	τ_τ (with trend)	τ_μ (without trend)	τ_τ (with trend)
LNREER	-0.30	-2.05	-6.17***	-6.07***
LNGDPP	3.11	-0.77	-4.60***	-5.83***
LNFINVEST	1.80	-1.03	-4.47***	-7.54***
LNGCON	2.19	-1.24	-6.17***	-7.17***
LNOPEN	0.00	-2.31	-6.06***	-5.93***
LNTOT	-0.12	-0.63	-4.74***	-4.82***

Notes: Numbers in the table are the t-statistics for testing the null hypothesis that the variable has a unit root. *** denotes rejection of the null hypothesis at the 1% significance level. The Bartlett kernel and the Newey-West Bandwidth are used.

Table A.2

Johansen (trance) test for Case 2 in Section 4.2

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.
None	0.46	79.62 ***	69.82	0.01
At most 1	0.33	48.03 **	47.86	0.05
At most 2	0.27	27.21	29.80	0.10
At most 3	0.18	10.71	15.49	0.23
At most 4	0.01	0.27	3.84	0.60

Notes: *** (**) denotes rejection of the null hypothesis at the 1% (5%) significance level. “Prob.” gives the p-values by the Eviews 6.0. The lags of the first differenced terms used in the auxiliary regression are selected by the LR, or AIC, or SC. The trend assumption is based on the characters of the variables.

Table A.3

Engel-Granger test for Case 7 in Section 4.2

Cointegrating equation	LNREER=5.93+0.13·LNGDPP-0.16·LNFINVEST+0.44·LNGCON-1.52·LNOPEN Adjusted R-squared=0.96, Durbin-Watson stat=0.63
The unit root test for the residual	D(Resid) = -4.37·Resid(-1) + 3.04·D(Resid(-1)) t-Statistic= -4.37, DW=1.93, 0.05 critical value= -4.15

Notes: “Resid” denotes the residual from the cointegrating equation. “Resid (-1)” denotes the lag of Resid. “D(X)” denotes the first difference of X. 0.05 critical value is from Engle and Yoo (1987, p. 158).

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