Why the Renminbi Might be Overvalued (But Probably Isn't)

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Abstract

The Renminbi (RMB) is evaluated using relative PPP, absolute PPP, and Balassa-Samuelson criteria. We find that some approaches imply substantial undervaluation of the RMB, while others imply little or none. Yet a few others indicate slight overvaluation. However, even when the estimated degrees of undervaluation are large, the gap between predicted and actual values is not always statistically significant. We also find that including measures of institutions, such as the absence of corruption, results in smaller estimates of RMB undervaluation.

1. Introduction

On July 21st, the Chinese[1] announced a long-anticipated revision to their exchange rate regime. Against a backdrop of rising protectionist sentiment in the United States, and increasingly intense mutual recriminations over the benefits and costs of an open international financial system, the move was warmly, albeit cautiously, welcomed. The wariness arises from the uncertainty surrounding the exact nature of the new exchange rate regime, and how rapidly the Chinese authorities are willing to allow the currency, the Renminbi (RMB), to rise in value.

In this paper, we step back from arguing about the merits of one exchange rate regime versus another,[2] and indeed, do not take a stand upon how large a revaluation – or devaluation – is necessary (although our conclusions will inform the debate over what the appropriate actions might be).

Rather, we re-orient the discussion of currency misalignment to refer back to theory; in particular, we want to focus on (1) disagreements regarding what is the "equilibrium real exchange rate" in theory (and in intervention ridden economies), (2) quantifying the uncertainty surrounding the level of the equilibrium, even when the model is settled upon, and (3) discussing what the profession has learned about equilibrium exchange rates in the wake of the East Asian crises of 1997-98. In this regard, we will neglect to some degree short term analyses, and focus on the underlying and longer term determinants of exchange rates.

[1] We use the term "China" to pertain to the People's Republic of China, exclusive of Hong Kong, SAR, Macao, SAR, and Taiwan, R.O.C, sometimes referred to as Chinese Taipei or Taipei, China.
[2] See among others, Eichengreen (2005), Goldstein (2005), Prasad et al. (2005) and Williamson (2005).

Why is such a re-assessment necessary? We think it is necessary to review the evidence and conclusions in the context of the various underlying premises. That is, like the story lines in the Rashomon, each analyst seems to have a different interpretation of what misalignment constitutes.[3] At the heart of the differences are contrasting ideas of what constitutes an equilibrium condition, over what time frame the equilibrium pertains to, and what econometric method to implement. Even when there is agreement on the fundamental model, questions typically remain about the right variables to use.

Take the approach adopted in the aftermath of the East Asian crisis of the mid 1990's. Often, the indicators of exchange rate overvaluation were measured as deviations from a trend. Adopting this approach in the case of China would not lead to a very satisfactory result. Consider first what a simple examination of the bilateral real exchange rate between the U.S. and the RMB implies. Figure 1 depicts the official exchange rate series from 1986q1 to 2005q2, deflated by the CPI's of the US and China. The rate is expressed so higher values constitute a stronger Chinese currency. In line with expectations, in the years since the East Asian crises, the RMB has experienced a downward decline in value. Indeed, over the entire sample period, the RMB has experienced a downward trend.

However, as with the case with economies experience transitions from controlled to partially decontrolled capital accounts and from dual to unified exchange rate regimes, there is some dispute over what exchange rate measure to use. In the Chinese case, an

[3] For a review of the concepts of misalignment and the distinction between short run and long run disequilibria, see articles in Hinkle and Montiel (1999). As Frankel (2005) observes, there is a question about whether there is such a thing as an "equilibrium" exchange rate when there are two or more targets (e.g., internal *and* external equilibrium).

argument can be made that, with a portion of transactions taking place at swap rates, the 1994 "mega-devaluation" was actually better described as a unification of different rates of exchange.[4]

The import of this difference can be gleaned from the fact that the imputed time trends then exhibit quite different behaviors, and imply different results. Using the "adjusted" rate, one finds a modest undervaluation in the second quarter of 2005 of 4.8%. Using the official rate, a slight, almost imperceptible, overvaluation of 1.4%, is implied.[5]

A natural reaction would be to argue that simple bilateral comparisons are faulty. We would agree. However, appealing to trade weighted exchange rates would not necessarily clarify matters. Figure 2 depicts the IMF's trade weighted effective exchange rate index, and a linear trend estimated over the available sample of 1980-2005. One finds that a simple trend (as used in the "early warning" literature) indicates the RMB is 25% overvalued.

A cursory glance at the data indicates that a simple trend will not do. A test on residuals from recursive regression procedure applied to the constant plus trend suggests a break with maximal probability in 1986q3. Fitting a broken trend – admittedly an ad hoc procedure – provides a fairly good fit, as illustrated in Figure 3. In the second portion of the sample, the estimated trend is essentially zero, a result which is consistent with purchasing power parity holding.

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[4] See Fernald, Edison and Loungani (1999) for a discussion, in the context of whether the 1994 "devaluation" caused the 1997-98 currency crises.

[5] In this introductory section, we ignore issues of trend vs. difference stationarity. It turns out that in all cases examined in this section, the series fail to reject the unit root null, using ADF tests (with constant, with constant and trend).

Obviously, a more formal test for stationarity is necessary. Following the methodology outlined in Chinn (2000a), we test for cointegration of the nominal (trade weighted) exchange rate and the relative price level. We find that there is evidence for cointegration of these two variables, with the posited coefficients (see Appendix 2 for detailed results). This means that we can use this trend line as a statistically valid indication of the mean value the real exchange rate series reverts to.

Interestingly, even here, the procedure indicates a very modest 2.1% undervaluation. These conclusions are not sensitive to the index. Using Deutsche Bank's PPI deflated index, similar movements in the RMB are detected.

All this is by way of prologue. A proper discussion of currency misalignment has to place the various studies in the context of both theory and empirics.

2. The Context of the Extant Literature

A couple of surveys of the literature of the RMB misalignment literature have compared the estimates of the degree to which the RMB is mis-aligned. GAO (2005) provides a comparison of the academic and policy literature, while Cairns (2005) briefly surveys recent point estimates obtained by different analysts. Here we survey the literature to focus on primarily theoretical papers and their economic and econometric distinctions.

Most of these papers fall into familiar categories, either relying upon some form of relative purchasing power parity (PPP) or cost competitiveness, a composite model incorporating several channels of effects (sometimes called behavioral equilibrium exchange rate (BEER) models), modeling of deviations from absolute PPP, or flow equilibrium models.

Table 1 provides a typology of these approaches, further disaggregated by the data dimension (cross section, time series or combined). Note that several authors rely upon multiple approaches.

The relative PPP comparisons are the easiest to make, in terms of calculations, as evidenced in the introductory section. Bilateral real exchange rates are easy to calculate, and there are now a number of trade weighted series that incorporate China. On the other hand, relative PPP in levels requires cointegration of the price indices with the nominal exchange rate (or equivalently, stationarity of the real exchange rate),[6] and as demonstrated previously, these conditions do not necessarily hold, regardless of deflator. Wang (2004) reports interesting IMF estimates of unit labor cost deflated RMB. This series has appreciated in real terms since 1997; of course, this comparison, like all other comparisons based upon *indices*, depends upon selecting a year that is deemed to represent equilibrium. Selecting a year before 1992 implies the RMB has depreciated over time.

Bosworth (2004), Frankel (2005), Coudert and Couharde (2005) and Cairns (2005b) estimate the relationship between the deviation from absolute PPP and relative per capita income. All obtain similar results regarding the relationship between the two variables, although Coudert and Couharde fail to detect this link for the RMB.

[6] For a technical discussion, see Chinn (2000a).

Zhang (2001), Wang (2004), and Funke and Rahn (2005) implement what could broadly be described as behavioral equilibrium exchange rate (BEER) specifications.[7] These models incorporate a variety of channels whereby which the real exchange rate is affected. Since each author selects different variables to include, the implied misalignments will necessarily vary.

Other approaches center on flow equilibria, considering savings and investment behavior, and the resulting implied current account. The equilibrium exchange rate is backed out from the implied medium term current account using import and export elasticities. In the IMF's "macroeconomic approach", the "norms" are estimated, in the spirit of Chinn and Prasad (2003). Wang (2004) discusses the difficulties in using this approach for China, but does not present estimates of misalignment based upon this framework. Coudert and Couharde (2005) implement a similar approach. Finally, the external balances approach relies upon assessments of the persistent components of the balance of payments condition (Goldstein, 2004; Bosworth, 2004). This last set of approaches is perhaps most useful for conducting short term analyses. But the wide dispersion in implied misalignments reflects the difficulties in making judgments about what constitutes persistent capital flows. For instance, Prasad and Wei (2005), examining the composition of capital inflows into and out of China, argue that much of the reserve accumulation that has occurred in recent years is due to speculative inflow; hence, the degree of misalignment is small.

Moreover, such judgments based upon flow criteria must condition their conclusions on the existence of effective capital controls. This is an obvious – and widely

[7] Also known as BEERs, a composite of exchange rate models. See Cheung, Chinn and Garcia Pascual (forthcoming) for a survey.

acknowledged – point (e.g., Holtz-Eakin, 2005: 5), but one that bears repeating, and indeed a point that we will return to at the end of this paper.

Two observations are of interest. First, as noted by Cairns (2005a), there is an interesting relationship between studies that adopt a particular approach and the implied degree of misalignment (all the studies reviewed by Cairns imply undervaluation or no misalignment). Analyses implementing relative PPP and related approaches indicate the least misalignment. Those adopting approaches focusing on the external accounts (either the current account or the current account plus some persistent component of capital flows) yield estimates that are in the intermediate range. Finally, studies implementing an absolute PPP methodology result in the greatest degree of estimated undervaluation.

Second, while all these papers make reference to the difficulty in making applying such approaches in the context of an economy ridden with capital controls and state owned banks,[8] and large contingent liabilities, few have attempted a closer examination of these issues.

This paper (denoted as CCF, 2005 in Table 1) contributes to this literature in the Balassas-Samuelson approach (where productivity differentials are used), and in implementing panel analyses of the PPP-income relationship, augmented by variables motivated from the BEER and Macroeconomic Balance literature.

3. The Productivity Approach

The role of productivity is central to thinking about the evolution of the Chinese currency. The standard point of reference in thinking about the impact of productivity is

[8] See Cheung, Chinn and Fujii, 2005 for a description of how financial links between the rest of the world and China are mediated by capital controls and the banking system.

the Balassa-Samuelson theory, which focuses on the differential between traded and nontraded sectors. Interestingly, to our knowledge, nobody has attempted to estimate the link between sectoral productivity estimates and the real exchange rate for China, with the exception of Chinn (2000b).

3.1 Nontradables, Productivity and the Real Exchange Rate in Theory

The starting point for most investigations of the linkage between the relative price of nontradables and the real exchange rate relies upon the following construction. Let the log aggregate price index be given as a weighted average of log price indices of traded (T) and nontraded (N) goods:

$$p_t = (1 - \alpha)\, p_t^T + \alpha\, p_t^N \qquad \textbf{(1)}$$

where α is the share of nontraded goods in the price index. Suppose further that the foreign country's aggregate price index is similarly constructed:

$$p_t^* = (1 - \alpha^*)\, p_t^{T*} + \alpha^*\, p_t^{N*} \qquad \textbf{(2)}$$

Then the real exchange rate is given by:

$$q_t \equiv (s_t + p_t^* - p_t) + \kappa \qquad \textbf{(3)}$$

where *s* is the log of the domestic currency price of foreign currency, and κ is a constant accounting for the fact that the price levels are indices. In other words, even though productivity is being accounted for, the very fact that we only have price and productivity indices means that we can only evaluate deviations from a relative PPP modified for productivity differentials.

For $\alpha = \alpha^*$, the following holds:

$$q_t = (s_t + p_t^T - p_t^{T*}) - \alpha[(p_t^N - p_t^T) - (p_t^{N*} - p_t^{T*}) + \kappa] \quad \textbf{(4)}$$

Although there are many alternative decompositions that can be undertaken, equation (4) is the most relevant since most economic models make reference to the second term as the determinant of the real exchange rate, while the first is assumed to be zero by purchasing power parity (PPP) as applied to traded goods.

In order to move away from accounting identities one requires a model, such as the Balassa-Samuelson framework. The relative prices of nontradables and tradables will be determined solely by productivity differentials, under the stringent conditions that capital is perfectly mobile internationally, and factors of production are free to move between sectors. Substituting out for relative prices yields:

$$q_t = (s_t - p_t^T + p_t^{T*}) - \alpha[(\frac{\theta^N}{\theta^T})a_t^T - a_t^N] + \alpha[(\frac{\theta^{N*}}{\theta^{T*}})a_t^{T*} - a_t^{N*}] + \tilde{\kappa} \quad \textbf{(5)}$$

where a^i is total factor productivity in sector *i*, and the θ's are parameters in the production functions.[9]

Most researchers have proceeded under the assumption that the first term is I(0). This implies cointegrating relationships of the form:

$$q_t = -\alpha(p_t^N - p_t^T) + \alpha(p_t^{N*} - p_t^{T*}) \quad \textbf{(6)}$$

and

$$q_t = -\alpha [a_t^T - a_t^N] + \alpha [a_t^{T*} - a_t^{N*}] \quad \textbf{(7)}$$

$$q_t = -\alpha [a_t^T - a_t^{T*}] + \alpha [a_t^N - a_t^{N*}] \quad \textbf{(7')}$$

respectively (where the production functions in the tradable and nontradable sectors are assumed to be the same, so that the θ's cancel out in equation (7), and the constants are suppressed). Equations (6) underpins the analysis by Funke and Rahn (2005). Equation (7') provides the basis for the empirical work in this section.[10]

3.2 Econometric Specification, Data and Results

The cointegrating relationship is identified using dynamic OLS (Stock and Watson, 1993). One lead and one lag of the right hand side variables are included. In a simple two variable cointegrating relationship, the estimated regression equation is:

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[9] Note that if the production functions have the same form in the two sectors, then the θ's drop out.

[10] Both equations have been exploited extensively. Equation (6) has been examined by Kakkar and Ogaki (1994) for several exchange rates. Equation (7) has been estimated by Hsieh (1982), Marston (1990), and most recently Lee and Tang (forthcoming) and Choudhri and Khan (2004).

$$q = \beta_0 + \beta_1 x + \sum_{i=-1}^{+1} \gamma_i \Delta x_{t+i} + u_t \tag{8}$$

Although this approach presupposes that there is only one long run relationship, this requirement is not problematic, as in these extended samples at most one cointegrating vector is usually detected.[11] A deterministic trend is also allowed in equation (8).

We take the two countries to be the U.S. and China. In principle, it would be preferable to consider China vs. the rest-of-the-world. However, data considerations, plus the fact that the mis-alignment debate revolves around the U.S.-China nexus, motivates us to adopt this perspective.

The data issues present the largest challenges. The straightforward calculations involve the exchange rate and the U.S. variables, although even in the former instance, there are some calculations. For reasons discussed in Section 1, we do not rely upon the official exchange rate in the years directly leading up to 1994. Rather, the real RMB/USD rate is measured using the nominal exchange rate, "adjusted" following Fernald et al. (1999), as described above, deflated by the respective CPIs. US data are derived from the Bureau of Labor Statistics and the Groningen Growth and Development Center.

Once one has to determine the appropriate Chinese productivity numbers, one enters a data quagmire. As is well known, even deciding upon the appropriate estimate of Chinese GDP can be a contentious matter (see Rossi, 2005). As demonstrated in Young's (2003) dissection of Chinese data, small changes in assumptions regarding the validity of

[11] Application of the Johansen maximum likelihood procedure indicates evidence of cointegration at the 5% marginal significance level, using asymptotic critical values. This statement applies for cases where either a deterministic trend is allowed or not allowed in the variables in the cointegrating vector, and 2 lags of the first differences (i.e., a VAR(3)).

the output numbers and the deflators can radically alter the implied output per worker and total factor productivity series substantially. Hence, all the estimates provided in this section should be viewed as heroic in nature.

Forging ahead, we follow the method adopted in Chinn (2000b). Average labor productivity is used as the proxy for sectoral total factor productivity, where average labor productivity is obtained by dividing real output in sector i by labor employment in sector i.[12] The tradables sector is proxied by the manufacturing sector, while the nontradables is proxied by the "Other" sector. This latter sector is defined as those sectors besides mining, manufacturing and agriculture.

Two limitations of the data should be stressed. First, since these labor employment statistics are not adjusted for part time workers, In Chinn (2000b), the results are cross-checked using the manufacturing productivity reported by the World Tables for several countries. These figures match quite well. These series also match quite well for manufacturing vs. tradables, and "other" versus nontradables. These outcomes serve to improve one's confidence that the proxies used are not implausible.

Second, the proxy variable is labor productivity, rather than TFP as suggested by the model. Canzoneri, Cumby and Diba (1996) have argued that use of labor productivity is to be preferred because it is less likely to be tainted by mis-estimates of the capital stock. In any event, there is little possibility of circumventing this problem. To my knowledge, almost all calculations of East Asian total factor productivity over long spans

[12] Unfortunately, we could not obtain long enough series of sector-specific deflators, so we used the aggregate GDP deflator reported in Holz (2005) to deflate the sectoral output reported in the ADB's *Indicators of Developing Asian and Pacific Countries.* The employment figures are also drawn from this source.

of time have been conducted on an economy-wide basis (with a few exceptions, including Young's 1995 and 2003 papers).

In addition to the productivity series calculated in the described manner, we also relied upon a manufacturing series obtained via a careful analysis of state owned enterprise (SOE) and township and village enterprise (TVE) output and employment figures, reported by Szirmai et al. (2005). The Chinese manufacturing productivity series, in logs, normalized to 1986=0, are shown in Figure 4. The productivity growth rates are 9.5% and 7.1%, respectively, over the 1987-2003 period. These are more rapid than the US manufacturing growth rate of 4.6%. Figure 5 depicts the Chinese "other" productivity series, which grows at 5.0% (compared to 2.0% for the US).

The DOLS results for estimations over the 1988-2002 period are reported in Table 2.[13] The estimates based upon productivity numbers calculated using output and employment figures are reported in columns [1]-[4], while those based upon the manufacturing estimates from Szirmai et al. (2005) are reported in columns [5]-[8].

In column [1], estimates from the most basic specification, corresponding to equation (7'), indicate that each one percent increase in Chinese manufacturing productivity over U.S. productivity results in a half percentage point appreciation in the RMB against the dollar, in real terms. Increases in nontraded sector productivity depreciates the RMB, in line with the theoretical prediction. However, the point estimate is somewhat large; in general, when the productivity coefficients in the tradable and nontradable sector are similar, then the coefficient should be about equal to the share of

[13] Since the DOLS procedure here uses one lead and lag of the right hand side variables, the sample is truncated to 2002 even when 2003 data is available. The levels observations for 2003 and 2004 are *not* used in the estimation procedure.

nontradables in the aggregate price index. On the other hand, the standard error is so large that the ±1 standard error bands would encompass plausible values of α.

In column [2], the specification is augmented by a time trend. The point estimate for the coefficient on traded sector productivity is now larger in absolute value; however, neither the nontradables term, nor the time trend itself, is statistically significant, casting doubt on the relevance of this specification. Constraining the coefficients on tradables and nontradables productivity to be the same yields a deterioration in the fit (the adjusted R^2 declines while the standard error of regression increases). Augmenting the constrained specification with a time trend produces estimates that are correctly signed, ascribes a large portion of the secular movement in the RMB to the time trend – 3.5% per year. This is certainly an undesirable result for prediction purposes, since the time trend is a proxy for our ignorance.

Using the Szirmai et al. manufacturing numbers produces interesting results. In column [5], the coefficients are correctly signed, albeit somewhat large in absolute value. Interestingly, the point estimates are not sensitive to the inclusion of a time trend (column [6]). Constraining the coefficients on tradable and nontradable productivity to be equal yields plausible estimates of α. Including a time trend, as in column [8], produces more imprecisely estimated coefficients, while leaving the time trend insignificant.

For reasons already alluded to, one may be dubious about these results. An additional reason for skepticism is that the sample is quite short; using the DOLS approach results in a sample of only 15 observations. An obvious question is why we do not extend the sample backward.

Two reasons guide our sample choice. First, the data are available on a more or less consistent basis over this time period. Second, and perhaps of even greater importance, it is not clear whether extending the data back in time would be appropriate. The end of the second phase of economic liberalization, which severed the link between firm management and Plan objectives, roughly coincides with the beginning of the sample.

The data can be extended backward in time. Using data utilized in Chinn (2000b), spliced to the series discussed above, the DOLS regressions can be re-estimated over the 1980-2004 period. This produces a sample of 22 observations (25 if simple OLS is implemented).

The results are surprisingly similar to those reported in the first two columns of Table 2. The elasticity of the real exchange rate with respect to the intercountry traded sector productivity differential is -0.50 (vs. -0.56), while the nontraded differential has an implausibly large impact (2.2 vs. 1.1). The pattern of estimates persists even with the inclusion of a time trend.[14]

Summing up, it appears that regardless of the measure of manufacturing productivity used, the coefficient estimates point in the directions predicted by the Balassa-Samuelson hypothesis.

3.3 Implied RMB Misalignment

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[14] However, the results are *not* similar if the coefficients on the traded and nontraded sectors are constrained to be equal and opposite. The impact of productivity differentials disappears in this longer sample, unless a time trend is included. The sensitivity of the results to the inclusion of time trends is another reason to focus on the shorter sample.

In order to assess whether the RMB is misaligned, we take the long run coefficients from the columns [1] and [5] of Table 2, and generate long run predicted values. One difficulty in conducting the assessment for the recent period is that the sectoral output and employment data is available only up to 2003. Indeed, Szirmai et al.'s estimated manufacturing labor productivity data extends only up to 2002. We assume that for the latter, the productivity growth rate in 2003 and 2004 is the same as that in 2002 (9.1% per annum), while for the former, the 2004 rate equals the 2003 rate of 4.8%.

Figure 6 depicts the results (higher values of the exchange rate imply weaker values of the RMB against the USD). Using the estimated productivity data, the RMB is only about 6.1% undervalued in 2004. Interestingly, the greatest degree of undervaluation is in 1993 – about 30%, and *drops* during the "devaluation" of 1994 to 16% by 1994. Using the Szirmai et al. data, the 2004 undervaluation is negligible, at about 1.4%.

These counter-intuitive results suggest that something may be missing from this approach. This framework assumes the relative prices of tradable and nontradable goods are determined solely by the relative production prices. This assumption in turn relies upon homothetic preferences across different per capita income levels. But this is unlikely to be the case; hence relative prices might be changing for reasons apart from differing productivity trends. In fact, the argument that much of spectacular growth in Chinese income is due to labor reallocation rather than rapid sectoral productivity growth is consistent with this view.[15]

Another difficulty with this approach is that it relies upon the relationship holding over the sample period. If the entire sample period were one in which the Chinese

[15] This argument for China is most closely associated with Young (2003), as well as Brandt et al. (2005).

economy were *adjusting* to a condition where the Balassa-Samuelson hypothesis held—without actually achieving that condition --, then this approach would be invalid. This is not a problem specific to this approach. It also occurs in cases where one is empirically validating purchasing power parity in levels, but using price indices. The limitation of such approaches, based upon indices, motivates the use of measures where price levels can directly compared.

4. Absolute Purchasing Power Parity Plus

In this section, we appeal to cross-country time-series evidence on the determinants of the real exchange rate, where the real exchange rate is measured in such a way that one can identify deviations from absolute purchasing power parity.

We will conduct the analysis in a series of steps. First, we will appeal to the well-known cross-sectional relationship between the relative price level and relative per capita income levels to determine whether the Chinese currency is undervalued. Obviously, this approach is not novel; it has been implemented recently by Coudarde and Couharde (2005) and Frankel (2005). However, we will expand this approach along several directions. First, we augment the approach by incorporating the time series dimension.[16] Second, we explicitly characterize the uncertainty surrounding our determinations of currency misalignment.

Our second step is to expand our view of the determinants of real exchange rates by incorporating those variables that should matter for intertemporal trade (via the current

[16] Coudert and Couharde (2005) implement the absolute PPP regression on a cross-section, while their panel estimation relies upon estimating the relationship between the relative price level to relative tradables to nontradables price indices.

account) and hence the real exchange rate. The variables that are included here are hence similar to those utilized in Chinn and Prasad (2003) in their examination of the current account norms.

The third step is to follow the lead of the recent literature that appeals to institutions as important determinants of macroeconomic behavior (Levine, et al.. 2000; La Porta et al., 1997, 1998). After determining the relevance of these variables, we once again assess whether the RMB is misaligned, by a statistically significant margin.

4.1 The Basic Real Exchange Rate-Income Relationship

Frankel (2005) exploits the well known relationship, noted in Summers and Heston (1991), between the real exchange rate and per capita income, as recorded in the Penn World Tables. When the real exchange value of a currency is expressed as the price in common currency terms ("International dollars") relative to the U.S. price level, there is a positive, monotonic relationship to the relative per capita income.

We amass a large data set encompassing up to 174 countries, over the 1975-2003 period. (Because some data are missing, the panel is unbalanced.) Most of the data are drawn from the World Bank's *World Development Indicators* (*WDI*), and the Penn World Tables (Summers and Heston, 1991). Since the PWT data stops in 2000, we update the sample using the *WDI* data up to 2003. Greater details on the data used in this subsection and elsewhere are reported in the Data Appendix.

We estimate the relationship using a pooled time series cross section regression, where all variables are expressed in terms relative to the U.S. The results are reported in Table 3, for cases where we measure relative per capita income in either market rates or PPP based exchange rates. Furthermore, to examine the robustness of the results to different specifications, we report not only the pooled time-series cross-section estimates (our preferred specification) but also fixed effects and random effects models.[17]

In all cases, the elasticity of the price level with respect to relative per capita income is always around 0.22-0.33, which compares favorably with Frankel's (2005) 1990 and 2000 year cross-section estimates of 0.38 and 0.32.[18] Interestingly, the elasticity estimate does not appear to be sensitive to measurement of per capita income. In Tables 4 and 5, the actual, and resulting predicted and standard error bands are reported.

We make two observations about these misalignment estimates. First, the RMB has been persistently undervalued by this criterion since the mid-1980s, even in 1997-98, when China was lauded for its refusal to devalue its currency despite the threat to its competitive position.

Second, and perhaps most importantly, in 2003, the RMB was more than one standard error -- but less than two standard errors -- away from the predicted value, which in the present context is interpreted as the "equilibrium" value. In other words, by the standard statistical criterion that applied economists commonly appeal to, the RMB is not undervalued (as of 2003) in a statistically significant sense. (Note that this uncertainty relies upon an agreement that we have identified *the* correct model; uncertainty regarding the true specification would add another layer of uncertainty).

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[17] Since the price levels being used are comparable across countries, in principle there is no need to incorporate currency specific constants as in fixed effects or random effects regressions. In addition, fixed effects estimates are biased in the presence of serial correlation, which obviously present in the data.

[18] In addition to the obvious difference in the sample, our estimates differ from Frankel's in that we measure each country's (logged) real GDP per capita in terms relative to the U.S. rather than in absolute terms. Hence, the resulting coefficient estimates are not necessarily directly comparable.

Figures 7 and 8 provide a graphical depiction of the actual vs. predicted values (for USD and PPP based per capita incomes), prediction intervals, and how the RMB fits into the more general relationship. The wide dispersion of observations in the scatterplots should give pause to those who would make strong statements regarding the exact degree of misalignment.

It is interesting to consider the path that the RMB has traced out in these graphs. It starts the samples as overvalued, and over the next three decades moves toward the predicted equilibrium value and then overshoots, so that by 2003, it is substantially undervalued, by between 47% to 54% in level terms (greater in log terms).

Notice that the deviations from the conditional mean are persistent; this has an important implication for interpreting the degree of uncertainty surrounding these measures of misalignment. This suggests that deviations from the PPP-relative income relationship identified by the regression are persistent, or exhibit serial correlation. Frankel (2005) makes a similar observation, noting that half of the deviation of the RMB from the 1990 conditional mean exists in 2000. We estimate the autoregressive coefficient in our sample at approximately 0.74 to 0.84 (USD and PPP based per capita income, respectively) on an annual basis. A simple, ad hoc, adjustment based upon the latter estimate suggests that the standard error of the regression should be adjusted upward by a factor equal to $[1/(1-\hat{\rho}^2)]^{0.5} \approx 2$. Figure 9 depicts the same data as presented in Figure 8, but now including the standard errors adjusted to account for the serial correlation. In this case, the actual value of the RMB is always within one standard error prediction interval surrounding the equilibrium value.

4.2 Including Demographics, Policy and Financial Development

Once one moves away from the idea of a simple world where the per capita income differential proxies for Balassa-Samuelson effects, a whole universe of additional determinants suggest themselves. In particular, if the income variable proxies not only for productivity differentials, but also non-homotheticity of preferences, or impediments to the free flow of capital, then one would wish to include variables that pertain to these factors. Hence we augment the relative per capita income with demographics – under 14 and over 65 dependency ratios – and with an index of capital account openness developed by Chinn and Ito (2005). We include a government deficit variable because Chinn and Prasad (2003) find that it explains part of current account balances over the medium term. Finally, financial deepening is proxied by an M2/GDP ratio. The results are reported in Table 6. Interestingly, the elasticity of the price level with respect to relative income is not drastically altered, while these additional variables enter in with statistical significance (with the exception of the government deficit variable).

Somewhat to our surprise, the implied RMB misalignments do not change qualitatively. Table 8 differs from Table 7 (per capita income measured in USD) in that in the former case, the undervaluation is more than two (unadjusted) standard errors from the conditional mean (although the caveat regarding the appropriate standard errors remains in place).

4.3 Income, Capital Account Openness and Institutions

One commonly heard argument is that the Chinese economy is special -- namely it is one that is characterized by extreme corruption. Moreover, an extensive capital control regime is still in place. We investigate whether these two particular aspects are of measurable importance in the determination of exchange rates, and if so, whether our conclusions regarding RMB misalignment are altered as a consequence.

We augment the basic real exchange rate-relative income relationship with the aforementioned Chinn-Ito capital account openness index. In addition we use the *International Country Risk Guide*'s (ICRG) Corruption Index as our measure of institutional development (where higher values of the index denote less corruption).

The results are reported in Table 9. Since the corruption index is very slow moving, with a small time-varying component, it does not make too much sense to look at the fixed effects and random effects estimates. Focusing on the pooled estimates, one observes that the per capita coefficient is largely in line with the previous estimates. Similarly, capital account openness enters in positively. On the other hand, the (lack of) corruption enters in positively only when income is measured in PPP terms: The less corruption, the stronger the local currency.

In Tables 10 and 11, the implications of these estimates are drawn out. Interestingly, when the lack of corruption enters significantly in the specification, the resulting standard error bands are wider, and the estimated degree of undervaluation commensurately smaller. In log terms, the undervaluation in 2003 is as small as 50% (or in level terms, 40%). In general, other specifications incorporating institutional factors such as Law and Order, or Political Risk (not reported), yield smaller undervaluation estimates for the RMB.

In other words, to the extent that lack of transparency is given at an instant, the RMB is less undervalued than would be indicated simply from an inspection of the relative price level.

5. Concluding Thoughts on Measuring Misalignments

The finding that capital account openness and (the lack of) corruption matters for the level of the exchange rate suggests that our understanding of when a currency is misaligned is highly circumscribed. Past experience may be helpful in illustrating this point. It is now widely acknowledged that by many conventional measures – largely based upon relative PPP – the Thai and Korean currencies did not appear terribly overvalued on the eve of their crises. For instance, Chinn's (2000a) measures indicated single digit overvaluations of the baht, and perhaps 10% misalignment for the won, based upon relative purchasing power parity measures. Yet, in light of the large contingent liabilities that were subsequently uncovered, they appeared in fact quite overvalued. The dynamics of contingent liability accumulation have been analyzed in a number of papers, with slightly different flavors, including Corsetti and Pesenti (1998), Dooley (2000), Chinn and Kletzer (2001) and Burnside et al. (1999). A similar argument can be made with respect to China: according to relative prices, the RMB may appear undervalued, but in the context of large stocks of contingent liabilities., the reverse may be true. Key among these contingent liabilities are the amount of nonperforming loans.

What determines the buildup of contingent liabilities? Obviously, this is not a resolved issue. However, Chinn, Dooley and Shrestha (1999) argue that the lack of transparency (loosely, corruption) is a determinant of financial crises. The widely acknowledged lack of transparency in the Chinese political economy appears relevant here as well. This might be one reason the corruption has an impact in the cross currency regressions of currency value determinants.

These concerns point out that the measurement of the misalignment cannot be made without conditioning the statement. In some sense, this is an obvious statement. Goldstein (2004) for instance couches his RMB undervaluation estimate in the context of continued capital controls. This makes sense, to the extent that conventional wisdom holds that those controls will be effective and in place for some years to come. However, it is all too easy to forget these conditions as one considers differing estimates of undervaluation.

Let's examine the implications of these contingent liabilities for the RMB misalignment issue more closely. The proportion of loans officially classified as nonperforming at the commercial banks is reported at 13.2% in 2004; but add in the amounts at the asset management corporations and assume 10% of the 2002-04 loans go sour, and one arrives at a 20% figure (CEQ, 2005: 11), which works out to about 19% of GDP.

One can fairly easily obtain higher estimates by making different, but plausible, assumptions. Setser (2005) observes that using official end-2002 figures (i.e., *not* making any assumptions regarding recent loans becoming nonperforming), but including NPLs at all banks and at the AMCs results in an estimated bad loan to GDP ratio of 35% by end-2004.

Consider what would happen if the liabilities associated with the 20% of loans that are nonperforming (a conservative estimate) were to be taken over by the central government. This liability could be financed with debt, or monetized. Assuming that it is monetized, the income elasticity of money demand is unity,[19] and assuming no interest or inflation elasticity of money holdings, the value of the RMB (ignoring capital controls) would decline by about 14%. Taking the 35% NPL estimate, the depreciation would be over 20%. This range brackets the average amount of undervaluation found in the survey by Cairns (2005b).

Taking all these arguments into consideration, we conclude that in the context of several models, and over several time frames, the RMB is undervalued. But several methodologies would indicate overvaluation, albeit of modest magnitude. Combined with uncertainty along statistical and theoretical lines, we would recommend circumspection in assertions of extreme RMB misalignment.

[19] Gu (2004) estimates the post 1986 real money demand elasticity as about 1.5, using both Johansen and DOLS approaches.

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Table 1: Studies of the Equilibrium Exchange Rate of the Renminbi

	Relative PPP, Competitiveness	Absolute PPP-Income Relationship	Balassa-Samuelson (with productivity)	BEER	Macroeconomic Balance/External Balance
Time Series	CCF (2005); Wang (2004)	Bosworth (2004)	CCF (2005)	Zhang (2001); Wang (2004); Funke & Rahn (2005)	Bosworth (2004); Goldstein (2004); Wang (2004)
Cross Section		Frankel (2005); Coudert & Couharde (2005)			
Panel		Cairns (2005b); CCF (2005)		CCF (2005)	Coudert & Couharde (2005)

Notes: Relative PPP indicates the real exchange rate is calculated using price or cost indices and no determinants are accounted for. Absolute PPP indicates the use of comparable price deflators to calculate the real exchange rate. Balassa-Samuelson (with productivity) indicates that the real exchange rate (calculated using price indices) is modeled as a function of sectoral productivity levels. BEER indicates composite models using net foreign assets, relative tradable to nontradable price ratios, trade openness, or other variables. Macroeconomic Balance indicates cases where the equilibrium real exchange rate is implicit in a “normal” current account (or combination of current account and persistent capital inflows, for the External Balance approach).

Table 2: Balassa-Samuelson Model of Real Exchange Rate of Renminbi, 1988-03

	Pred.	Official Deflator	Official Deflator	Official[a/] Deflator	Official[a/] Deflator	Szirmai Mfg.	Szirmai Mfg.	Szirmai Mfg. [a/]	Szirmai Mfg. [a/]
		[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
Mfg. prody	(-)	**-0.556**	**-0.921**	**-0.275**	**-0.987**	**-1.322**	-1.204[†]	**-0.512**	-1.145
		[0.184]	**[0.231]**	**[0.088]**	**[0.224]**	**[0.550]**	[0.616]	**[0.242]**	[0.735]
Oth. Prody	(+)	**1.122**	**1.087**	**0.275**	**0.987**	**1.788**	**1.882**	**0.512**	1.145
		[0.516]	**[0.527]**	**[0.088]**	**[0.224]**	**[0.748]**	**[0.724]**	**[0.242]**	[0.735]
Trend			0.028		**0.035**		-0.007		0.010
			[0.022]		**[0.009]**		[0.014]		[0.008]
Adj R2		0.77	0.76	0.71	0.8	0.79	0.76	0.73	0.73
N		15	15	15	15	15	15	15	15
SER		0.049	0.049	0.054	0.046	0.047	0.050	0.053	0.052

Notes: "Official Deflator" refers to estimates obtained using productivity figures calculated using official deflator as reported by Holz (2005); "Szirmai" refers estimates obtained using manufacturing productivity reported in Szirmai et al. (2005). All estimates use estimated effective exchange rate as described in Fernald et al. (1999). Estimates obtained using dynamic OLS (DOLS) with one lead and lag of the right hand side variables. "Mfg." ("Other") prody is the differential labor productivity in the manufacturing (other) sectors. "Pred." is the predicted sign according to the Balassa-Samuelson hypothesis. SER is the standard error of regression.
[a/] Manufacturing and Other productivity are constrained to have equal and opposite signs.

Table 3: Panel Estimation Results of the Absolute PPP Plus

Ln(price)=c+b1*Ln(GDPpc)+u

	USD-based GDP per capita				PPP-based GDP per capita			
	Pooled OLS	Between	Fixed effects (Within)	Random effects	Pooled OLS	Between	Fixed effects (Within)	Random effects
GDP p.c.	0.245** (0.003)	0.252** (0.016)	0.330** (0.032)	0.276** (0.012)	0.294** (0.006)	0.297** (0.028)	0.217** (0.032)	0.250** (0.017)
Constant	-0.023* (0.009)	-0.041 (0.052)	-	0.026 (0.043)	- 0.140** (0.012)	-0.183** (0.064)	-	-0.272** (0.044)
Adjusted R^2	0.483	0.601	0.752	0.483	0.338	0.399	0.745	0.338
F-test for Homo. C			27.871**				40.466**	
Hausman Chisq(1)				3.277[#]				1.410
# of obs.	3880				3880			

Notes: Unbalanced panel of 174 countries x 29 years (1975-2003). **, * and [#] indicate 1%, 5% and 10% levels of significance, respectively. Heteroskedasticity-robust standard errors are in the parentheses.

Table 4: Actual and predicted price levels for China by panel (pooled OLS): USD-based GDP per capita

Year	Actual	Predicted	+2 std. err.	+1 std. err.	-1 std. err.	-2 std. err.
1975	-0.245	-1.249	-0.452	-0.851	-1.647	-2.046
1976	-0.344	-1.267	-0.470	-0.869	-1.666	-2.064
1977	-0.354	-1.261	-0.464	-0.863	-1.660	-2.058
1978	-0.308	-1.248	-0.451	-0.850	-1.647	-2.045
1979	-0.272	-1.239	-0.442	-0.840	-1.637	-2.035
1980	-0.287	-1.220	-0.423	-0.822	-1.619	-2.017
1981	-0.486	-1.215	-0.418	-0.816	-1.613	-2.011
1982	-0.661	-1.190	-0.393	-0.791	-1.588	-1.986
1983	-0.716	-1.176	-0.380	-0.778	-1.575	-1.973
1984	-0.872	-1.160	-0.363	-0.761	-1.558	-1.957
1985	-1.041	-1.140	-0.343	-0.741	-1.538	-1.936
1986	-1.174	-1.129	-0.332	-0.730	-1.527	-1.925
1987	-1.233	-1.111	-0.315	-0.713	-1.510	-1.908
1988	-1.161	-1.097	-0.300	-0.698	-1.495	-1.894
1989	-1.114	-1.097	-0.300	-0.699	-1.495	-1.894
1990	-1.331	-1.093	-0.296	-0.695	-1.491	-1.890
1991	-1.406	-1.071	-0.274	-0.673	-1.469	-1.868
1992	-1.385	-1.046	-0.249	-0.648	-1.445	-1.843
1993	-1.313	-1.021	-0.224	-0.623	-1.420	-1.818
1994	-1.555	-1.002	-0.205	-0.603	-1.400	-1.798
1995	-1.443	-0.983	-0.186	-0.585	-1.381	-1.780
1996	-1.399	-0.969	-0.173	-0.571	-1.367	-1.766
1997	-1.405	-0.959	-0.162	-0.561	-1.357	-1.756
1998	-1.453	-0.950	-0.153	-0.552	-1.348	-1.747
1999	-1.490	-0.944	-0.147	-0.545	-1.342	-1.740
2000	-1.510	-0.933	-0.136	-0.534	-1.331	-1.729
2001	-1.522	-0.915	-0.119	-0.517	-1.313	-1.712
2002	-1.530	-0.900	-0.103	-0.502	-1.298	-1.697
2003	-1.517	-0.885	-0.088	-0.487	-1.283	-1.682

Notes: Values in log terms. Based upon Table 3, USD pooled estimates.

Table 5: Actual and predicted price levels for China by panel (pooled OLS): PPP-adjusted GDP per capita

Year	Actual	Predicted	+2 std. err.	+1 std. err.	-1 std. err.	-2 std. err.
1975	-0.245	-1.176	-0.274	-0.725	-1.627	-2.078
1976	-0.344	-1.199	-0.297	-0.748	-1.649	-2.100
1977	-0.354	-1.190	-0.289	-0.740	-1.641	-2.092
1978	-0.308	-1.175	-0.274	-0.724	-1.626	-2.077
1979	-0.272	-1.164	-0.263	-0.713	-1.615	-2.066
1980	-0.287	-1.141	-0.240	-0.691	-1.592	-2.043
1981	-0.486	-1.134	-0.232	-0.683	-1.584	-2.035
1982	-0.661	-1.101	-0.200	-0.650	-1.552	-2.003
1983	-0.716	-1.090	-0.188	-0.639	-1.541	-1.991
1984	-0.872	-1.068	-0.167	-0.617	-1.519	-1.969
1985	-1.041	-1.044	-0.143	-0.593	-1.495	-1.946
1986	-1.174	-1.033	-0.131	-0.582	-1.483	-1.934
1987	-1.233	-1.010	-0.109	-0.560	-1.461	-1.912
1988	-1.161	-0.990	-0.089	-0.539	-1.441	-1.891
1989	-1.114	-0.994	-0.092	-0.543	-1.444	-1.895
1990	-1.331	-0.991	-0.089	-0.540	-1.441	-1.892
1991	-1.406	-0.964	-0.063	-0.514	-1.415	-1.866
1992	-1.385	-0.935	-0.034	-0.485	-1.386	-1.837
1993	-1.313	-0.906	-0.005	-0.455	-1.357	-1.807
1994	-1.555	-0.883	0.019	-0.432	-1.333	-1.784
1995	-1.443	-0.854	0.048	-0.403	-1.304	-1.755
1996	-1.399	-0.837	0.064	-0.386	-1.288	-1.738
1997	-1.405	-0.825	0.076	-0.374	-1.275	-1.726
1998	-1.453	-0.810	0.091	-0.359	-1.261	-1.711
1999	-1.490	-0.802	0.099	-0.351	-1.253	-1.703
2000	-1.510	-0.786	0.115	-0.336	-1.237	-1.688
2001	-1.522	-0.765	0.136	-0.315	-1.216	-1.667
2002	-1.530	-0.750	0.151	-0.299	-1.201	-1.651
2003	-1.517	-0.735	0.166	-0.285	-1.186	-1.636

Notes: Values in log terms. Based upon Table 3, PPP pooled estimates.

Table 6: The Panel Estimation Results of the Augmented BS Regression:
Ln(price)=c+b1*Ln(GDPpc)+b2*(Pop14)+b3*(Pop65)+b4*(KOPEN)+b5*(Gov. Deficit/GDP)+b6*(M2/GDP)+u

	USD-based GDP per capita				PPP-based GDP per capita			
	Pooled OLS	Between	Fixed effects (Within)	Random effects	Pooled OLS	Between	Fixed effects (Within)	Random effects
GDP p.c.	0.242** (0.007)	0.269** (0.027)	0.397** (0.034)	0.265** (0.017)	0.243** (0.014)	0.274** (0.049)	0.273** (0.034)	0.254** (0.024)
POP14	0.394** (0.036)	0.625** (0.146)	0.003 (0.062)	0.120* (0.056)	0.320** (0.044)	0.620** (0.181)	-0.020 (0.063)	0.070 (0.058)
POP65	0.307** (0.034)	0.433* (0.167)	0.357** (0.088)	0.115 (0.083)	0.380** (0.041)	0.529** (0.200)	0.427** (0.089)	0.260** (0.087)
KOPEN	0.099** (0.012)	0.014 (0.066)	0.064** (0.016)	0.078** (0.015)	0.152** (0.014)	0.099 (0.078)	0.061** (0.016)	0.079** (0.015)
GDEF	0.000 (0.000)	-0.002 (0.001)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	-0.002 (0.002)	0.000 (0.000)	0.000 (0.000)
M2/GDP	0.228** (0.025)	0.365** (0.136)	0.206** (0.037)	0.177** (0.039)	0.338** (0.029)	0.571** (0.161)	0.253** (0.037)	0.242** (0.040)
Constant	-0.897** (0.073)	-1.300** (0.315)		-0.294* (0.133)	-1.051** (0.086)	-1.638** (0.376)		-0.559** (0.137)
Adjusted R^2	0.593	0.730	0.798	0.584	0.516	0.610	0.791	0.504
F-test for Homo. C			22.111**				28.240**	
Hausman Chisq(2)				30.000**				14.385**
# of obs.	2453							

Notes: Unbalanced panel of 174 countries x 29 years (1975-2003). Import and government deficit (GDEF) are relative to GDP. **, * and # indicate 1%, 5% and 10% levels of significance, respectively. Heteroskedasticity-robust standard errors are in the parentheses.

Table 7: Actual and predicted price levels for China by panel (pooled OLS): USD-based GDP per capita

Year	Actual	Predicted	+2 std. err.	+1 std. err.	-1 std. err.	-2 std. err.
1987	-1.233	-1.203	-0.513	-0.858	-1.549	-1.894
1988	-1.161	-1.208	-0.517	-0.863	-1.553	-1.898
1989	-1.114	-1.211	-0.521	-0.866	-1.557	-1.902
1990	-1.331	-1.204	-0.514	-0.859	-1.549	-1.895
1991	-1.406	-1.182	-0.492	-0.837	-1.528	-1.873
1992	-1.385	-1.162	-0.472	-0.817	-1.508	-1.853
1993	-1.313	-1.118	-0.428	-0.773	-1.464	-1.809
1994	-1.555	-1.103	-0.412	-0.757	-1.448	-1.793
1995	-1.443	-1.105	-0.414	-0.759	-1.450	-1.795
1996	-1.399	-1.088	-0.398	-0.743	-1.433	-1.778
1997	-1.405	-1.067	-0.377	-0.722	-1.412	-1.757
1998	-1.453	-1.052	-0.362	-0.707	-1.397	-1.742
1999	-1.490	-1.044	-0.354	-0.699	-1.389	-1.734
2000	-1.510	-1.024	-0.334	-0.679	-1.369	-1.714
2001	-1.522	-1.012	-0.322	-0.667	-1.357	-1.702
2002	-1.530	-0.988	-0.297	-0.643	-1.333	-1.678
2003	-1.517	-0.983	-0.293	-0.638	-1.328	-1.673

Notes: Values in log terms. Based upon Table 6, USD pooled estimates.

Table 8: Actual and predicted price levels for China by panel (pooled OLS): PPP-adjusted GDP per capita

Year	Actual	Predicted	+2 std. err.	+1 std. err.	-1 std. err.	-2 std. err.
1987	-1.233	-1.024	-0.271	-0.648	-1.401	-1.777
1988	-1.161	-1.029	-0.276	-0.652	-1.405	-1.782
1989	-1.114	-1.030	-0.277	-0.654	-1.407	-1.783
1990	-1.331	-1.016	-0.263	-0.639	-1.393	-1.769
1991	-1.406	-0.990	-0.237	-0.614	-1.367	-1.744
1992	-1.385	-0.969	-0.216	-0.593	-1.346	-1.722
1993	-1.313	-0.911	-0.159	-0.535	-1.288	-1.664
1994	-1.555	-0.893	-0.141	-0.517	-1.270	-1.646
1995	-1.443	-0.896	-0.143	-0.520	-1.272	-1.649
1996	-1.399	-0.879	-0.126	-0.502	-1.255	-1.631
1997	-1.405	-0.859	-0.107	-0.483	-1.236	-1.612
1998	-1.453	-0.832	-0.080	-0.456	-1.208	-1.584
1999	-1.490	-0.824	-0.072	-0.448	-1.200	-1.576
2000	-1.510	-0.803	-0.050	-0.426	-1.179	-1.555
2001	-1.522	-0.787	-0.035	-0.411	-1.163	-1.539
2002	-1.530	-0.757	-0.005	-0.381	-1.133	-1.509
2003	-1.517	-0.755	-0.003	-0.379	-1.131	-1.507

Notes: Values in log terms. Based upon Table 6, PPP pooled estimates.

Table 9: The Panel Estimation Results of the BS Regression with KOPEN and institutional variables (Corrupt)

Ln(price)=c+b1*Ln(GDPpc)+b2*(KOPEN)+b3*(Corrupt)+u

	USD-based GDP per capita				PPP-based GDP per capita			
	Pooled OLS	Between	Fixed effects (Within)	Random effects	Pooled OLS	Between	Fixed effects (Within)	Random effects
GDP p.c.	0.276** (0.006)	0.276** (0.024)	0.283** (0.068)	0.289** (0.015)	0.290** (0.013)	0.261** (0.042)	0.051 (0.063)	0.290** (0.025)
KOPEN	0.055** (0.015)	0.055 (0.065)	0.054** (0.017)	0.053** (0.016)	0.168** (0.19)	0.228** (0.080)	0.055** (0.017)	0.069** (0.017)
CORRUPT	0.044 (0.032)	0.080 (0.126)	-0.074# (0.037)	-0.059 (0.037)	0.176** (0.042)	0.291# (0.163)	-0.088* (0.037)	-0.043 (0.039)
Constant	-0.026 (0.035)	-0.068 (0.138)		0.067 (0.057)	- 0.331** (0.046)	-0.495** (0.174)		-0.180** (0.064)
Adjusted R^2	0.691	0.765	0.880	0.689	0.554	0.615	0.878	0.537
F-test for Homo. C			22.930**				37.949**	
Hausman Chisq(2)				0.034				20.420***
# of obs.	1516				1516			

Notes: Unbalanced panel of 174 countries x 29 years (1975-2003). **, * and # indicate 1%, 5% and 10% levels of significance, respectively. Heteroskedasticity-robust standard errors are in the parentheses.

Table 10: Actual and predicted price levels for China by panel (pooled OLS): USD-based GDP per capita

Year	Actual	Predicted	+2 std. err.	+1 std. err.	-1 std. err.	-2 std. err.
1989	-1.114	-1.239	-0.596	-0.918	-1.561	-1.883
1990	-1.331	-1.232	-0.589	-0.910	-1.554	-1.876
1991	-1.406	-1.215	-0.571	-0.893	-1.537	-1.858
1992	-1.385	-1.187	-0.543	-0.865	-1.508	-1.830
1993	-1.313	-1.138	-0.494	-0.816	-1.460	-1.781
1994	-1.555	-1.116	-0.472	-0.794	-1.437	-1.759
1995	-1.443	-1.095	-0.451	-0.773	-1.416	-1.738
1996	-1.399	-1.079	-0.436	-0.758	-1.401	-1.723
1997	-1.405	-1.063	-0.420	-0.742	-1.385	-1.707
1998	-1.453	-1.053	-0.410	-0.732	-1.375	-1.697
1999	-1.490	-1.050	-0.407	-0.729	-1.372	-1.694
2000	-1.510	-1.038	-0.395	-0.716	-1.360	-1.681
2001	-1.522	-1.036	-0.393	-0.714	-1.357	-1.679
2002	-1.530	-1.015	-0.371	-0.693	-1.336	-1.658
2003	-1.517	-0.998	-0.355	-0.676	-1.319	-1.641

Notes: Values in log terms. Based upon Table 9, USD pooled estimates.

Table 11: Actual and predicted price levels for China by panel (pooled OLS): PPP-adjusted GDP per capita

Year	Actual	Predicted	+2 std. err.	+1 std. err.	-1 std. err.	-2 std. err.
1989	-1.114	-1.148	-0.374	-0.761	-1.535	-1.922
1990	-1.331	-1.134	-0.360	-0.747	-1.521	-1.908
1991	-1.406	-1.138	-0.364	-0.751	-1.524	-1.911
1992	-1.385	-1.109	-0.335	-0.722	-1.496	-1.882
1993	-1.313	-1.011	-0.237	-0.624	-1.397	-1.784
1994	-1.555	-0.988	-0.214	-0.601	-1.374	-1.761
1995	-1.443	-0.959	-0.186	-0.572	-1.346	-1.732
1996	-1.399	-0.943	-0.169	-0.556	-1.329	-1.716
1997	-1.405	-0.913	-0.140	-0.526	-1.300	-1.687
1998	-1.453	-0.899	-0.125	-0.512	-1.285	-1.672
1999	-1.490	-0.908	-0.135	-0.522	-1.295	-1.682
2000	-1.510	-0.893	-0.120	-0.506	-1.280	-1.666
2001	-1.522	-0.941	-0.168	-0.555	-1.328	-1.715
2002	-1.530	-0.910	-0.137	-0.523	-1.296	-1.683
2003	-1.517	-0.895	-0.122	-0.509	-1.282	-1.669

Notes: Values in log terms. Based upon Table 9, PPP pooled estimates.

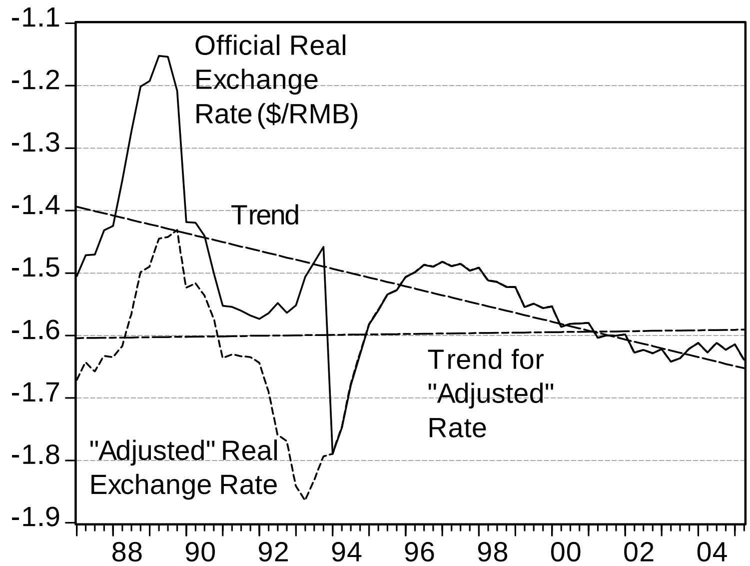

Figure 1: Real USD/RMB Exchange Rate, in logs (Official and "Adjusted") and Trends

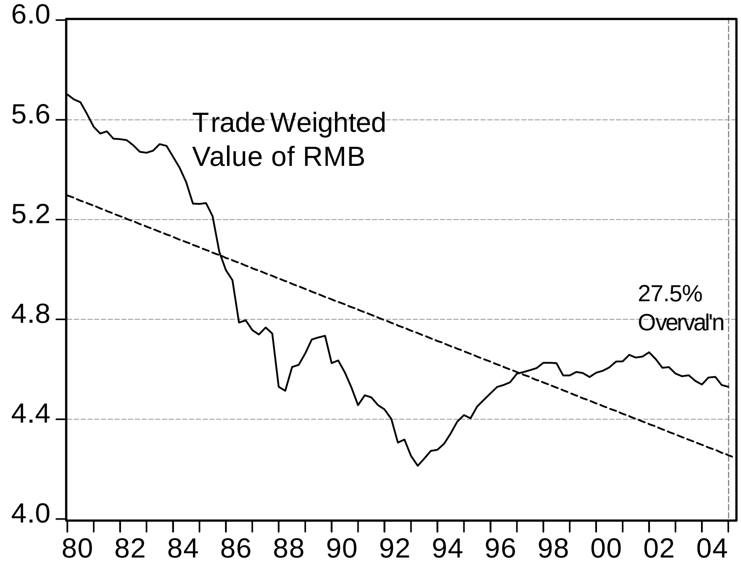

Figure 2: Real Trade Weighted Value of RMB, in logs, and Trend.

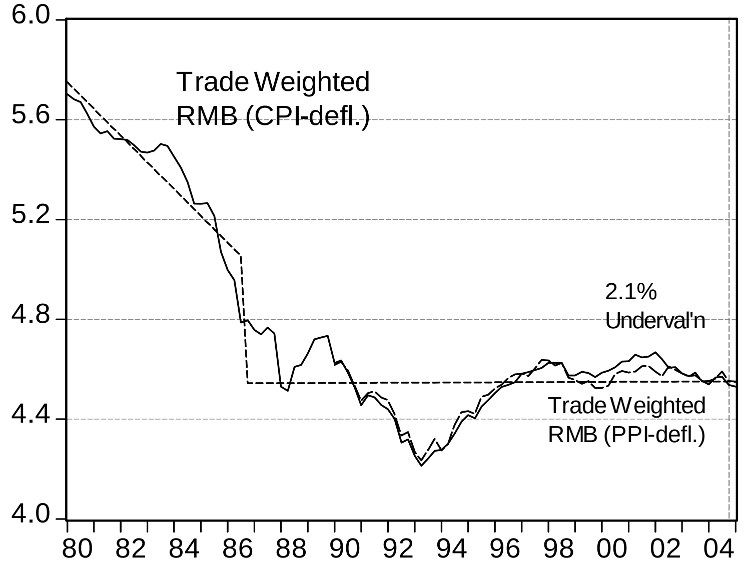

Figure 3: Real Trade Weighted Indices of RMB, in logs, and Segmented Trend. Sources: IMF, Deutsche Bank and Author's Calculations.

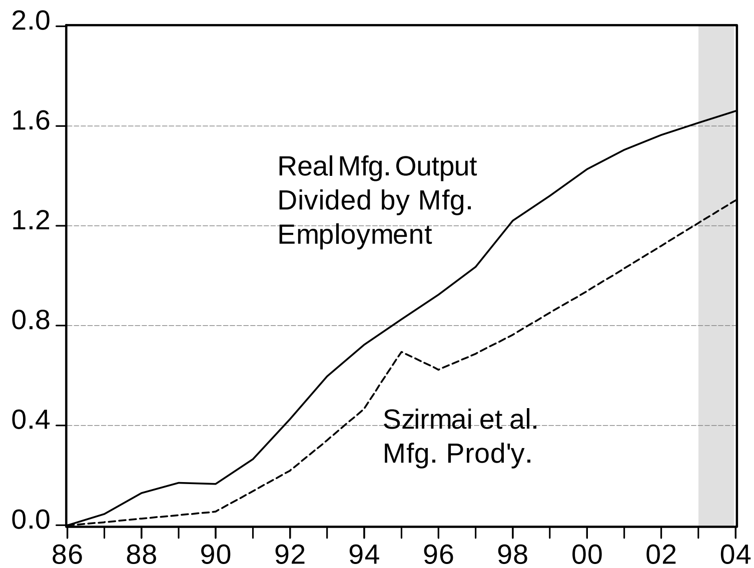

Figure 4: Measures of Chinese Manufacturing Productivity, in logs, normalized to 1986=0.

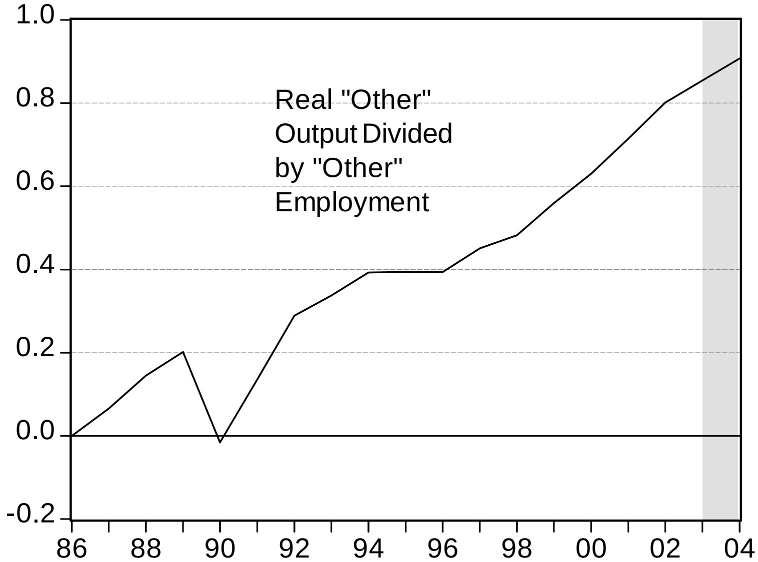

Figure 5: The Measure of “Other” Productivity, in logs, normalized to 1986=0.

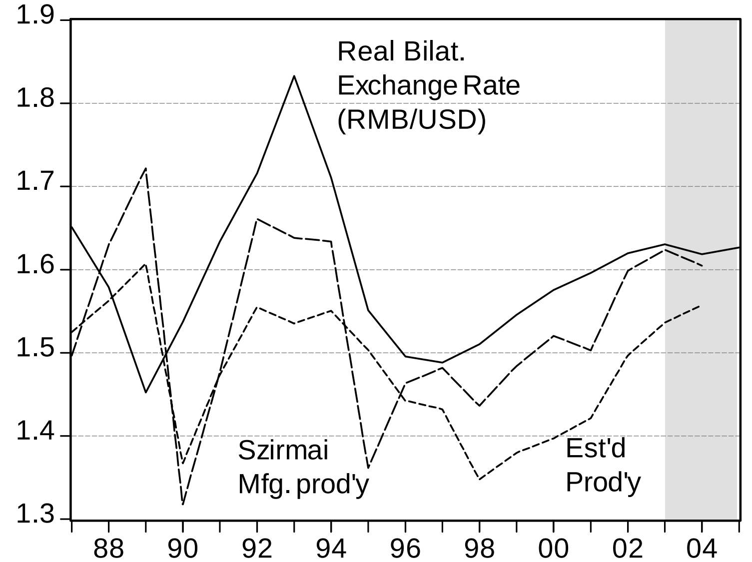

Figure 6: Real Bilateral (“Adjusted”) Exchange Rate, and Predicted Long Run Rate, in logs, based upon Estimated Productivity and Szirmai et al. Manufacturing Productivity.

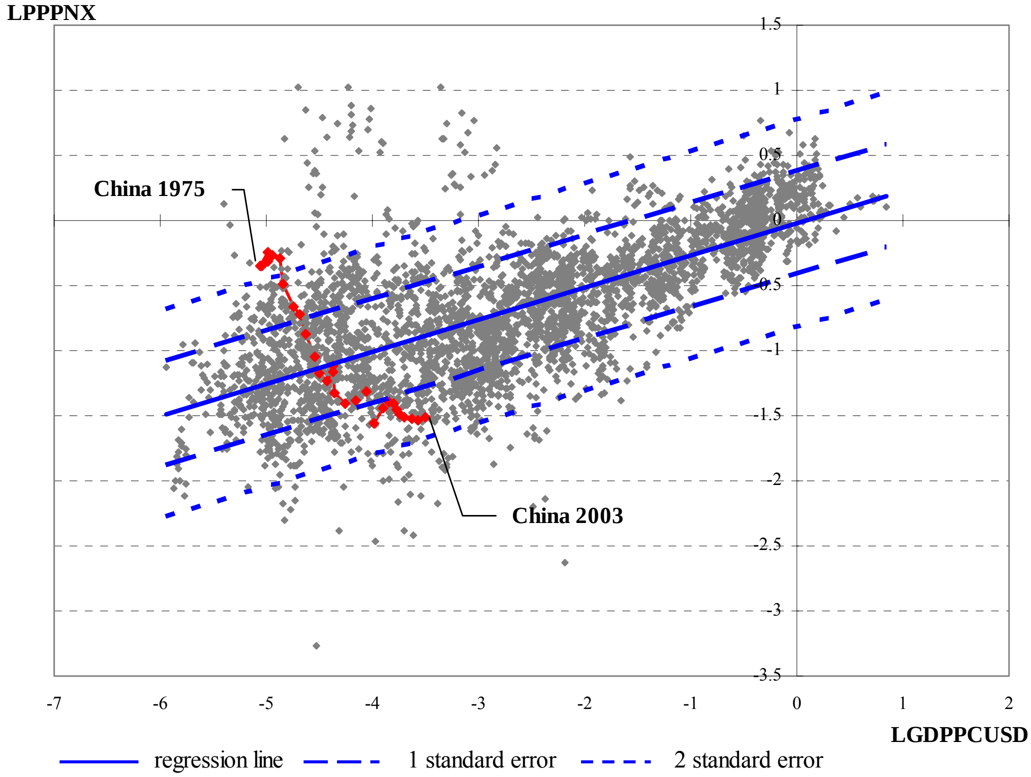

Figure 7: Scatterplot of Relative Price Level against Relative Per Capita Income (in USD), Conditional Mean, and Prediction Intervals

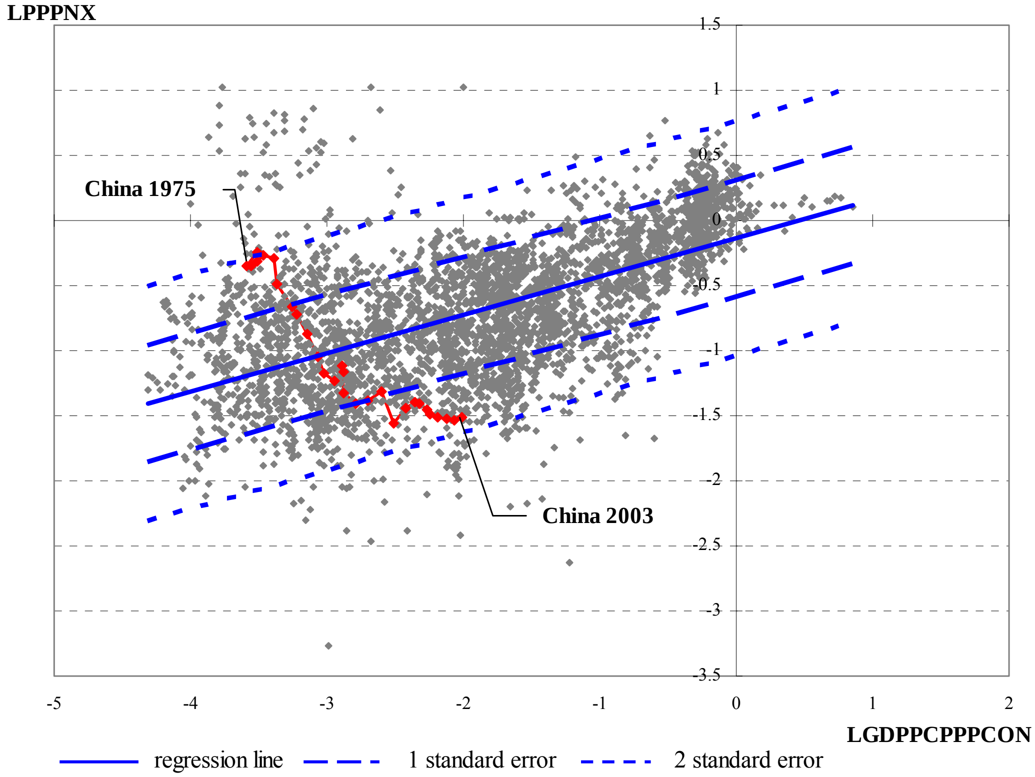

Figure 8: Scatterplot of Relative Price Level against Relative Per Capita Income (in PPP terms), Conditional Mean, and Prediction Intervals

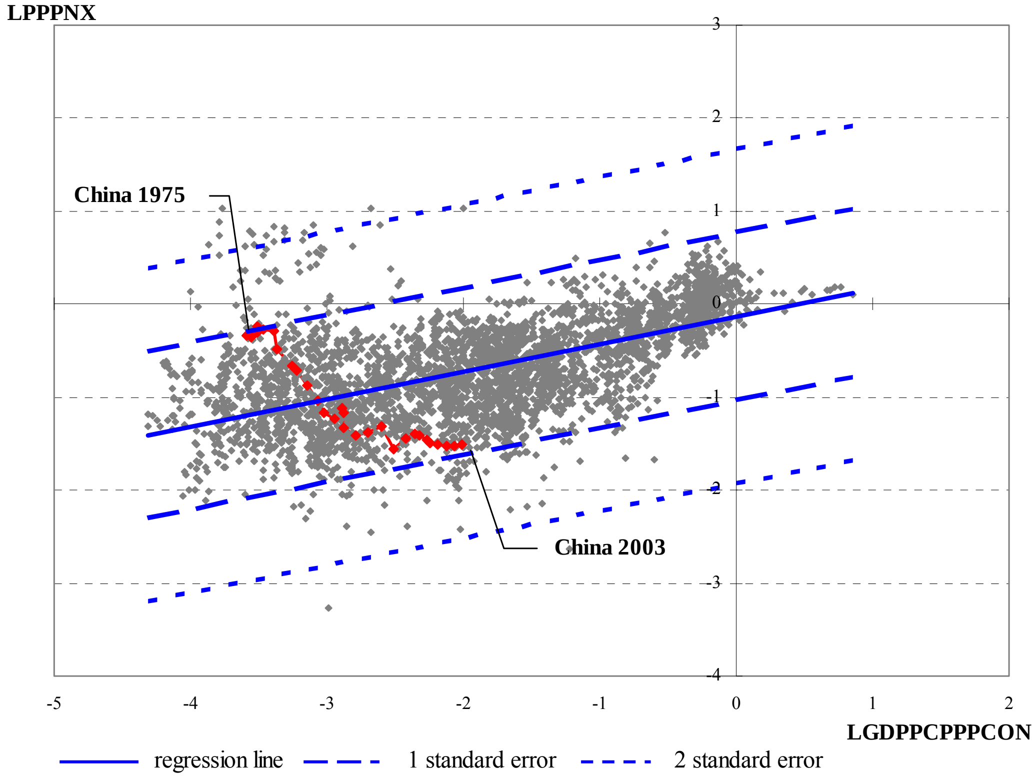

Figure 9: Scatterplot of Relative Price Level against Relative Per Capita Income (in PPP terms), Conditional Mean, and Serial Correlation Adjusted Prediction Intervals

Appendix 1
Data and Sources

For Section 1:

The nominal Renminbi exchange rate is the bilateral period average, expressed against the US$ (in $/f.c.u.), obtained from the IMF's *International Financial Statistics*, and from Hali Edison, for the "adjusted" exchange rates (Fernald et al., 1999). The CPI's are drawn from the CEIC database, extrapolated for 2004 and 2005 by using the CPI growth rates reported in *IFS.* The CPI deflated trade weighted exchange rate is drawn from IFS, while the PPI deflated series was provided by Michael Spencer at Deutsche Bank.

For Section 3

The nominal Renminbi exchange rate source is described in Section 1. Tradables and nontradables are proxied by manufacturing, and for "other", which includes mostly services, construction, and transportation, respectively.

For the United States, labor productivity in manufacturing: BLS (Foreign Labor Statistics website) "International Comparisons of Manufacturing Productivity and Unit Labor Cost Trends, Supplementary Tables, 1950 – 2003". http://www.bls.gov/fls/prodsupptabletoc.htm . U.S. productivity in 2004 calculated from output and hours from BLS website, accessed 21 August. Labor productivity in "other" for 1979-2002 from 60-Industry Database (latest update February 2005) http://www.ggdc.net/dseries/60-industry.shtml from Groningen Growth and Development Center. 1995 chained value added data and employment numbers for all industries above SIC 3. Productivity growth rate for 2003-04 set at 2002 rate.

For China, the basic productivity data is calculated as the ratio of nominal sectoral output to sectoral employment, as reported in the Asian Development Bank's *Key Indicators of Developing Asian and Pacific Countries*. The Chinese real output series are obtained by deflating using the GDP price deflator (base year 2000), as reported in Holz (2005). The alternative manufacturing productivity index is drawn from Szirmai et al. (2005). 2003 data assumes 2002 productivity growth continues. 2004 figures for all Chinese data are extrapolated from 2003 growth rates.

Some additional results are also reported using a 1980-2004 sample. These results are based upon spliced series, where 1980-85 data on Chinese productivity is drawn from the database used in Chinn (2000b). Manufacturing productivity is that reported by the World Bank's World Tables, while "Other" productivity is generated in the method described using data from the ADB and the ILO. The effective exchange rate is assumed to equal the official over the 1980-86 period.

For Section 4

The data for macroeconomic aggregates are mostly drawn from the World Bank's *World Development Indicators*. These include demographic variables, per capita income and government deficits. Relative price levels and per capita income are drawn from the Penn World Tables (Summers and Heston, 1991), as drawn from http://pwt.econ.upenn.edu/. Financial development indicators, including lending, stock and bond market capitalization, are drawn from the Beck, et al. (2000). The capital controls index is from Chinn and Ito (forthcoming). The (inverse) corruption index is drawn from the *International Country Risk Guide*. Data for Taiwan are drawn from the Central Bank of China, ICSEAD, and ADB, *Key Indicators of Developing Asian and Pacific Countries.*

Appendix 2
Relative Purchasing Power Parity Tests

	Bilateral		Trade Weighted	
Panel A: Johansen Cointegration Tests				
k	3	3	2	2
#,#[#,#]	1,1[1,1]	2,2[2,2]	1,0[0,0]	2,0[2,0]
Spec.	w/o	w/trend	w/o	w/trend
β_1	1	1	1	1
β_2	1.503***	1.455***	0.765*	0.828
	(0.125)	(0.118)	(0.168)	(0.162)
Panel B: Horvath-Watson Cointegration Tests				
Wald	12.556		11.427	
Smpl	87q4-05q2	87q4-05q2	87q1-05q1	87q1-05q1
N	71	71	73	73

Notes: Panel A: *k* is lag in VAR specification. #,#[#,#] is the number of cointegrating vectors according to a likelihood ratio test on the trace, maximal eigenvalue statistic, using asymptotic [finite sample] critical values. Spec. indicates whether a deterministic trend is assumed to be in the data ("w/trend"), or not ("w/o"). Finite sample critical values from Cheung and Lai (1993). βi are cointegrating vector coefficients. *(**)[***] denotes significance at the 10%(5%)[1%] MSL for the null hypothesis of $\beta_2 = 1$. Panel B: Wald is the Wald test statistic for the joint null that the reversion coefficients in the VECM representation are zero. Critical values are 9.72 (11.62)[15.41], from Horvath and Watson (1995). Smpl is sample, N is number of observations.