Department of Economics

Is the Chinese Currency Substantially Misaligned to Warrant Further Appreciation?

Duo Qin and Xinhua He

Working Paper No. 660 February 2010 ISSN 1473-0278

Queen Mary
University of London

Is the Chinese currency substantially misaligned to warrant further appreciation?

Duo Qin
Department of Economics
Queen Mary, University of London

Xinhua He
Institute of World Economics & Politics
Chinese Academy of Social Sciences

January 2010

Abstract

This study provides quarterly time-series estimates of the misalignment in the REER of the Renminbi (RMB). The estimation is based on a commonly used economic approach, but with a wider and more up-to-date coverage of data and a more extensive use of econometric modelling techniques. Our estimates corroborate and explain most of the previous estimates. More importantly, our estimates demonstrate that there is no significant undervaluation in the REER of the RMB though downward misalignment exists in the trilateral rates between the RMB, US$ and euro. The finding refutes the claim that RMB appreciation is the primary and necessary solution to the current global trade imbalance.

JEL classification: F31; F41

Keywords: real exchange rate misalignment

1. Introduction

The real value of China's currency *renminbi* (RMB) has been a hot topic following the phenomenal expansion of the country's exports over the last decade. Although its nominal rate against US$ has appreciated over 17% since the mid 2005,[1] the belief that the RMB is still substantially undervalued is becoming widely held as political pressure from the US demanding for the RMB appreciation resurges in the wake of the latest economic recession. However, there is no conclusive evidence to show that the RMB is indeed significantly undervalued. Although the majority of empirical studies find the RMB undervalued, the range of estimated degrees of undervaluation is too wide to be credible, spanning from zero to over fifty percent in terms of the real exchange rate (RER) or real effective exchange rate (REER); The figures go even larger when the RMB to US$ bilateral rate is used (see Table 14 in Coudert and Couharde (2005), Table 4.1 in Cline and Williamson (2008) for summaries of the studies during 2000-2007, and Table 1 for a summary of post-2007 studies).

Cline and Williamson (2008) relate the dispersive estimates to different modelling methods. Cheung *et al.* (2009) show that the estimates can change substantially with different data samples and that all their estimates lack statistical significance. The present study attempts to produce more credible estimates of RER misalignments of the RMB by improving on the use of both modelling methods and data. In particular, we follow the common empirical practice of defining the misalignment as deviations from the real equilibrium exchange rate, which is modelled as the long-run solution conditioned upon a set of fundamentals. We focus our attention on how sensitive the estimated misalignment series are to choice of data

[1] On 21st July 2005, China lifted its *de facto* fixed peg of the RMB to the US$ entered into the managed float system.

sample, conditioning variable, model specification and estimation method. Our extensive modelling exercise tells us that there is no significant misalignment in the REER of the RMB: the current global recession has wiped out its possibly undervalued margin during the earlier part of this decade, although possible misalignments remain with the trilateral rate between RMB vis-à-vis the US$ and euro. These findings oppose the assertion that a unilateral appreciation of RMB could resolve the global trade imbalance issue.

Sections 2 to 5 of the paper is organised as follows: our modelling method, data and related measurement issues, the main results, and a summary of the main findings and their policy implication.

2. Methodology

Empirical models of real exchange rate misalignment commonly define it as the gap between the real exchange rate and its long-run equilibrium rate, which is estimated from the relationship between the real rate and a set of fundamentals (eg see Baffes *et al.* 1997). Following the modelling route explored by MacDonald and Ricci (2007), we condition the real equilibrium rate on two fundamentals – productivity differentials and the relative size of net foreign assets. We disregard the relative real interest rate variable because of the significant domestic control on interest rates and capital mobility in China. Due to aggregate data limitation, the factor of productivity differentials is widely approximated by either the relative real per capita income (eg see MacDonald and Dias, 2007; Cheung *et al.* 2009), or the relative ratios of CPI (consumer price index) to PPI (producer price index) (eg see Kakkar and Ogaki, 1999; Funke and Rahn, 2005). Clearly, the measurement gap in employing PPI as the tradable sector price and CPI as the non-tradable sector price is too large to disregard, but on the other hand, the theoretical link between per capita income to productivity

differentials entails stringent equilibrium conditions (eg see Bergstrand, 1991), which are virtually impossible to meet in reality. Considering these shortcomings, we adopt both variables to examine the effect of the variable choice.

Extending the panel model framework of MacDonald and Ricci (2007), we relax the restriction of homogeneous long-run coefficients for all the economies concerned and model the real equilibrium rates of the RMB on a country-by-country basis, ie estimating individually the following bilateral relationship between China and each of its trading partners, *i*:

$$\ln\left(r_{it}^{e}\right) = f\left(X_{it}, \boldsymbol{\beta}_i\right) \qquad i = 1, \cdots, n \tag{1}$$

where r_{it} is CPI-based RER and its increase corresponds to an appreciation of the RMB, r_{it}^{e} denotes the empirical equilibrium rate, X_{it} a set of fundamentals and $\boldsymbol{\beta}_i$ the associated long-run parameter set. Notice that r_{it}^{e} differs from what is theoretically regarded as the equilibrium rate since the observed X_{it} are unlikely to be at the equilibrium state. Specifically, we estimate two versions of model (1):

$$\begin{aligned} \ln\left(r_{it}\right) &= \beta_{10i} + \beta_{11i}\ln\left(GDP_{it}\right) + \beta_{12i}NFA_{it} + u_{1it} \\ \ln\left(r_{it}\right) &= \beta_{20i} + \beta_{21i}\ln\left(RPI_{it}\right) + \beta_{22i}NFA_{it} + u_{2it} \end{aligned} \tag{2}$$

where GDP_i, RPI_i and NFA_i denote the relative real per capita GDP, the relative CPI-PPI ratios, and the relative per capita net foreign assets between China and economy *i*.[2] The Appendix gives the detailed description of the variable definitions.

In order to obtain the long-run coefficient estimates of model (2), two methods are employed – the Johansen cointegration method and the single-equation based dynamic long-run solution, thereafter referred to as the ML method and the OLS method. The first method requires the assumption of *I*(1) nonstationarity and

[2] The relative NFA variable is normally scaled by GDP to adjust for the country size in the literature. We find it more consistent to scale it by population for the model design.

cointegration of all the variables while the second assumes weak exogeneity of X_{it} but not necessarily nonstationarity. To assess the sensitivity of the coefficient estimates of the two conditioning variables, simple regression variants of model (2) are also run, eg dropping the NFA_i variable from (2). Under the standard theoretical setting, $\beta_{11} \geq 0$ and $\beta_{21} \geq 0$ are expected of the Balassa-Samuelson effect. But opposite signs can occur when there is imperfect substitution between tradable and non-tradable goods as well as imperfect competition (eg see Benigno and Theonissen, 2003; MacDonald and Ricci, 2007; MacDonald and Dias, 2007). Likewise, $\beta_{12}, \beta_{22} \geq 0$ are normally expected though the opposite is possible under the situation when sustained foreign direct investment could result in deterioration of a country's NFA position and appreciation of its currency (eg see Burgess *et al.* 2003).

Once estimated, we shall be able to derive the bilateral real rate misalignment series $\{u_{1it}\}$ and $\{u_{2it}\}$ from (2). Notice that we cannot interpret these series as solely RMB's misalignments as they contain the misalignments of the counterparty's currency as well. Misalignment series of the REER of the RMB is obtained by taking the trade-weighted geometric mean:[3]

$$\begin{aligned} m_{1t} &= \exp\left\{\sum_{i=1}^{n} w_{it} u_{1it}\right\} \\ m_{2t} &= \exp\left\{\sum_{i=1}^{n} w_{it} u_{2it}\right\} \end{aligned} \tag{3}$$

where w_{it} denotes the trade weight of country/economy *i* with China in the *n*-economy group. Difference between m_{1t} and m_{2t} reflects the effect of choice of proxy variables for productivity differentials.

[3] We adopt geometric mean instead of arithmetic mean as the former is used by IMF, BIS and many other international organisations.

To examine the effect of heterogeneity, we carry out dynamic panel estimation of the special case of model (2):

$$\begin{aligned} \ln\left(r_{it}\right) &= \beta_{10i} + \beta_{11}\ln\left(GDP_{it}\right) + \beta_{12}NFA_{it} + u_{1it}^{p} \\ \ln\left(r_{it}\right) &= \beta_{20i} + \beta_{21}\ln\left(RPI_{it}\right) + \beta_{22}NFA_{it} + u_{2it}^{p} \end{aligned} \tag{4}$$

Specifically, we use the panel dynamic OLS (DOLS) method developed by Kao *et al* (1999) (see also Kao and Chiang, 2000) to estimate (4), similar to what MacDonald and Ricci (2007) have done. To ensure the validity of the DOLS estimates, panel unit-root tests are carried out prior to the estimation and residual unit-root tests are carried out after the estimation. We also perform the DOLS estimation on model (2), ie relaxing the homogeneity hypothesis of all the theoretical parameters of interest. The resulting two sets of panel estimates allow us to test the homogeneity hypothesis of all the long-run coefficients, ie $\beta_{11i} = \beta_{11}$, $\beta_{12i} = \beta_{12}$, $\beta_{21i} = \beta_{21}$, $\beta_{22i} = \beta_{22}$ for all i. Finally, we use residuals from the panel DOLS estimation to derive a pair of misalignment series of the REER of the RMB, m_{1t}^{p} and m_{2t}^{p}, effectively by the same formula as (3).

3. Data and measurement issues

In order to estimate the bilateral RER models (2), we use quarterly data for the period 1994Q1-2009Q2.[4] Twenty two economies are chosen and they cover roughly 70% of China's total foreign trade. These economies are the highest-ranking trading partners with China. The detailed list is given in tables 2 and 3. One simple way of checking the adequacy of the economy coverage is via the REER. Figure 1 shows the REER series calculated by the trade weights of our twenty-two economy group (denoted by '22-economy base'), along with the REER series from IMF (International Monetary Fund) and BIS (Bank of International Settlement). The proximity of the

[4] The sample ends at 2008Q4 or 2009Q1 for a few countries.

series indicates that our economy coverage provides an adequate proxy for China's REER.[5]

All the real exchange rates are CPI-based; the calculation of NFA_t basically follows Funke and Rahn (2005), ie via adding up the current account balance, a method suggested by Lane and Milesi-Ferretti (2001). For those data series when only annual observations are available, eg the population series, quarterly series are produced through simple interpolation. Since the real GDP series for OECD countries from the IMF source are seasonally smoothed, we carry out seasonal adjustment for China and a few other economies using the X12 seasonal adjustment procedure in Eviews. All the RER series are rescaled by taking 2000Q1 as one. For trade weights, the bilateral-trade weighting method is adopted. We are aware that both IMF and BIS employ the more sophisticated double-weighting method in combination with certain disaggregation of traded goods. Their method has the advantage of accounting for the effect of indirect competition via the third market, which is ignored by the bilateral-trade weighting method, eg see Turner and Van't dack (1993). But their method is too data demanding to update the weights regularly.[6] The relatively lighter data requirement of the bilateral-trade weighting method enables us to keep a quarterly updated weight data set, which we consider to be more important for China. As shown in Figure 1, our REER is remarkably close to those by IMF and IBS in spite of the simpler weighting method and smaller economy coverage of our series.

Since a number of the partner economies suffered from financial crises in the late 1990s, we perform model estimation using the full sample and a sub sample starting from 1999Q1 onwards. The resulting two sets of estimates would allow us to

[5] BIS's REER covers 58 economies and IMF's series covers 185 economies.
[6] BIS adjusts its trade weights every three years (see Klau and Fung, 2006) and and IMF adjusts its trade weights every ten years (see Bayoumi *et a.* 2005).

assess coefficient constancy over the changing samples. In view of the quarterly nature of the data, four lags are used in the long-run estimation.

Now we are faced with a serious task of choosing the misalignment series, since eight sets of different estimation results are obtained per economy for each version of the models in (2): four sets for each choice of sample size, and within the four, two from the two estimation methods of the full model version and the other two for the simple-regression version without the NFA_i variable using the two estimation methods. Several criteria are used for making the choice. Statistical significance of the coefficient estimates is the primary criterion. Moreover, the OLS method is preferred when one or more of the variables fail unit-root tests; the result of the ML method is disregarded when the corresponding long-run matrix decomposition fails to give a negative feedback coefficient.[7] When there is no dominant single set, we take a simple average of the misalignment series from the remaining sets when the series are fairly similar to each other, whereas when they are not, we choose the series which demonstrates the largest downward misalignment to let our results reflect the worst possible case of undervaluation.

As for the panel exercise, panel unit-root tests on each of the four variables confirm nonstationarity. After performing the DOLS estimation with one lead and one lag of the difference variable terms, unit-root tests on the residuals reject nonstationarity. Similar to the economy-by-economy exercise, we exercise the panel estimation on both the full-sample and the sub-sample data, and on simpler versions of model (4) dropping the NFA variable as well. The final choice of the panel

[7] Unit-root tests are carried out for every single time series in our models, but the results are not reported here for brevity. Likewise, the full ML estimation results are not reported, neither the various unit-root tests during the panel estimation.

estimation results is made dominantly on the statistical significance of the long-run coefficient estimates.

4. Empirical results

Tables 2 and 3 report the sets of statistically significant results (at 5%) from the economy-by-economy long-run estimation of models (2). Estimates of intercepts, β_{10i} and β_{20i}, are omitted due to lack of space. The estimates in bold indicate the chosen sets for calculating the bilateral misalignment series, $\{u_{1t}\}$ and $\{u_{2t}\}$. Notice there are a few cases where no significant coefficients are obtained, eg the RPI-based results for Germany and Singapore, but the intercepts are significant in these cases. What is immediately noticeable from the tables is the wide dispersion in the estimates, equation versions and estimator as well as sample choices. This gives us a cautious perspective regarding panel estimation results. Nevertheless, a certain degree of similarity is discernible among the euro countries, and less so among the East Asian economies.[8] Another salient feature when comparing the two tables is the opposite signs of estimated β_{11i} and β_{21i} for a number of economies. Many of estimated β_{11i} are negative (see Table 2), whereas the estimated β_{21i} are dominantly positive (see Table 3). Thailand is the only case of having both estimates negative. Upon a closer inspection, most of the negative β_{11i} estimates are with more advanced economies. This suggests that China, in comparison to those economies, has yet to reach the stage where its faster per capita income growth generates stronger demand for non-tradable goods to result in a rise in its relative price, as expected from standard theory (see Bergstrand, 1991). Under the circumstance, the relative price variable, RPI_i, should be a better proxy for productivity differentials. On balance, the dominantly positive

[8] It may be desirable to aggregate the euro countries into one, but the lack of aggregate price indices has prevented us from doing so.

β_{21i} estimates, along with the positive estimates of both β_{11} and β_{21} from panel estimation (see Table 4), indicate significant Balassa-Samuelson effect. As for the NFA_i variable, it is insignificant in many cases. However, its collinearity with the productivity differential variables is quite strong in a number of cases. Here, the US deserves special attention. A significantly negative effect of NFA_i is estimated from both model versions, indicating that a sustained deterioration of the US external debt position has not prevented its bilateral real rate from appreciation. Notice from Table 2 that the simple regression case is not chosen for the US. This is because the corresponding residuals demonstrate more upward than downward misalignments, while the multiple regression case shows substantial downward misalignments.

Let us now turn to the panel estimation results. After experimenting with various model versions, only the full-sample results yield significant DOLS estimates, see in Table 4. As already mentioned above, the estimates of β_{11} and β_{21} demonstrate significant Balassa-Samuelson effect. Omission of NFA_i does not affect the estimate of β_{11} much but affects β_{21} significantly, indicating relatively high collinearity between $\ln(RPI_i)$ and NFA_i. Although the DOLS coefficient estimates for NFA_i lack statistical significance at the conventional 5%, we have decided to use the version with them when calculating the misalignment series m_{1t}^p and m_{2t}^p, on the consideration of overall fit as well as the economic importance of having the NFA effect. Unsurprisingly, the homogeneity hypothesis is rejected for both equations. Nevertheless, we have carried on calculating the misalignment series. Since the panel method is widely used in previous studies, we intend to facilitate the comparison with our economy-by-economy estimates by using these misalignment series as comparable estimates to the previous studies.

Due to the use of different sample estimates in Tables 2 and 3, we have only calculated the post-1999 misalignment series. Figure 2 plots the percentage ratios of the misalignment series, m_{1t} versus m_{1t}^{p}, and m_{2t} versus m_{2t}^{p} to the 22-economy based REER. There are noticeable differences between the series derived from individual-economy estimation and panel estimation, as well as between the GDP-based version and the RPI-based version. The series from individual-economy estimation are more volatile than those from the panel estimation. While the series from individual-economy estimation exhibits greater tendency of undervaluation than those from the panel estimation in the GDP-based version, the opposite is observed in the RPI-based version though the two curves there bear closer similarity. The particularly large and persistently negative misalignment prior to 2008 found in the GDP-based series agrees broadly with the findings of substantial undervaluation from several studies using relative income as the main explanatory variable for REER (eg Coudert and Couharde, 2005; Frankel, 2005; MacDonald and Dias, 2007; Cheung *et al*. 2009), in spite of the numerous differences among these studies concerning the choice of model specification, data sample and estimation method. Remarkably, the sharp turning of the series into overvaluation since 2008 confirms the finding reported by Cheung *et al.* (2009) that there is a 14.2% overvaluation at 2008Q3 when they apply the cointegration technique to an update data sample.

Since averaging provides a simple and effective way of reducing the uncertainty in model specification, sample window and estimation method is to take an average (eg see Pesaran *et al.* 2008), we plot the average of the four series in the bottom panel of the figure. The series corroborates the finding of no REER undervaluation and possibly some overvaluation at 2003 by Wang (2004). On the whole, our results indicate that evidence of undervaluation of RMB existed during

2003-2007 period up to around 10% of its REER but that the undervaluation has been wiped out by the latest worldwide recession.

Next, we examine the effect of reduced economy-group coverage. In particular, we recalculate the misalignment series by including only the US and the euro countries in the trading partner group. Note that we exclude Japan as we find from both our individual-economy estimates and panel estimates that the relevant residuals exhibit no significant undervaluation. The resulting series are plotted in Figure 3. Interestingly, the evidence of undervaluation is now persistent and substantial, well exceeding 10% since 2003 though significantly reduced by the current recession, as shown from the average curve. In particular, our results corroborate the estimates of around 3-6% undervaluation at 2002 by Funke and Rahn (2005), whose model is RPI-based covering only the US, Japan and the Euroland. Furthermore, our results demonstrate how a narrow choice of the US plus Euroland country base can produce strong evidence of a substantially undervalued RMB. Note, however, it is erroneous to interpret the evidence as such because the misalignment series represent an undervalued RMB vis-à-vis the US$ and euro as much as overvalued US$ and euro vis-à-vis the RMB. Since this small country group accounts now only for roughly one quarter of China's total trade and no significant misalignment of the RMB is found when it is evaluated against the 22-economy group, misalignment found from the trilateral real rates can only indicate imbalance between the three parties concerned rather than a unilateral problem of a single currency – the RMB.

The sharp contrast between the REER misalignment series based on the 22-economy group and the trilateral misalignment series not only tells us how a narrow choice of country coverage can bias the misalignment estimates substantially, but also indicate that the RMB has been slightly overvalued with respect the currencies of the

rest of the twenty two economies, most of which are Asian economies. This suggests that the basket of Asian currencies should have borne the blunt of the ongoing currency undervaluation attack, rather than China's RMB alone.

5. Concluding remarks

The present study provides quarterly time-series estimates of the misalignment in the REER of RMB. The estimation is based on the economic approach widely adopted in the relevant empirical literature, a wider and more up-to-date coverage of data information and a more extensive use of econometric modelling techniques. As a result, we are able to corroborate and explain most of the previous estimates in the literature with our estimated misalignment series.

Our key finding is that there is currently no significant undervaluation in RMB as far as its REER against a wide economy basket is concerned, though downward misalignment still exists in the trilateral real rates between RMB, US$ and euro, as also shown from the summary graph in Figure 4. This finding helps to locate the root of the ongoing claim that RMB is significantly undervalued: a reliance on highly biased evidence, ie taking the US and the Euroland as China's trading base, if not on outdated data evidence. The claim only has political sense but lacks solid economic ground. The argument for the RMB appreciation as the primary and necessary solution to the current global trade imbalance is therefore economically invalid.

Then, what would be an economically feasible solution? An immediate suggestion from our finding is to further decouple the *de facto* peg of the RMB to the US$ and widen as well as enlarge the weights of other currencies in its anchoring basket. However, the suggestion may not be feasible as it would certainly trigger further devaluation of the US$ and appreciation of the RMB following the appreciation of a wide range of currencies due to the US$ devaluation. Considering

the factors (a) the global recession and the appreciation of the RMB since 2005 have effectively corrected the undervalued misalignment in the RMB of the recent years, (b) the degree of real rate imbalance between the US$ and euro versus Asian currencies is more severe than between the US$ and euro versus the RMB, and (c) the current financial system in China is immature for a freely floating currency, it is economically desirable to let the RMB rate remain fixed to maintain its stability, especially before the popular belief of its being undervalued disperses, as suggested by McKinnon and Schnabl (2009). In fact, our findings corroborate their viewpoint that the RMB re-evaluation is not the solution to the trade-led imbalance between China versus the US and the West and that the practical way forward for China lies in the direction of enhancing policies which further encourage outward private investment and channel its foreign currency savings into more diversified assets.

Appendix. Variable definitions and sources

Variable definitions:

r_i : (CPI(China)/CPI$_i$)(e_i /e(China)); e = exchange rate per US$; all r_i series are adjusted to having the 2000Q1 value as one.

GDP_i = (per capita GDP(China)/per capita GDP$_i$)(e_i /e(China))

RPI_i : (CPI(China)/PPI(China))/(CPI$_i$/PPI$_i$); all series are adjusted to having the 2000Q1 value as one.

NFA_i = (per capita NFA(China)/per capita NFA$_i$); NFA is calculated as the historical sum of the balance of payment series

w_i = (China's export$_i$ + China's import$_i$)/(sum of China's exports and imports to all the economies concerned)

Data sources and derivation:

Exchange rates: from Datastream

CPI: China series is updated from the PCI series used in Qin *et al* (2007) using the year-on-year quarterly CPI growth rate from Datastream; Taiwan series is from Datastream; the rest are from IMF International Financial Statistics

PPI: China series is updated from the wholesale price series used in Qin *et al* (2007) using the year-on-year quarterly wholesale price growth rate from Datastream; the rest are 'wholesale prices/producer prices' from Datastream

Population: from Datastream, annual observations interpolated into quarterly series

Balance of Payment: Current account balance in US$ from Datastream; data for Saudi Arabia are annual and used as the end of year observation in the summation for NFA

Exports and imports: all series from China online economic information network http://db.cei.gov.cn/haiguan.htm

GDP in constant value: China data are derived from current value GDP (from Datastream) and GDP deflator calculated from updating the series used in Qin *et al* (2007) by the quarterly GDP growth rates published by the National Bureau of Statistics of China; Brazil and Russian series are derived from their quarterly nominal GDP series and annual GDP deflators, which are interpolated into quarterly series (all raw data from Datastream), India GDP is interpolated from annual series using the weights from quarterly industrial production series (all from Datastream); Saudi Arabia series is interpolated from annual series using the weights from quarterly M1; constant price GNP series is used for the Philippines because of its non-negligible net income receipts from abroad (from Datastream); the rest are from Datastream as 'seasonally adjusted constant price series'; seasonal adjustment is carried out on the GDP series of China, India, Malaysia, the Philippines, Russia, Saudi Arabia, Taiwan.

REER (BIS): from www.bis.org/statistics/eer/index.htm

REER (IMF): from IFS-CDROM Nov. 2009

References

Baffes, J., I.A. Elbadawi and S.A. O'Connell (1997). Single-equation Estimation of the Equilibrium Real Exchange Rate. The World Bank Policy Research Working Paper 1800.

Bayoumi, T., J. Lee and S. Jayanthi (2005). New Rates from New Weights, IMF Working Paper WP/05/99.

Bergstrand, J.H. (1991). Structural Determinants of Real Exchange Rates and National Price Levels: Some Empirical Evidence. *The American Economic Review* 81(1): 325-34.

Benigno, G., and C. Theonissen (2003). Equilibrium Exchange Rates and Supply-side Performance. *The Economic Journal* 113: C103-24.

Burgess, R., S. Fabrizio and Y. Xiao (2003). Competitiveness in the Baltics in the Run-up to EU Accession. IMF Country Report, 03/114.

Cheung, Y.W., M.D. Chinn and E. Fujii (2009). China's Current Account and Exchange Rate. NBER Working Paper 14673.

Cline, W., and J. Williamson, (2008). Estimates of the Equilibrium Exchange Rate of the Renminbi: Is Ehere a Consensus and If Not, Why Not? In M. Goldstein and N. Lardy (eds.), *Debating China's Exchange Rate Policy*, Washington DC, Peterson Institute for International Economics, pp.131-54.

Cline, W., and J. Williamson (2009). 2009 Estimates of Fundamental Equilibrium Exchange Rates. Policy Brief 09-10, Peterson Institute for International Economics.

Coudert, V., and C. Couharde (2005). Real Equilibrium Exchange Rate in China. CEPII Working Paper 2005-01.

Frankel, J.A. (2005). On the Yuan: The Choice Between Adjustment Under a Fixed Exchange Rate and Adjustment Under a Flexible Rate. NBER Working Paper 11274.

Funke, M., and J. Rahn (2005). Just How Undervalued Is the Chinese Renminbi? *World Economy* 28(4): 465-89.

Kakkar, V., and M. Ogaki (1999). Real Exchange Rates and Nontradables: A Relative Price Approach. *Journal of Empirical Finance* 6: 193-215.

Kao, C., M.-H. Chiang and B. Chen (1999). International R&D Spillovers: An Application of Estimation and Inference in Panel Cointegration. *Oxford Bulletin of Economics and Statistics* 61(S1): 693-711.

Kao, C., and M.-H. Chiang (2000). On the Estimation and Inference of a Cointegrated Regression in Panel Data. In B. Baltagi (ed.), *Advances in Econometrics: Nonstationary Panels, Panel Cointegration and Dynamic Panels*, vol. 15, Amsterdam: JAI Press, pp. 179-222.

Klau, M., and S.S. Fung (2006). The New BIS Effective Exchange Rate Indices. *BIS Quarterly Review*, 51-65.

Lane, P.R., and G.M. Milesi-Ferretti (2001). The External Wealth of Nations: Measures of Foreign Assets and Liabilities for Industrial and Developing Countries. *Journal of International Economics* 55(2): 263–94.

MacDonald, R., and D. Dias (2007). Behavioural Equilibrium Exchange Rate Estimates and Implied Exchange Rate Adjustments for Ten Countries. Department of Economics, University of Glasgow, Working Paper 2007-12.

MacDonald, R., and L.A. Ricci (2007). Real Exchange Rates, Imperfect Substitutability, and Imperfect Competition. *Journal of Macroeconomics* 29: 639-64.

McKinnon, R., and G. Schnabl (2009). China's Financial Conundrum and Global Imbalances. BIS Working Paper 277.

Pesaran, M.H., T. Schuermann and L.V. Smith (2008). Forecasting Economic and Financial Variables with Global VARs. CESifo Working Paper 2263.

Qin, D., M.A. Cagas, G. Ducanes, X.-H. He, R. Liu, S.-G. Liu, N. Magtibay-Ramos and P. Quising (2007). A Macroeconometric Model of the Chinese Economy. *Economic Modelling* 24(5): 814-22.

Reisen, H. (2009). On the Renminbi and Economic Convergence. *Vox.EU, 17 December*.

Turner, P., and J. Van't dack (1993). Measuring International Price and Cost Competitiveness. BIS Economic Paper 39.

Wang, T. (2004). Exchange Rate Dynamics. Part 4 in E. Prasad (ed.), *China's Growth and Integration in the World Economy,* IMF Occasional Paper 232, pp. 21-8.

Table 1. Summary of recent studies on the *RMB* misalignment

Study	Is *RMB* undervalued?	Theory & key conditioning factor	Econometrics & data type
Cheung *et al* (2009)	Unsure: (a) yes, 40~50% in 2005-06; (b) not in 2005-06	BEER: real rate conditioned on PPP based and US$ based income	Panel: 168 countries; annual samples (a) 1975-2005 on WB 2006 real GDP data; (b) 1980-2006 on WB 2008 real GDP data
Cline and Williamson (2009)	Yes, over 20%	FEER: real rate on current account balance	Own model simulation using IMF 2009 data
Reisen (2009)	Yes, 12% in 2008	BEER: real rate conditioned on US$ based income	Cross section: 145 countries; 2008

Table 2. Long-run coefficient estimates of the upper equation of (2)

		Simple regression		Multiple regression			
Conditioning variable		**GDP**		**GDP**		**NFA**	
		full sample	sub sample	full sample	sub sample	full sample	sub sample
Japan	OLS	0.1689	0.2580				
	sd	0.0592	0.1016				
	ML	0.1672	**0.2820**				
	sd	0.0486	0.0682				
Korea	ML	**-1.9080**			-15.7500		5.1090
	sd	0.6350			2.4490		0.5858
Taiwan	OLS	0.2649	**0.4261**				
	sd	0.0420	0.1039				
	ML	0.2650	0.4307		0.3915		0.4678
	sd	0.0365	0.0910		0.0524		0.1399
Malaysia	OLS	0.2490					
	sd	0.0350					
	ML	**0.2124**					
	sd	0.0277					
Thailand	ML		**-0.5625**				
	sd		0.1810				
Singapore	OLS			**0.1644**		**-0.7929**	
	sd			0.0720		1.2700	
Philippines	ML			0.3399	**0.3339**	0.0199	**0.0212**
	sd			0.0356	0.0597	0.0063	0.0060
Indonesia	ML		**-0.4036**				
	sd		0.1806				
India	ML			**-0.1972**		**-0.0019**	
	sd			0.1221		0.0007	
Saudi Arabia	OLS	0.1530	**0.3830**				
	sd	0.0550	0.1940				
	ML	0.1140	**0.4808**		0.4061		0.1688
	sd	0.0510	0.1100		0.1376		0.0565
Russia	OLS		**-1.2940**				
	sd		0.5960				
	ML		**-1.6166**				
	sd		0.4758				
Belgium	ML	**-0.3867**	**-0.4912**				
	sd	0.1821	0.2050				
France	OLS	-0.8367	-1.3539				
	sd	0.3864	0.6818				
	ML	**-0.7581**	**-1.1946**				
	sd	0.1816	0.3453				
Germany	ML	**-0.5338**	**-0.9455**	-0.3395	-0.6267	-0.0565	-0.0844
	sd	0.1544	0.3237	0.1220	0.2052	0.0214	0.0191
Italy	OLS	**-0.8545**					
	sd	0.3896					
	ML	-0.7297	-1.1105				
	sd	0.1871	0.3435				
Netherland	OLS	-0.6314	-0.8274				
	sd	0.1837	0.3500				
	ML	**-0.6192**	**-0.9051**				
	sd	0.1277	0.2859				
Spain	OLS	-1.4143	-2.1985				
	sd	0.5654	1.0730				
	ML	**-1.3086**	**-1.9503**				
	sd	0.2566	0.4987				
UK	OLS		**0.5040**				
	sd		0.1803				
	ML	0.5717	**0.3828**				
	sd	0.1460	0.0525				
Canada	OLS	**-1.1466**					
	sd	0.2942					
	ML	-1.1367		-1.5456		0.1642	
	sd	0.1793		0.2894		0.0677	
US	ML		0.9005		**-0.0621**		**-2.3088**
	sd		0.2167		0.0420		0.1440
Australia	OLS	**-1.2710**					
	sd	0.6174					
	ML	-1.1026					
	sd	0.2549					
Brazil	ML			**0.4490**		**0.0741**	
	sd			0.0297		0.0189	

Note: Sub sample starts from 1999Q1; four lags are used in the estimation; sd stands for standard deviation; coefficients in bold indicate the versions chosen for the calculation of $\{u_{1it}\}$.

Table 3. Long-run coefficient estimates of the lower equation of (2)

		Simple regression		Multiple regression			
Conditioning variable		**RPI**		**RPI**		**NFA**	
		full sample	sub sample	full sample	sub sample	full sample	sub sample
Japan	ML		**2.0030**				
	sd		0.6020				
Korea	OLS		**1.8899**				
	sd		0.8660				
Taiwan	OLS		**1.6400**				
	sd		0.6880				
	ML		1.9696				
	sd		0.4770				
Malaysia	OLS		**0.8018**				
	sd		0.6595				
	ML		**0.1304**				
	sd		0.0750				
Thailand	OLS		**-0.8670**				
	sd		0.3611				
	ML		-0.8536				
	sd		0.3427				
Singapore	OLS	**0.3075**					
	sd	0.2400					
Philippines	ML		**0.8042**				
	sd		0.3151				
Indonesia	OLS	1.8223			**1.2130**		**-0.0056**
	sd	0.6189			0.5366		0.0016
	ML	1.7845	2.4292				
	sd	0.5544	1.2455				
India	OLS			3.0615		0.0013	
	sd			1.1580		0.0005	
	ML			**3.1012**	1.3993	**0.0018**	0.0015
	sd			0.7611	0.6619	0.0004	0.0003
Saudi Arabia	OLS			**-1.4504**			**0.1279**
	sd			1.3680			0.0525
Russia	OLS		**0.6405**	0.5014		1.2100	
	sd		0.2677	0.3578		0.5727	
	ML			0.8323	3.7000	1.0390	1.7690
	sd			0.1231	0.7174	0.2670	0.4590
Belgium	OLS				**9.0168**		**-10.2405**
	sd				1.4130		3.0100
	ML			3.3436	**9.6867**	3.0910	**-11.5980**
	sd			1.2880	0.7466	1.0262	1.4066
France	OLS		**4.2592**				
	sd		1.5000				
	ML		**7.0315**	18.5620	4.5067	33.4510	-5.3311
	sd		1.3197	7.6043	0.9051	3.2123	0.7307
Germany	OLS	**2.5177**					
	sd	3.0420					
Italy	OLS		**5.2990**				
	sd		2.3770				
	ML		**3.4534**				
	sd		1.7448				
Netherland	OLS	3.3949	5.3320				
	sd	1.5930	2.5760				
	ML	**1.7378**	**3.3711**		6.7061		-9.0785
	sd	0.9025	1.5495		1.7390		3.0593
Spain	OLS	2.3165	4.1770				
	sd	0.8390	1.2660				
	ML	**1.3806**					
	sd	0.5177					
UK	ML			**0.8928**		**-0.8535**	
	sd			0.3130		0.2771	
Canada	OLS	**1.7424**	1.8704				
	sd	0.4468	0.7555				
	ML	**1.7741**	3.0427	2.5815	2.7456	0.1029	0.0688
	sd	0.3340	0.4316	0.2161	0.1719	0.0175	0.0111
US	OLS	1.8660	2.5558	1.7964		-0.5490	
	sd	0.3256	0.7448	0.3016		0.2685	
	ML	1.5258	3.0471	**1.7922**		**-0.5684**	
	sd	0.2520	0.6349	0.1998		0.0262	
Australia	ML				**16.1130**		**-0.2977**
	sd				5.1551		6.3697
Brazil	ML		**-3.2002**				
	sd		1.1236				

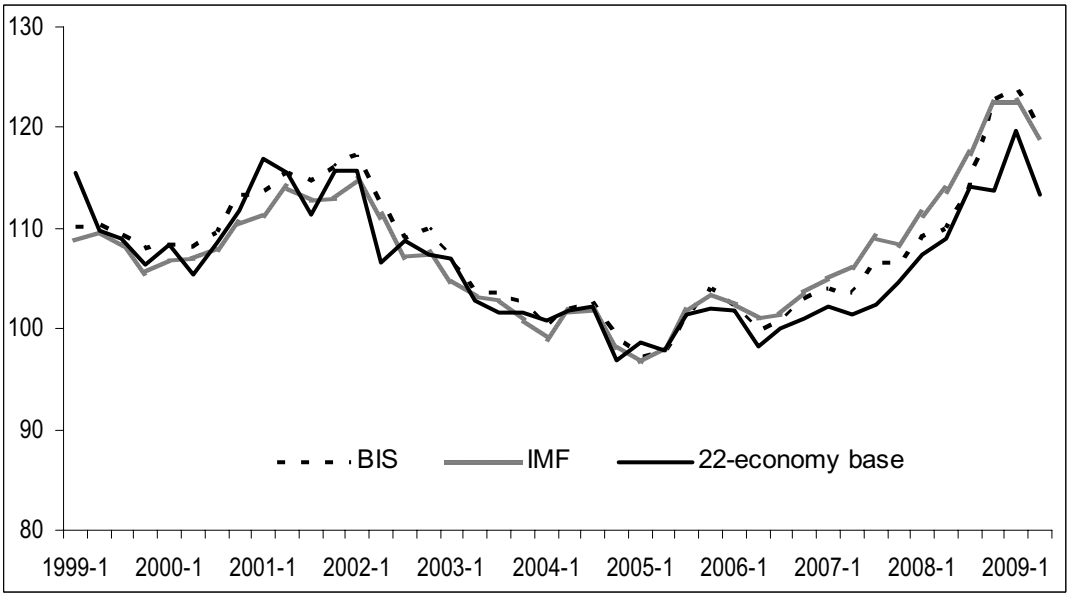
Note: Coefficients in bold indicate the versions chosen for the calculation of $\{u_{2it}\}$. See also the note in Table 2.

Table 4. Panel estimation results

	Upper equation of (4)		Lower equation of (4)	
Conditioning variables	$\ln(GDP_i)$	NFA_i	$\ln(RPI_i)$	NFA_i
DOLS sd	0.1311 0.0094		0.2268 0.0302	
$\overline{R}^2$	0.5451		0.4524	
DOLS sd	**0.1368** 0.0097	**-0.0001** 0.000054	**0.3603** 0.03266	**-0.00009** 0.000006
$\overline{R}^2$	0.5865		0.5049	
Homogeneity tests	H_0: $\beta_{11i} = \beta_{11}$ and $\beta_{12i} = \beta_{12}$ $F(42, 1165) = 18.479$ Critical value at 5% = 1.5		H_0: $\beta_{21i} = \beta_{21}$ and $\beta_{22i} = \beta_{22}$ $F(42,1165) = 11.453$ Critical value at 5% = 1.5	

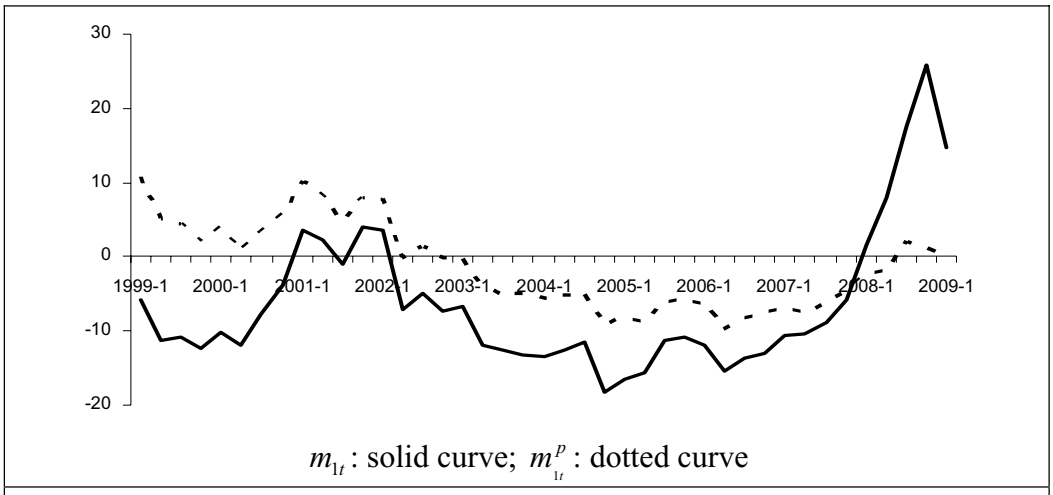
Note: sd stands for standard deviation; coefficients in bold indicate the estimated versions chosen for the calculation of the misalignment series; The *F* test: $F = \frac{(S_2 - S_1)/((n-1)\times 2)}{S_1/(nT-1-n\times 6)}$; where $n = 22$, $T = 59$, S_1 and S_2 are the sum of squared residuals from the unrestricted and restricted regressions respectively.

Figure 1. REER series of the RMB (quarterly)

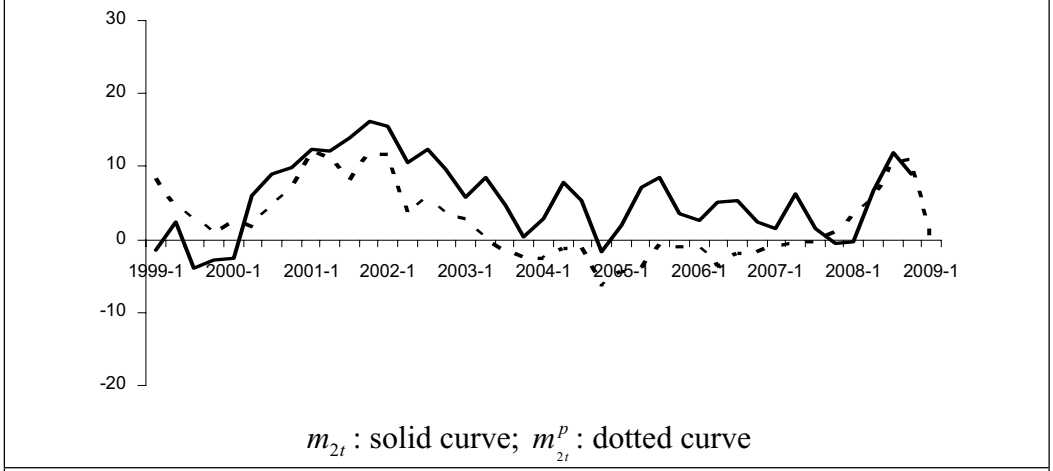


Note: Our series is derived from the simple method of bilateral trade weighting, while BIS and IMF use more complicated weighting methods. See the Appendix for the source of BIS and IMF series.

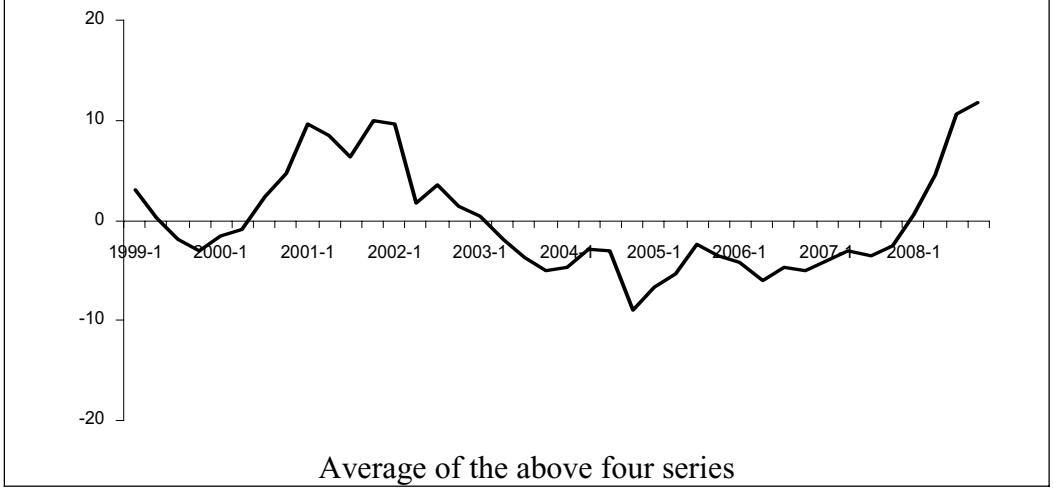
Figure 2. Misalignments as percentage of the 22-economy based REER:



m_{1t} : solid curve; m_{1t}^{p} : dotted curve



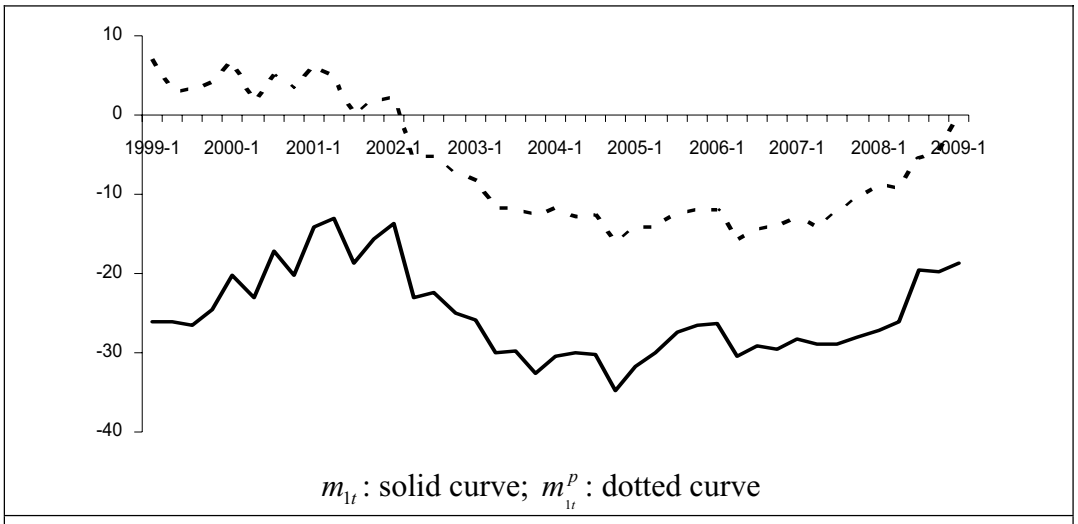
m_{2t} : solid curve; m_{2t}^{p} : dotted curve



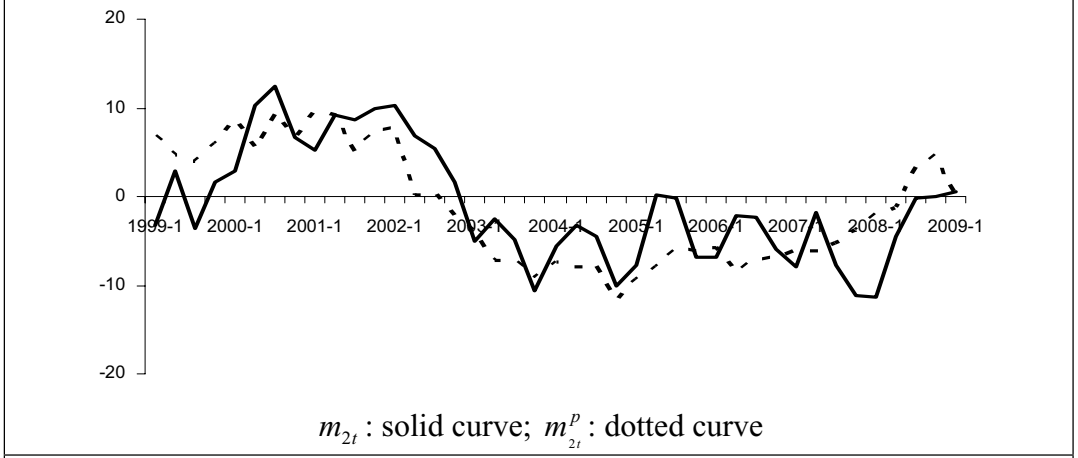
Average of the above four series

Note: negative values indicate undervaluation and appreciation pressure for the RMB.

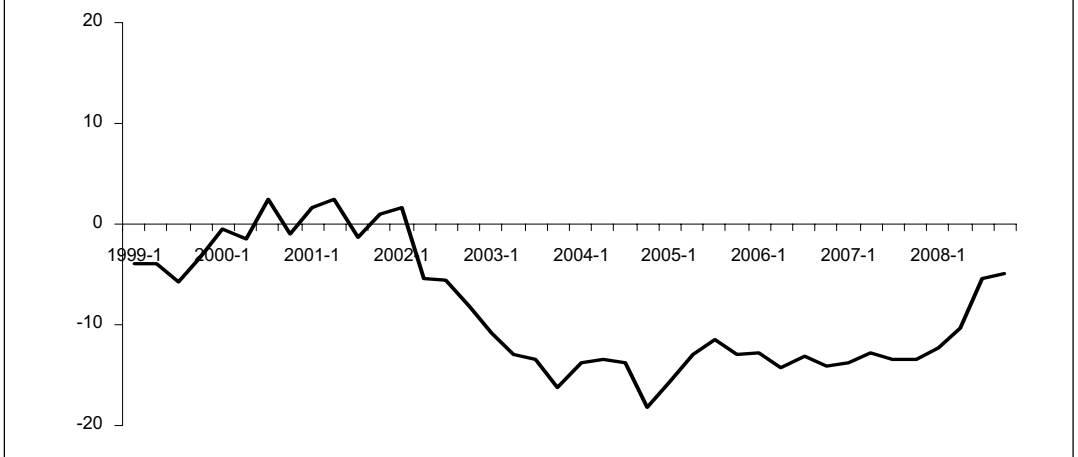
Figure 3. Misalignments as percentage of the US and euro-country based REER:



m_{1t} : solid curve; m_{1t}^{p} : dotted curve



m_{2t} : solid curve; m_{2t}^{p} : dotted curve

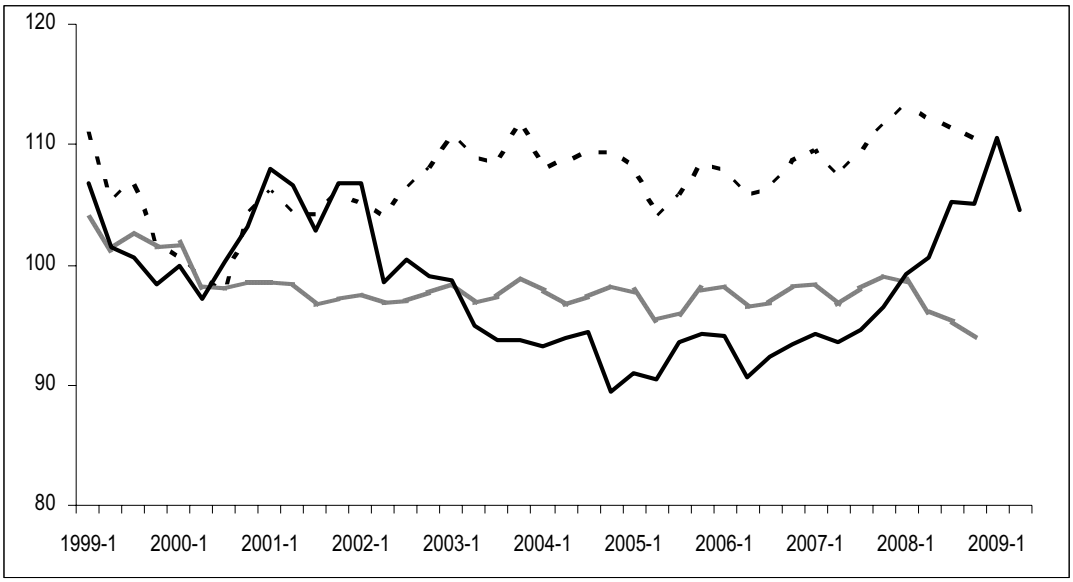


Average of the above four series

Note: negative values indicate undervaluation and appreciation pressure for the RMB.

Figure 4. REER, its long-run equilibrium rates and the trilateral long-run rates

Solid curve: 22-economy base REER; grey curve: long-run equilibrium rate of the22-economy base REER; dotted curve: long-run trilateral rate between RMB, US$ and euro



Note: The long-run equilibrium series is derived from REER minus the misalignment series in the bottom panel of Figure 2; the long-run trilateral series is from REER minus the series in the bottom panel of Figure 3.

This working paper has been produced by
the Department of Economics at
Queen Mary, University of London

Department of Economics
Queen Mary, University of London
Mile End Road
London E1 4NS
Tel: +44 (0)20 7882 5096
Fax: +44 (0)20 8983 3580
Web: www.econ.qmul.ac.uk/papers/wp.htm