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# Renminbi misaligned – Results from meta-regressions



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All opinions expressed are those of the authors and do not necessarily reflect the views of the Bank of Finland.

Iikka Korhonen and Maria Ritola

## Renminbi misaligned - Results from meta-regressions<sup>1</sup>

### Abstract

We collect data from 29 separate papers estimating the equilibrium level and possible undervaluation of the Chinese currency, the renminbi. These papers yield a total of 97 individual observations on misalignment, which we analyse with the help of meta-analysis. We find that the vast majority of observations point to renminbi undervaluation in recent years and that the undervaluation is more pronounced when the US dollar exchange rate is used instead of the real effective exchange rate. We find several characteristics of papers and authors that clearly seem to influence the reported misalignments. For example, when the author is affiliated with an investment bank, the reported misalignment is smaller. Using time-series techniques also results in lower estimates of undervaluation. On the other hand, refereed journals seemingly are inclined to publish papers that report larger misalignments. Results caution against trusting too much in any one study concerning renminbi undervaluation.

Key words: equilibrium exchange rate, exchange rate misalignment, meta-analysis, China

JEL codes: C82, F31

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likka Korhonen and Maria Ritola

## Renminbi misaligned - Results from meta-regressions

### Tiivistelmä

Tässä keskustelualoitteessa tutkitaan Kiinan rahan, juan renminbin, mahdollista aliarvostusta käytämällä aineistona 29:ää aiheesta tehtyä tutkimusta. Tutkimuksissa raportoidaan yhteensä 97 arviota, jotka koskevat valuutan poikkeamista tasapainoarvostaan. Näitä arvioita käsitellään tässä työssä meta-analyysin keinoin. Suurimmassa osassa tutkimuksia juan renminbin arvioidaan olevan aliarvostettu. Aliarvostus on merkittävämpää, jos tutkimuksessa on käytetty juan renminbin valuuttakurssia suhteessa Yhdysvaltain dollariin. Useat tutkimukseen ja tutkijoihin liittyvät tekijät näyttävät selittävän merkittävän osan valuutan raportoidusta aliarvostuksesta. Esimerkiksi investointipankeissa tehdyissä tutkimuksissa juan renminbin aliarvostusta pidetään pienempää. Myös aikasarjamenetelmien käyttö johtaa siihen, että aliarvostuksien raportoidaan olevan pienempiä. Toisaalta vertaisarvioituissa tieteellisissä aikakauslehdissä julkaistaan tutkimuksia, joiden mukaan aliarvostukset ovat suurempia. Tämän työn tulosten perusteella yksittäisten tutkimusten tuloksiin Kiinan valuutan aliarvostuksesta kannattaa suhtautua varovaisesti.

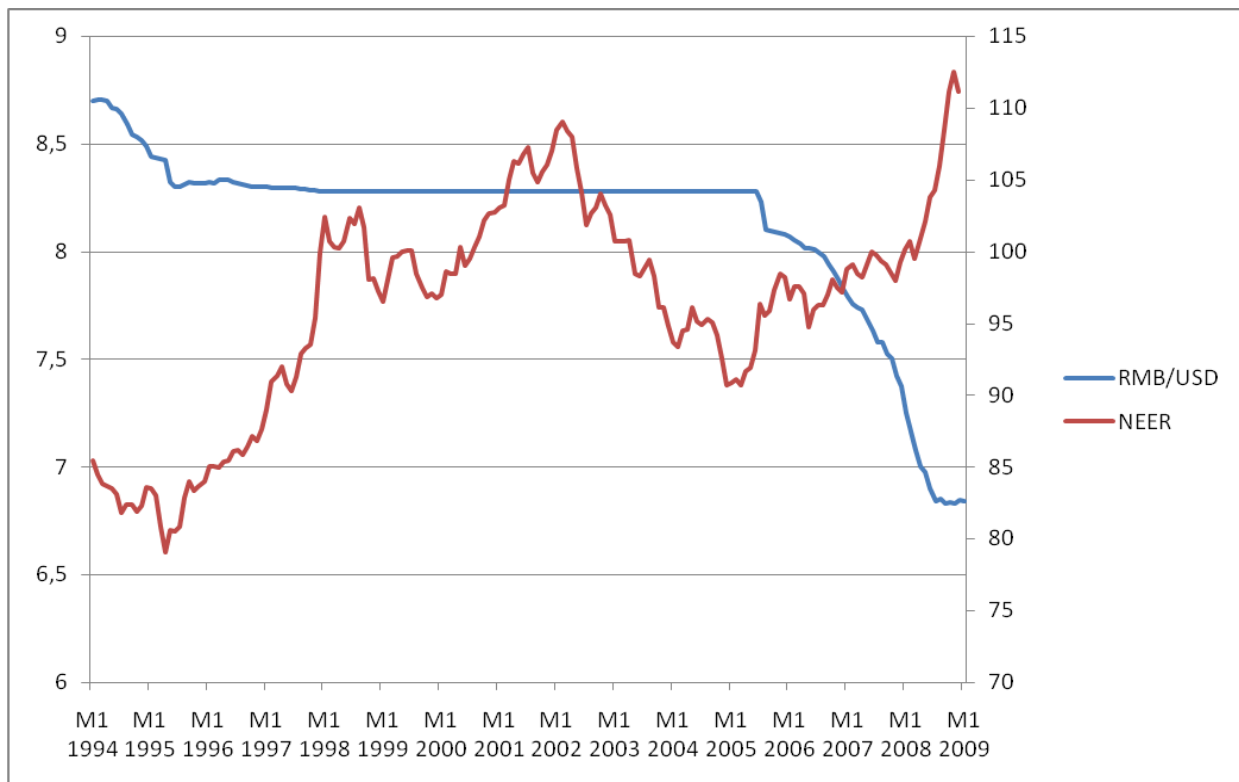
Asiasanat: tasapainovaluuttakurssi, valuuttakurssin poikkeaminen tasapainoarvostaan, meta-analyysi, Kiina

# 1 Introduction

In this paper we assess the degree of potential misalignment of the Chinese currency, the renminbi, vis-à-vis its equilibrium value. We analyze the issue with the help of meta-analysis. The possible undervaluation of the Chinese currency and the resulting trade surplus have evoked considerable attention in the recent years, and as the Chinese exports have continued to increase, the discussion has become more heated. In 2008 China's trade surplus was \$296bn, or approximately seven per cent of GDP. At the same time, the US has experienced record-high current account deficits, which has led to calls for political action against China, while some commentators claim China is "unfairly manipulating" its real exchange rate.

Throughout recent decades China's exchange rate policy has been oriented towards the US dollar. The year 1994 marked a significant change in China's exchange rate policy, as China unified the various exchange rates still in use, and devalued the official rate. From 1994 to July 2005, the official rate of the renminbi against the US dollar was kept very stable, despite e.g. pressures caused by the Asian exchange rate crisis of the late 90s. In July 2005 the renminbi was revalued slightly against the US dollar, and from that time on until September 2008 it depreciated constantly against the US dollar. However, the Chinese authorities have always wanted to maintain stability also in the foreign exchange markets, and that is the reason that month-to-month movements in the exchange rate have been relatively small. As the trade balance has been in surplus and there have also been sizeable capital flows into China, this policy of gradual appreciation has meant that the currency reserves have increased. Figure 1 depicts the evolution of the renminbi exchange rate against the US dollar (left vertical axis) and China's nominal effective exchange rate (right vertical axis). It should be noted that for the bilateral exchange rate downward movement signifies appreciation, whereas for the nominal effective exchange rate upward movement means appreciation. We can see that in recent times the effective exchange rate has appreciated both because the renminbi has appreciated against the US dollar and because the US dollar has appreciated against other currencies.

Figure 1 Evolution of RMB/USD and China's nominal effective exchange rate, 1994-2009



Naturally, China's tremendous growth performance and large current account surplus have sparked a large body of literature on the determinants of China's real exchange rate. Early attempts to estimate the degree of renminbi undervaluation include Chou and Shih (1998) as well as Zhang (2001). Chou and Shih look at the renminbi's equilibrium exchange rate between 1978 and 1994, and conclude that the renminbi was undervalued between 1990 and 1994. However, the degree of undervaluation was relatively modest, less than ten per cent. Zhang (2001) uses annual data to look at exchange rate misalignment between 1952 and 1997. According to the paper, the renminbi was undervalued in 12 of the 20 years between 1978 and 1997; in four of those years, the exchange rate was very close to its equilibrium value. These two early papers already established the central result of our paper: during the past decade or decade-and-a-half, the renminbi appears to have been undervalued.

In our meta-analysis we use data from 29 research papers estimating the extent of real exchange rate misalignment. These papers give us 97 different estimates of the misalignment; although it should be mentioned that most of the papers present only one estimate, while some give several. We take this difference into account in our empirical analysis. We use the well-known techniques associated with meta-analysis, namely relating the reported misalignment (in percent) to



the attributes of the paper and author(s) in question. These attributes range from the underlying theoretical framework and data frequency to authors' affiliations. As mentioned above, practically all the papers report undervaluation of the renminbi at the end of the data period, but we are also able to ascertain that several attributes of the papers themselves do influence the results. It seems clear that studies using the USD-based exchange rate - instead of the real effective exchange rate - tend to report more pronounced undervaluation. The affiliation of authors also has an effect. If one of the writers works in an investment bank or similar institution, the paper is more likely to report smaller undervaluation. Journals tend to publish papers with larger reported misalignments, indicating a possible publication bias. Reporting these effects is one of the main contributions of this paper.

The paper is structured as follows. In the next section we present a brief literature survey, relating to both meta-analysis and China's equilibrium exchange rate. In the third section we describe the data, and the fourth section presents the empirical results. The fifth section concludes.

## 2 Literature survey

There are several survey articles concerning the computation of equilibrium exchange rates. In developing countries the situation is somewhat more complicated, and more factors need to be taken into account. Hinkle and Montiel (1999) present a fairly comprehensive overview of factors potentially affecting equilibrium exchange rates in developing and emerging market countries and discuss the related empirical research. For our purposes, it suffices to note a few things. As a country's standard of living rises, its real exchange rate is expected to appreciate, *ceteris paribus* - the Balassa-Samuelson effect. Moreover, the higher an economy's public consumption, the stronger its real exchange rate is expected to be. This obtains because public expenditures are generally oriented more towards non-tradable goods, and excess demand for them raises their prices, which is equivalent to a stronger real exchange rate. And, a country with more foreign debt needs a weaker real exchange rate, as it must export more to service its foreign debt, as explained by Lane and Milesi-Ferretti (2004).

## 2.1 Equilibrium exchange rate of the renminbi

A fairly recent overview of the literature dealing with the equilibrium exchange rate of the renminbi can be found in Cline and Williamson (2008), which assesses results from 18 papers dealing with the topic. The common finding is that the Chinese currency has been undervalued relative to its equilibrium value, although the estimated degree of undervaluation differs significantly from one paper to another. The average undervaluation using the real effective exchange rate (REER) is 19% for the whole sample, and it reaches 40% when measured by the bilateral real exchange rate between the US and China. Papers published between 2005 and 2007 report an average undervaluation of 27% for REER and 38% for the bilateral USD exchange rate. Cline and Williamson also differentiate between papers utilizing the different theoretical frameworks. In the discussion they differentiate among papers according to the theoretical background, whether purchasing power parity (or a variant), behavioral equilibrium exchange rate (BEER) or fundamental equilibrium exchange rate (FEER). For example, they find that the number and nature of right-hand variables differ significantly from one BEER study to another.

As mentioned in the introduction, we found 29 papers of fairly recent vintage that estimate, in one way or another, the equilibrium exchange rate of the Chinese renminbi and hence its misalignment from that equilibrium value. We chose to use only papers published before the end of 2008 in our sample, to provide a clear cut-off date. These 29 papers give us 97 different observations for the renminbi misalignment. It should be noted that most papers report just one value for the equilibrium exchange rate, although Frait and Komárek (2008) report 24 individual misalignment observations. Table 1 reports the papers used in the study and many of their salient characteristics. Here we merely highlight some studies with different theoretical underpinnings.

Bénassy-Quere et al. (2004, 2006, 2008) have published several estimates of the renminbi's equilibrium exchange rate, all based on the BEER methodology. In the first paper they use annual data between 1980 and 2001 to calculate equilibrium exchange rates for the G-20 countries. In this paper the real effective exchange rate is influenced by a country's net foreign asset position (NFA) and the ratio of consumer prices to producer prices. The latter variable is intended to capture the Balassa-Samuelson effect, and is used in many BEER studies. Negative NFA (net liabilities vis-à-vis the rest of the world) tends to lead to a weaker real exchange rate. In order to service its foreign debt, a country must export more, and this is achieved through a weaker exchange rate. Misalignment of the renminbi ranges from 16% to 44%. Bénassy-Quere et al. (2006) use quarterly data for 15 countries between 1980 and 2004, and again the real exchange rate is a function of NFA and the

ratio of consumer prices to producer prices. They find that undervaluation actually ranges from about 30% to almost 60%. Bénassy-Quere et al. (2008) use annual data, but they expand the list of right-hand variables in explaining real-exchange-rate developments. In addition to NFA and the ratio of consumer to producer prices mentioned earlier, they use the ratio of service prices to prices in the agricultural and industrial sectors, GDP per capita, GDP per employed person, terms of trade and interest rate differentials. In this framework the undervaluation estimates cluster around 30%.

Goldstein (2004) analyses renminbi undervaluation starting with the "underlying balance" approach, where the equilibrium current account position is equal to capital flows, so that there are no changes in the foreign currency reserves. He uses the average capital account surplus over 1999-2002 and calculates the necessary exchange rate adjustment for generating a current account deficit of similar magnitude. This approach results in renminbi undervaluation of between 15 and 30 per cent (a fairly wide range). Coudert and Couharde (2005) start with a similar basic premise, but they utilize the NIGEM model of the international economy, which produces misalignments of the selected economic blocks as functions of their output gaps and deviations from medium-term current account balance (not necessarily zero, as some countries are net importers of capital and some are net exporters). These calculations arrive at fairly large undervaluation of the renminbi in 2003: 30% for the REER and 54% for the real USD exchange rate.

Although published after our end-2008 cut-off, we should note Cheung et al. (2009), who analyse the renminbi's potential misalignment on the basis of purchasing power parity. They start from the well-known discovery that deviations from absolute purchasing power parity are correlated with income level. Hence they regress observations of real USD exchange rate for 160 countries between 1975 and 2005 on the real per capita income (relative to the US figure). The results imply that the elasticity of the real exchange rate with respect to per capita income is between 0.3 and 0.4. The renminbi is found to be undervalued by some 40% at the end of the sample period. However, when the same exercise is performed with more recent (and presumably more accurate) data, renminbi undervaluation almost disappears completely. This result underscores the sensitivity to the underlying data of empirical research on the equilibrium exchange rate.

The main point here is that, irrespective of the countries in the panel estimation, the exact estimation methodology and so on, in the recent years the Chinese renminbi is always found to be undervalued relative to its equilibrium value.

Table 1 Summary of analysed studies

Author	Year	Method	Frequency	Data dimension	Construction of real exchange rate
Anderson (2006)	2006	FEER	yearly	cross-section	REER
Bénassy-Quéré et al (2004)	2004	BEER	yearly	panel	REER, RER_USD
Bénassy-Quéré et al (2006)	2006	BEER	quarterly	panel	REER, RER_USD
Bénassy-Quéré et al (2008)	2008	BEER	yearly	panel	REER
Chen (2007)	2007	BEER, PEER	quarterly	time series	REER
Cheung et al (2008)	2008	BEER	yearly	panel	RER_USD
Cline (2005)	2005	FEER	yearly	cross-section	REER, RER_USD
Cline (2007)	2007	FEER	yearly	cross-section	RER_USD
Coudert & Couharde (2005)	2005	FEER	quarterly	panel	REER, RER_USD
Frait & Komárek (2008)	2008	FEER (debt adjusted)	yearly	time series	RER_USD, RER_YEN REER,
Funke & Rahn (2005)	2005	BEER, PEER	quarterly	panel	Nominal_ER_USD
Goh & Kim (2006)	2006	BEER	yearly	time series	REER
Goldstein & Lardy (2006)	2006	FEER	yearly	time series	REER
Goldstein & Lardy (2007)	2007	FEER	yearly	cross-section	REER
Goldstein & Lardy (2004)	2004	FEER	yearly	cross-section	REER
Jeong & Mazier (2003)	2003	FEER	yearly	panel	REER, RER_USD
Ma (2000)	2000	BEER	quarterly	time series	REER
MacDonald & Dias (2007)	2007	PEER	quarterly	panel	REER
Peng et al (2008)	2008	PEER	quarterly	time series	Nominal_ER_USD
Stolper & Fuentes (2007)	2007	BEER	yearly	panel	RER_USD
Tyers et al (2008)	2008	FEER	yearly	time series	REER
Wang (2004)	2004	BEER, FEER	yearly	time series	REER
Wang et al (2007)	2007	BEER	yearly	time series	REER
Wren-Lewis (2004)	2004	FEER	yearly	cross-section	RER_USD
Zhang, X. (2002)	2002	BEER	quarterly	time series	REER
Zhang, Z. (2001)	2001	BEER	yearly	time series	RER_USD
Zhao & Kanamori (2005)	2005	BEER	yearly	time series	NEER

## 2.2 Meta-analysis

Meta-analysis has a long history e.g. in medicine, but in recent years it has gained popularity also in economics. Meta-analysis is a way to statistically summarise and aggregate research results on a given topic. For example, Knell and Stix (2005) look at reported income elasticities of money demand in a number of studies. Meta-regression analysis is a technique for examining a series of publications and presentations. By explaining differences among empirical estimates, it can identify the extent to which research choices involving such things as data dimension, theoretical assumptions and operational aspects can affect estimation results. Ultimately we are of course interested in getting the most reliable estimates for the phenomenon in question, so that analysing numerous studies on the same topic is more likely to produce a “truer” picture.

Stanley (2001) identified different stages involved in conducting meta-regressions. At first, all the relevant studies are collected in a non-discriminatory manner in order to prevent any distortions from publication selection. Second, the resulting sample is specified in terms of dependent and independent variables. In the present case, the dependent variable captures the difference between estimated equilibrium exchange rate and observed real exchange rate. The independent variables are dummy variables representing theoretical background, data dimension, author affiliations, construction of variables and possible publication bias, among other things. After the tracking down and coding of relevant factors from the research papers is completed, one can run the actual meta-regressions.

Our present study is close to Égert and Halpern (2006), who conduct a meta-analysis of papers dealing with the equilibrium exchange rates in the Central and Eastern European countries. They find that the theoretical framework and definition of the real exchange rate significantly affect the reported equilibrium exchange rates. For example, estimates based on the behavioural equilibrium exchange rate (BEER) yield consistently smaller misalignment estimates, as does using dollar wages as a proxy for the real exchange rate. Of course, they looked at studies of ten countries, whereas we assess research concentrating on a single country. A recent paper by Bineau (2009) conducts meta-regression analysis on a number of papers reporting on the renminbi’s equilibrium exchange rate. He uses the real USD exchange rate and time-series techniques and finds wider misalignments. However, our contribution differs from that paper in a number of ways. First, we use considerably more papers in our sample. Second, we use a greater variety of control variables in

looking at the factors affecting the estimated equilibrium exchange rates. For example, we control for authors' affiliations as well as the publication dates of the studies.

### 3 Description of the data

In this study we take into account all available estimates of China's real exchange rate misalignment published between the years 1998 and 2008, in order to avoid any biases arising from selecting the publications. Some of the research papers provide estimation results for misalignments based on several methods. We include all the presented results of each paper in our estimations in accordance with Égert and Halpern (2006). Therefore the dataset that covers 29 research papers provides us with a total of 97 observations for real misalignments. If there are several versions of the paper, we take the most recent one, which is often a journal publication. Table 2 gives some descriptive statistics.

Table 2 Summary statistics for reported real misalignments

<b>Summary of misalignments</b>		
	1998-2007	2004-2007
No. of observations	97	72
Mean	18	17
Median	12	12
Max	67	64
Min	-10	-10
Standard deviation	19	18
Overvalued	8.2 %	5.6 %
Undervalued	79.4 %	76.4 %
Fairly valued	12.4 %	18.1 %
<b>Total</b>	<b>100.0 %</b>	<b>100.0 %</b>

The sample length and number of countries included vary considerably across the studies. Roughly 42 % and 18 % of estimations are carried out by time series and cross-section data techniques, respectively. The important distinction is that the time-series papers typically concentrate on one country; and, because of the nature of the regression analysis, the real exchange rate is observed to oscillate around its equilibrium value. In the cross-section analysis this is not the case, of course.

Applying panel techniques adds power to the statistical tests. In some previous meta-regressions panel studies were often further divided in two categories, in-sample and out-of-sample

(see e.g. Hovárth & Komárek, 2006). In in-sample estimations the country of interest is included in the panel estimation, and the equilibrium exchange rate is calculated in a straightforward manner. In out-of-sample estimations the country of interest is excluded from the estimation sample, but the coefficients derived from the estimation and the data for the country are used to calculate its equilibrium exchange rate. The implicit assumption is that the countries in the estimation sample are in some way comparable to the country of interest. The panel studies collected for our study fall into the in-sample category, but vary greatly in the number of countries included. Most of the panels were formulated on the grounds of countries' economic importance. A small number of papers include nearly the whole world in the estimations.

As mentioned above, the dependent variable represents the misalignment between estimated equilibrium exchange rate and observed real exchange rate in per cent. In the studies where the misalignment range is provided, the mean is presented as the misalignment.<sup>2</sup> Over 43 % of estimations for real misalignment are based on real effective exchange rates (REER), and the others use bilateral real exchange rates against a particular currency, most often the US dollar. In calculating real exchange rates, the majority of the papers employ consumer price indices (CPI), while producer price indices (PPI) and GDP deflators are used less frequently. In our sample almost 90 % of all observations are based on CPI figures, and so we do not control for construction of the real exchange rate variable.

Around 75 % of the observations represent real misalignment for the years 2004–2007. Therefore, these more recent results dominate our estimations. Summary statistics or real misalignments are provided in Table 2, for both the whole sample and for the period 2004–2007. The table shows that most of the real misalignments are undervaluations (nearly 80 % of estimations for the whole sample). Furthermore, the reported real misalignments range from 67 % (undervaluation) to 10 % (overvaluation). To obtain a better understanding of trends in the data, we also show the evolution of the estimated misalignments in Figures 2 and 3, for REER and for the real USD exchange rate, respectively. Observations for each year represent the studies with data sample ending in that year. The line shows the evolution of average misalignment over the years, and the vertical lines denote the maximum and minimum misalignments reported for a given year. First, we can easily see that misalignment is much larger for the USD-based real exchange rate. However, there has been a downward trend in the USD-based misalignment estimates, whereas no such trend is visible in the REER estimates. Also, it is clear that even within a year estimates can vary substantially. For

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<sup>2</sup> The variable is defined so that a positive misalignment signifies undervaluation.

example, in 2004 the REER-based undervaluation estimates ranged from zero to over 60%. These wide ranges also caution against relying too much on any one estimate.

Figure 2 Evolution of reported renminbi misalignment (REER), 2000-2007

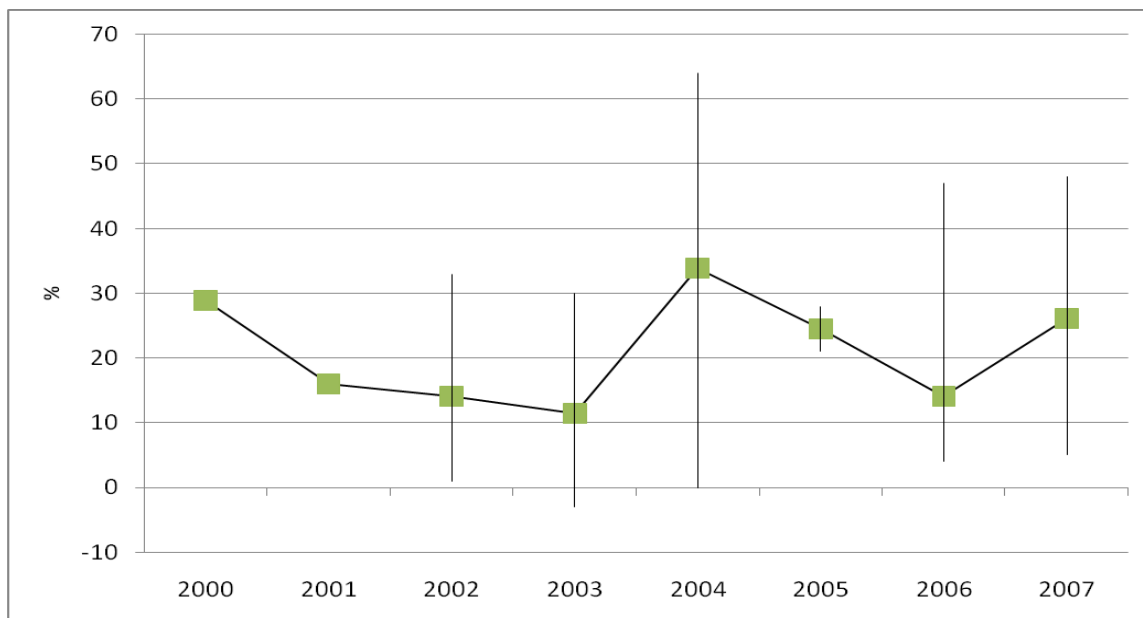
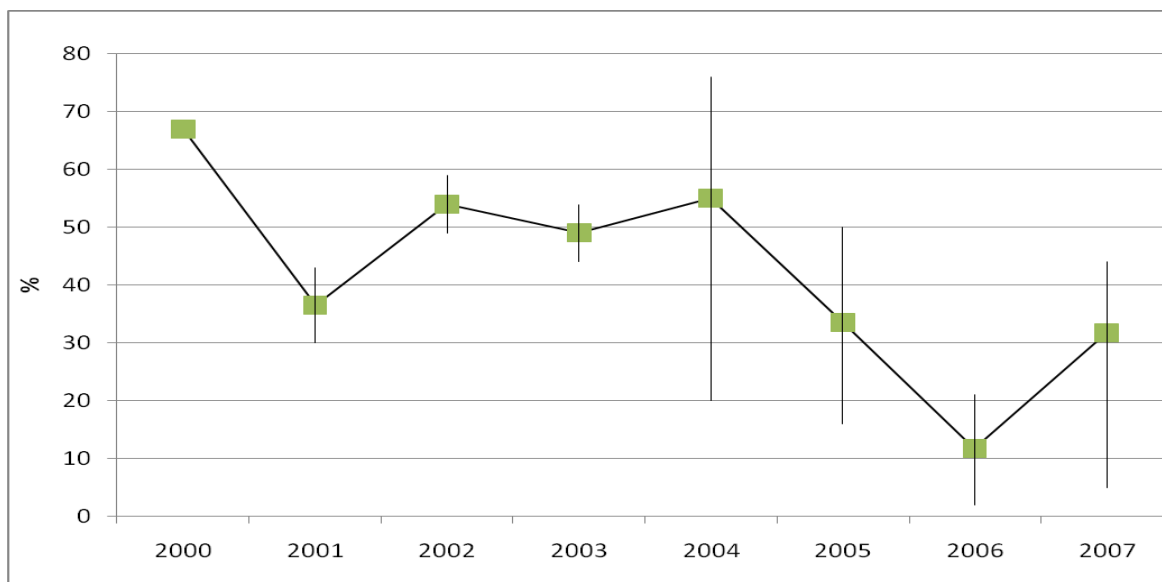


Figure 3 Evolution of reported renminbi misalignment (real USD exchange rate), 2000-2007



Next, we describe the variables used to explain the reported misalignments. As will be explained below, we use them in groups, and so we introduce them in groups. We have already shown that papers using the real USD exchange rate definitely report larger misalignments, and so in all re-



ported regressions we use the dummy variable RER\_USD to indicate the observations where the bilateral real exchange rate is used. The overwhelming majority of the remaining papers use the real effective exchange rate.

- **Variables related to authors and their affiliations.** We use dummy variables to indicate whether there are one or two authors (AUTHORS1 and AUTHORS2), whether any had affiliation in mainland China (CHINA), whether any have a Chinese name (CHINESE\_NAME, which may indicate some other connection to mainland China), or whether any were affiliated with an investment bank (INVESTMENTBANK) or international organisation (INTERNATIONALORG).
- **Variables related to number of observations, their frequency, publication year and the end of the data sample.** We use data on the number of observations (OBS), year of publication (YEAR) and the last year of the data sample used in the analysis (LAST\_DATE), as well as dummy variables for the data frequency (MONTHLY and QUARTERLY). In addition, several papers using the FEER approach actually report results from a calibrated macroeconomic model. These models are tagged with a dummy variable, ONEOBS. It should be noted that LAST\_DATE is an important variable in the sense that it is the main means of controlling for different sample periods, although it is also correlated with YEAR.
- **Variables related to dimensions of the data used in the analysis.** We have dummy variables denoting whether the paper uses time-series (TIME\_SERIES) or cross-sectional analysis (CROSS\_SECTION).
- **Variables related to the theoretical framework.** We have dummy variables indicating whether a paper uses the BEER or FEER framework (BEER, FEER).
- **Variables related to the statistical significance of the estimates.** Some of the reported misalignment estimates are not statistically significant, and for them we use the dummy variable NOTSIGNIFICANT. Some papers report goodness-of-fit measures such as  $R^2$ , indicated by the dummy variable R2PRESENT.
- **Variables relating to publication.** We have dummy variables indicating whether the paper has been published in a refereed journal (JOURNAL) or as a chapter in a book (BOOK).

## 4 Meta-regressions

In this section we present results from the meta-regressions. To reiterate, the idea is to explain reported misalignments of the renminbi from its equilibrium value on the basis of observable characteristics of the papers and authors. We perform the following simple regression using ordinary least squares estimation:

$$x = \alpha + \sum_i \beta_i D_i + \varepsilon \quad (1)$$

Here  $x$  is the reported misalignment,  $\alpha$  is the constant term, the  $D_i$  are dummy variables, and  $\varepsilon$  is the error term.

As we do not have unlimited observations, we start by regressing the reported misalignment on groups of related variables. Within these groups we start with all the variables, and then drop the insignificant variables one by one until only significant (at 10% level) variables remain. When all the variable groups have been estimated, we take all the significant variables from the first-round regressions and regress the misalignment on them. Again, we drop insignificant variables one by one until only significant variables remain, and this is then our preferred estimation. It should be noted that one paper, Frait and Komarek (2008), accounts for 24 observations in our sample. To ensure that our results are not driven by this one paper, we employ two strategies. In the main empirical estimations we include a dummy for observations from this paper. In addition, we report in the Appendix the results from a similar empirical exercise where all the misalignment observations from this paper are removed. As can be seen, the results are qualitatively very similar, and even individual coefficient values are very close to those obtained for the whole sample. Therefore, we conclude that the results are not driven by this one paper.

Table 3 displays results from our regressions. Only variables with a statistically significant coefficient in at least one specification are reported. We can see that both paper and author characteristics have a definite effect on reported misalignment, and that in all specifications RER\_USD has a positive, statistically significant and economically large effect on the reported undervaluation. The effect is generally between 13 and 20 percentage points. If this result is taken at face value, it might indicate that Chinese exchange rate policy has been more concerned with the external value of the renminbi against the US dollar than against other currencies.

Affiliation and number of authors each has a clear and robust relationship with the reported misalignment of the renminbi vis-à-vis its equilibrium level. It seems that papers with only one au-

thor consistently report smaller misalignments. It may be that authors working alone are reluctant to report "excessive" misalignments. Authors' affiliation also plays a role; a robust finding seems to be that when one or more authors has an affiliation with an investment bank or comparable institution, the papers report significantly smaller misalignments. Perhaps even more interesting is the finding that authors with Chinese affiliation or Chinese name also report smaller misalignments. However, these effects are smaller than that of investment bank affiliation. Furthermore, when all previously significant variables are thrown into the final specification, CHINA and CHINESE\_NAME dummies are not significant. Upon closer inspection, this appears to be because they are very highly correlated with the TIME\_SERIES dummy, which indicates that most authors with Chinese affiliation have preferred to analyse the issue using time series methodology. This result shows how different indicators may be correlated.

The year of publication seems to affect the results; later papers report larger misalignment, although this effect is relatively small in an economic sense. Having more observations leads to the reporting of smaller misalignments.

Using time series methodology instead of the panel or cross-sectional approach produces significantly smaller reported misalignments. Time series studies typically involve only one country (China), and in such case the currency will on average be at its equilibrium level, although at any point in time it may of course deviate from the equilibrium. As mentioned above, many researchers affiliated with Chinese institutions have utilized time series techniques in focusing solely on China.

Theoretical framework seems to affect the reported misalignments. The BEER approach is associated with smaller reported misalignments. It should be noted that the BEER approach does not rely on any one theory of exchange rate determination, which may at least partially explain the result. There are several theories of exchange rate determination and perhaps relying on any one of them in empirical work means that some important variables are omitted. Because the BEER approach does not suffer from this, it may produce results more in line with the underlying reality.

The reported significance of the estimations (proxied by  $R^2$ ) and publication in a refereed journal each has a bearing on the reported misalignments; both seem to lead to more pronounced undervaluations. It may be that only those researchers finding relative large misalignments bother to report descriptive statistics like  $R^2$ . It may also be that there is a tendency for journals to reject papers which report "too small" misalignments, as they are perhaps deemed economically not as significant. Thus, we find some evidence on publication bias of sorts.

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In the final specification (regression 6) we see that the variation in the reported misalignment is explained reasonably well by just a handful of variables, and  $R^2$  is close to 0.7. As expected, papers using the real USD exchange rate against consistently report greater renminbi misalignment. Those with affiliation with an investment bank consistently find smaller misalignments. For reasons explained above, papers using time series techniques are perhaps more likely to find smaller misalignment, and there may be publication bias at work in that papers published in journals report larger undervaluation. Therefore, should take into account several attributes of papers when interpreting the reported renminbi misalignment in terms of its equilibrium value. Especially those factors that are statistically significant - by themselves or when other variables are added to the estimation - need to be controlled when assessing reported misalignments. The results are not due to outliers in the data; the Jarque-Bera test does not reject the null hypothesis of normally distributed residuals for any of the specifications reported in Table 3

Table 3 Meta-regressions of renminbi misalignment

	1	2	3	4	5	6
<b>RER_USD</b>	18.50*** (6.00)	20.28*** (6.04)	14.48*** (4.96)	22.03*** (6.46)	19.86*** (5.70)	13.58*** (5.15)
<b>AUTHORS1</b>	-11.09** (-2.53)					
<b>AUTHORS2</b>	5.41* (1.64)					
<b>CHINA_AFFILIATION</b>	-12.55** (-1.99)					
<b>CHINESE_NAME</b>	-10.04*** (-2.48)					
<b>INVESTMENTBANK</b>	-27.17*** (-3.05)					-21.89*** (-4.15)
<b>OBS</b>		-0.15* (1.67)				
<b>YEAR</b>		3.21*** (3.00)				
<b>TIME_SERIES</b>			-27.81*** (-9.66)			-27.01*** (-9.98)
<b>BEERDUMMY</b>				-9.32*** (-2.18)		
<b>R2PRESENT</b>				12.97*** (2.93)		
<b>JOURNAL</b>					9.60** (2.45)	9.57*** (3.42)
<b>FRAITANDKOMAREK</b>	-30.06*** (-7.73)	-30.64*** (-7.11)		-24.25*** (-5.40)	-18.56*** (-4.30)	
<b>C</b>	28.39*** (10.27)	-6413.74*** (-2.99)	29.03*** (12.64)	20.82*** (6.49)	16.21*** (5.86)	26.46*** (10.82)
<b>R<sup>2</sup></b>	0.60	0.47	0.59	0.45	0.43	0.67
<b>Jarque-Bera test of normality</b>	0.466	1.746	0.184	0.979	0.268	0.069
<b>N</b>	97	97	97	97	97	97

t-values in parenthesis, \*, \*\*, and \*\*\* denote significance at 10%, 5% and 1% level, respectively

## 5 Discussion and conclusions

In this paper we analyzed 29 papers on China's equilibrium exchange rate. To our knowledge, no other paper has surveyed as many papers on the topic, and used so many variables to explain the reported misalignments. First, by looking at simple descriptive statistics for the reported misalignments, we can say that the vast majority of papers agree on the fact that the renminbi has been undervalued relative to its equilibrium value. The real USD exchange rate appears to produce more undervaluation than the real effective exchange rate, which may explain some of the political discussion in the US on the issue. The reported misalignments differ greatly from one paper to another, which renders interpretation of the results in any one paper more challenging. Therefore, meta-analysis offers a useful way to summarize the results of the literature. Our meta-regressions suggest that practically all papers report that the renminbi is undervalued relative to its equilibrium value, especially in recent years.

We find that characteristics related to the published papers and their authors help to explain a great deal of the variation in reported misalignments, which is a common finding in other meta-analyses as well. For example, when surveying the papers assessing the degree of business cycle correlation in the new EU member countries with respect to the euro area, Fidrmuc and Korhonen (2006) report that authors with central bank affiliation tended to find lower correlation coefficients than others. For China's equilibrium exchange rate, being affiliated with an investment bank seemingly leads to lower reported misalignments, as does Chinese affiliation, although the latter result is not robust in all specifications. Because of their inherent assumptions, time series estimations are associated with smaller misalignment as well. Journals appear to publish papers with larger reported misalignments, so there appears to be a publication bias of some sorts.

Our results mean that the reader needs to proceed with caution in interpreting results from any one paper regarding renminbi equilibrium value. However, taken together, this body of literature informs us that the renminbi has very likely been undervalued, regardless of whether we use the real effective exchange rate or the real US dollar exchange rate. Moreover, the average of reported misalignments has been quite high, even for the most recent years. Nevertheless, results of Cheung et al. (2009) indicate that this result may in fact change as more reliable data are obtained.

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## Appendix

Table A1 Meta-regressions of renminbi misalignment excl. observations from Frait and Komarek (2008)

	1	2	3	4	5	6
<b>RER_USD</b>	23.02*** (5.77)	25.49*** (5.96)	27.56*** (9.96)	27.04*** (6.26)	24.21*** (5.41)	14.66*** (3.98)
<b>AUTHORS1</b>	-13.23*** (-2.82)					
<b>CHINA_AFFILIATION</b>	-11.85* (-1.71)					
<b>CHINESE_NAME</b>	-8.01* (-1.93)					
<b>INVESTMENTBANK</b>	-22.45** (- 2.41)					-21.42** (- 2.58)
<b>YEAR</b>	3.41*** (2.93)					
<b>TIME_SERIES</b>			-25.35*** (-5.68)		-28.39*** (- 7.01)	
<b>BEERDUMMY</b>	-9.70** (-2.09)					
<b>R2PRESENT</b>	13.41*** (2.79)					
<b>JOURNAL</b>					8.82** (2.05)	10.28*** (3.05)
<b>C</b>	28.29*** (9.48)	-6827.54*** (-2.92)	27.56*** (10.00)	19.11*** (5.36)	15.01*** (4.84)	25.64*** (9.18)
<b>R<sup>2</sup></b>	0.54	0.39	0.53	0.40	0.36	0.64
<b>Jarque-Bera test of normality</b>	0.06	0.909	0.119	1.075	0.294	0.140
<b>N</b>	73	73	73	73	73	73

t-values in parenthesis, \*, \*\*, and \*\*\* denote significance at 10%, 5% and 1% level, respectively

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