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China's Current Account and Exchange Rate

Yin-Wong Cheung, Menzie D. Chinn, and Eiji Fujii

7.1 Introduction

China—and Chinese economic policy—has loomed large on the global economic stage in recent years. Yet, even as arguments over the normalcy of the Chinese trade balance and the value of the Chinese currency continue, there is substantial debate in both academic and policy circles surrounding what the determinants of these variables are.

Interestingly, there are very few studies that simultaneously assess the Chinese exchange rate and trade/current account balance. This is partly an outcome of the peculiar characteristics of the Chinese economy. In this study, we attempt to inform the debate over the interactions between the exchange rate and the current account by recourse to two key methodologies. First, we identify the equilibrium real exchange rate from the standpoint of cross-country studies. Second, we attempt to obtain more precise estimates of Chinese trade elasticities, both on a multilateral and bilateral (with the United States) basis. In doing so, we hope to transcend the current limited debate based upon rules of thumb.

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To anticipate our results, we obtain several interesting findings. First, the renminbi (RMB) was substantially below the value predicted by our cross-country estimates (although that conclusion does not survive the advent of revised data). The economic magnitude of the misalignment is substantial—on the order of 50 percent in log terms. However, we also find that the misalignment is typically not statistically significant, in the sense of being more than 1 standard error away from the conditional mean. Moreover, substantial revisions to the underlying data provide even more reason to be circumspect about estimates of currency misalignment.

Second, we find that Chinese multilateral trade flows do respond to relative prices—as represented by a trade-weighted exchange rate—but that that relationship is not always precisely estimated. In addition, the direction of effects is different than expected a priori. For instance, we find that Chinese ordinary imports rise in response to a RMB depreciation. However, Chinese exports do appear to respond to RMB depreciation in the expected manner, as long as a supply variable is included. So, in this sense, Chinese trade is not exceptional.

Furthermore, Chinese trade with the United States appears to behave in a standard manner—especially after the expansion in the Chinese manufacturing capital stock is accounted for. Thus, the China-U.S. trade balance should respond to real exchange rate and relative income movements in the anticipated manner. However, in neither the case of multilateral nor bilateral trade flows should one expect quantitatively large effects arising from exchange rate changes. And, of course, our results are not informative with regard to the question of how a change in the RMB U.S. dollar (USD) exchange rate would affect the overall U.S. trade deficit.

Finally, we highlight the fact that considerable uncertainty surrounds both our estimates of RMB misalignment and the responsiveness of trade flows to movements in exchange rates and output levels. In particular, our results for trade elasticities are sensitive to econometric specification, accounting for supply effects, and the inclusion of time trends.

7.2 Placing Matters in Perspective

A discussion of the Chinese economy, and its interaction with the global economy, is necessarily complicated, in large part because of its recent—and incomplete—transition from a central command economy to a market economy.[1]

Take, for instance, the proper measure of the exchange rate in both nominal and real terms, the central relative prices in any open macroeconomy.

1. See Cheung, Chinn, and Fujii (2007a) for discussion of various issues related to the transformation of the Chinese economy.

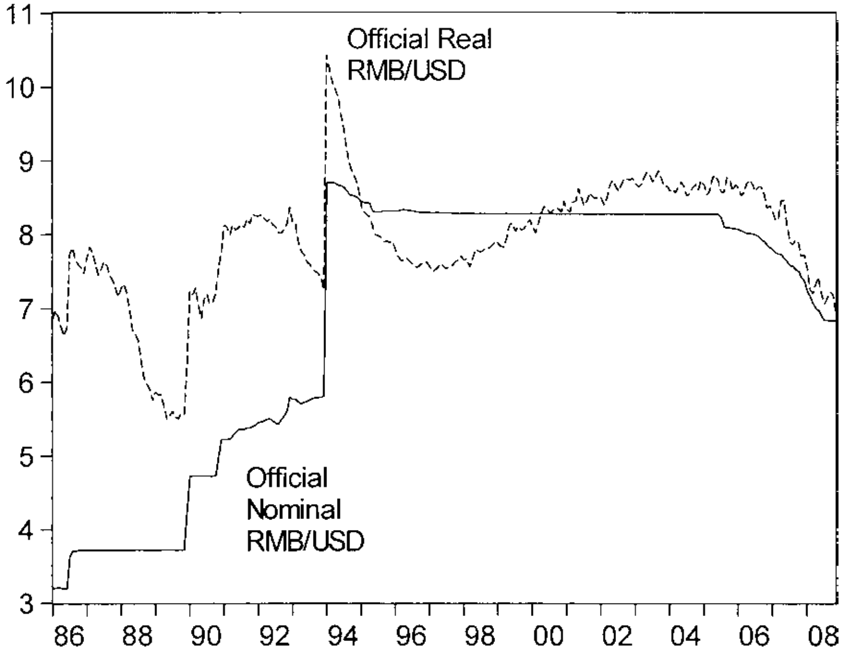

Fig. 7.1 Official nominal and real RMB/USD, 1986M01–2008M11
Sources: IMF, *International Financial Statistics,* and authors' calculations.

Figure 7.1 depicts the official bilateral value of the Chinese currency over the last twenty years. Taking the standard approach in the crisis early warning system literature, one can calculate the extent of exchange rate overvaluation as a deviation 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 United States and the RMB implies. In figure 7.1, the rate is expressed so higher values constitute a weaker Chinese currency. Over the entire sample period, the RMB has experienced a downward trend in value.

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 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. Figure 7.2 shows the official rate (the solid line) at which some transactions took place, and a floating rate—often called the "swap-market rate"—shown with the thick dashed line. Using a transactions-weighted average of these two rates (called the "adjusted rate") yields a substantially

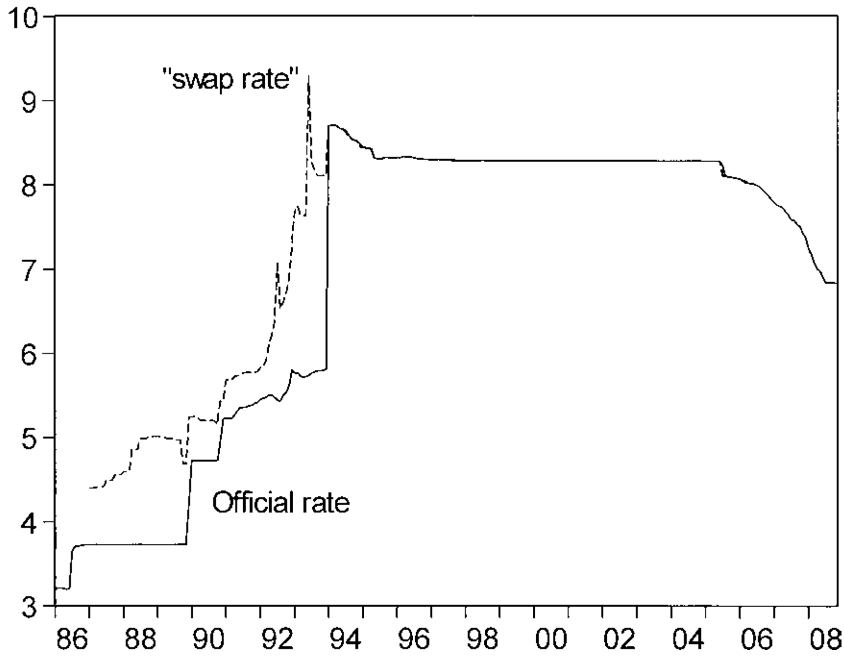

Fig. 7.2 Official and "swap" RMB/USD rate, 1986M01–2007M06
Sources: IMF, *International Financial Statistics* and Fernald, Edison, and Loungani (1999).

different profile for the RMB's path, with a substantially different (essentially flat) trend, as depicted in figure 7.3.[2]

The trade-weighted exchange rate is arguably more relevant. Figure 7.4 depicts the International Monetary Fund's (IMF)s effective exchange rate index (logged) and a linear trend estimated over the available sample of 1986-2008M09. Following the methodology outlined in Chinn (2000a), Cheung, Chinn, and Fujii (2009a) 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. This means that we can use this trend line as a statistically valid indication of the mean value, which the real exchange rate series reverts to. Interestingly, repeating this procedure for the more recent period yields a 14.2 percent *over*valuation in 2008M09.

It is obviously an understatement to say that the Chinese current and trade accounts have elicited substantial interest in policy and academic circles over the past few years, in part because of the apparent break in the behavior of these flows. Figure 7.5 shows the current account balance expressed in dollar

2. See Fernald, Edison, and Loungani (1999) for a discussion in the context of whether the 1994 "devaluation" caused the 1997 to 1998 currency crises.

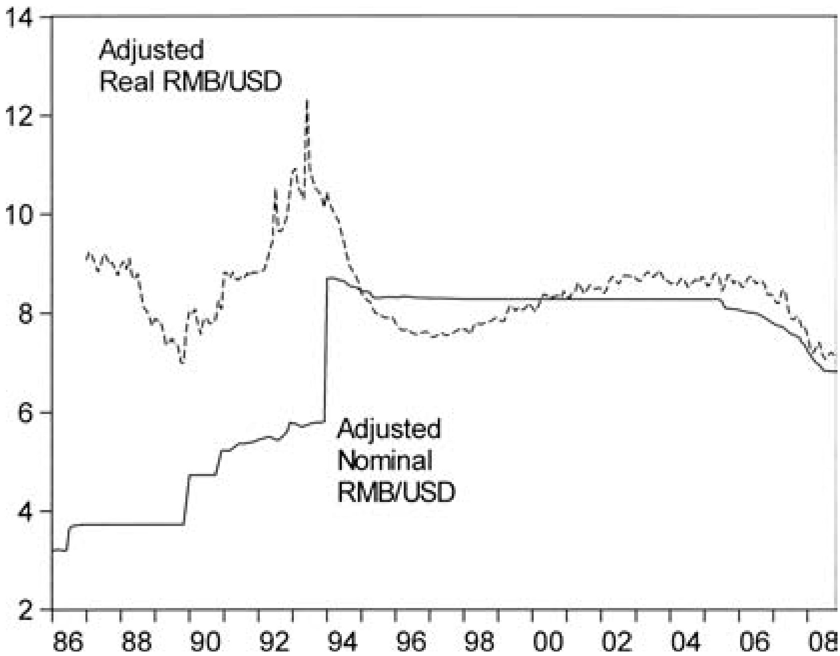

Fig. 7.3 Adjusted nominal and real RMB/USD, 1986M01–2008M11
Sources: IMF, *International Financial Statistics,* Fernald, Edison, and Loungani (1999), and authors' calculations.

terms and as a share of gross domestic product (GDP). Clearly, the Chinese current account balance has ballooned in recent years, sparking the debate over the "normalcy" and propriety of a large emerging market running such a large surplus. Of course, normalcy is in the eye of the beholder. Chinn and Ito (2007) argue that China's current account surplus over the 2000 to 2004 period—while exceeding the predicted value—was within the statistical margin of error, according to a model of the current account based upon the determinants of saving and investment.[3]

The current account balance is driven largely by the trade balance.[4] Figure 7.6 shows the trade balance in dollar terms. Until about 2004, the Chinese trade account was in rough balance, with deficits against other countries offsetting a trade surplus with the United States.

This brings us to one interesting aspect of the Chinese experience—the

3. Chinn and Ito's analysis is based upon the Chinn and Prasad (2003) approach to estimating the "normal" level of a current account balance, using as fundamentals the budget balance, per capita income, demographic variables, and various other control variables.

4. Although the gap has increased in recent years, with the current account exceeding the trade balance as income on China's increasing foreign exchange reserves offsets income payments to a greater and greater extent.

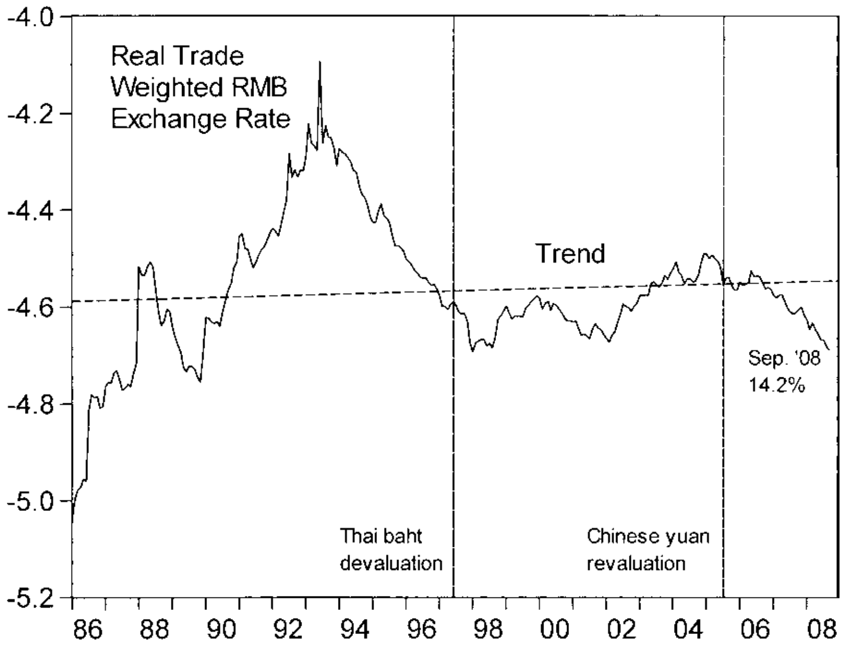

Fig. 7.4 Log trade-weighted real RMB exchange rate, 1986M01–2008M11, and linear time trend

Sources: IMF, *International Financial Statistics* and authors' calculations. Pre-1994 data from March 2007 *International Financial Statistics.*

fact that such a large portion of the Chinese surplus is accounted for by the United States. Figure 7.6 also shows the bilateral surplus with the United States, highlighting the fact that the behavior of overall Chinese trade balances differs substantially from that of the China-U.S. trade balance.[5] This divergence reflects in part China's role in the global supply chain.

It is because of this disjuncture between some of the measures of equilibrium exchange rates and the behavior of the external accounts that we adopt the procedure of examining first a model of the equilibrium exchange rate, and then—taking the exchange rate as largely exogenous—estimating the responsiveness of trade flows to the various macroeconomic variables in a partial equilibrium framework.

5. Note that in this figure, we have used the Chinese measure of the China-U.S. trade balance, which differs from the U.S. measure, due to both differences in valuation measures and treatment of reexports via Hong Kong.

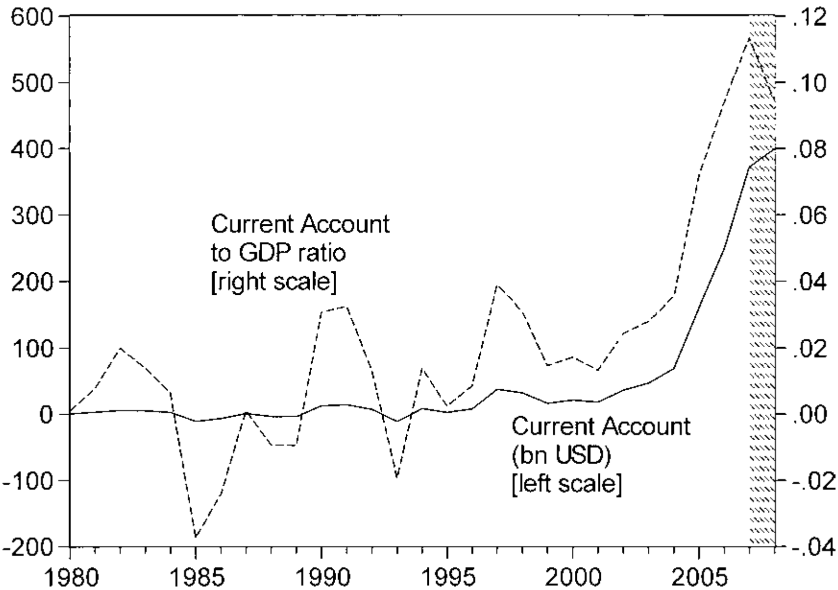

Fig. 7.5 Current account balance (in billions of U.S. dollars, left scale) and current account-GDP ratio (right scale)

Source: IMF, *World Economic Outlook* (October 2008).

Note: Statistics for 2008 are IMF projections.

7.3 The Chinese Equilibrium Exchange Rate

7.3.1 An Overview of Approaches

Several surveys have compared the estimates of the degree to which the RMB is misaligned. The Government Accountability Office (2005) provides a comparison of the academic and policy literature, while Cairns (2005b) briefly surveys recent point estimates obtained by different analysts. Here, we review the literature to focus primarily on the economic and econometric distinctions associated with the various analyses. We also restrict our attention to those studies conducted in recent years.

Many of these papers fall into familiar categories, either relying upon some form of relative purchasing power parity (PPP) or cost competitiveness calculation, the modeling of deviations from absolute PPP, a composite model incorporating several channels of effects (sometimes called "behavioral equilibrium exchange rate models"), or flow equilibrium models. Table 7.1 provides a typology of these approaches, further disaggregated by the data dimension (cross-section, time series, or both).

The relative PPP comparisons are the easiest to make, in terms of calculations. However, relative PPP in levels requires the cointegration of the

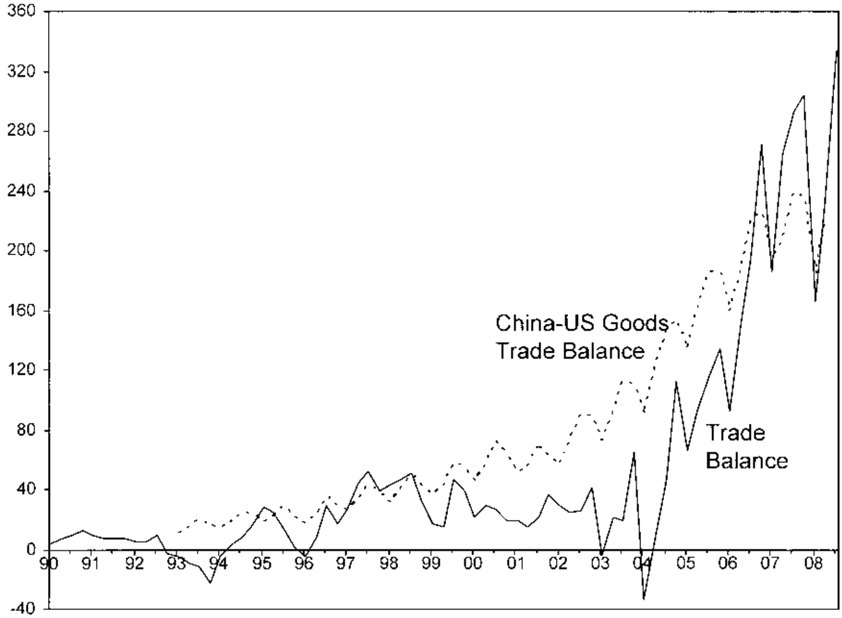

Fig. 7.6 Trade balance and bilateral China-U.S. trade balance, in billions of U.S. dollars at annual rates

Sources: CEIC, BEA/Census via Haver, and authors' calculations.

Note: China-U.S. balance is simple average of Chinese and U.S. data.

relevant price indexes with the nominal exchange rate (or, equivalently, the stationarity of the real exchange rate), but these conditions do not necessarily hold and are seldom tested for. Wang (2004) reports some 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 indexes, depends upon selecting a year that is deemed to represent equilibrium. Selecting a year before 1992 would imply that the RMB has depreciated over time.

Bosworth (2004), Frankel (2006), 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.

Wang (2004) and Funke and Rahn (2007) implement what could broadly be described as behavioral equilibrium exchange rate (BEER) specifications. These models incorporate a variety of channels through which the real exchange rate is affected. Because each author selects different variables to include, the implied misalignments will necessarily vary, as discussed in Dunaway et al. (2009) as well as McCown, Pollard, and Weeks (2007).

Table 7.1 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 (2009a); Wang (2004)	Bosworth (2004)	CCF (2009a)	Zhang (2001); Wang (2004); Funke and Rahn (2005)	Bosworth (2004); Goldstein (2004); Wang (2004)
Cross section		Frankel (2006); Coudert and Couharde (2005)			
Panel		Cairns (2005b); CCF (2007b)		CCF (2009a)	Coudert and Couharde (2005)

Notes: Relative purchasing power parity (PPP) indicates the real exchange rate is calculated using price or cost indexes 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 indexes) is modeled as a function of sectoral productivity levels. Behavioral equilibrium exchange rate (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). CCF denotes Cheung, Chinn, and Fujii.

A different set of approaches eschews the price-based approaches and views the current account as the residual of savings and investment behavior. The equilibrium exchange rate is derived from the implied medium-term current account using import and export elasticities. In the IMF's macroeconomic approach, the norms are estimated. Coudert and Couharde (2005) implement a closely related approach for China.

A final set of approaches, popular in the policy arena, focuses on the persistent components of the balance of payments (Goldstein 2004; Bosworth 2004). This last set of approaches—what we will term the "external accounts approach"—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 the period before the current account surge was due to speculative inflow; hence, the degree of misalignment was small. That assessment has been viewed as less applicable as the current account balance has surged in the past two years.[6]

Two observations regarding these various estimates are of interest. First, as noted by Cairns (2005a), there is an interesting relationship between the particular approach adopted by a study and the degree of misalignment found. Analyses implementing relative PPP and related approaches indicate the least misalignment. Those adopting approaches focusing on the external accounts yield estimates that are in the intermediate range. Finally, studies implementing an absolute PPP methodology result in the greatest degree of estimated undervaluation.

Given that the last approach is the most straightforward in terms of implementation, we adopt it, cognizant of the tendency of this approach to maximize the estimated extent of misalignment.

7.3.2 A Framework

The key problem with explaining the Chinese exchange rate and current account imbalance is that China deviates substantially from cross-country norms for at least its currency value.

Following Cheung, Chinn, and Fujii (2007b), we exploit a well-known relationship between deviations from absolute PPP and real per capita income using panel regression methods. By placing the RMB in the context of this well-known empirical relationship exhibited by a large number of developing and developed countries, over a long time horizon, this approach addresses the question of where China's real exchange rate stands relative to

6. In addition, such flow-based measures must be conditioned on the existence of capital controls, the durability and effectiveness of which must necessarily be a matter of judgment.

the equilibrium level. In addition to calculating the numerical magnitude of the degree of misalignment, we assess the estimates in the context of statistical uncertainty. In this respect, we extend the standard practice of considering both economic and statistical significance in coefficient estimates to the prediction aspect.

The price-level variable in the Penn World Tables (Summers and Heston 1991) and other PPP exchange rates attempt to circumvent measurement problems arising from heterogeneity in goods baskets across countries by using *prices* (not price indexes) of goods and calculating the aggregate price level using the same weights. Assume for the moment that this can be accomplished, but that some share of the basket (α) is nontradable (denoted by N subscript), and the remainder is tradable (denoted by T subscript). Then:

(1) $$p_t = \alpha p_{N,t} + (1 - \alpha)p_{T,t}.$$

By simple manipulation, one finds that the real exchange rate is given by:

(2) $$q_t \equiv s_t - p_t + p_t^* = (s_t - p_{T,t} + p_{T,t}^*) - \alpha(p_{N,t} - p_{T,t}) + \alpha(p_{N,t}^* - p_{T,t}^*).$$

Rewriting, and indicating the first term in parentheses, the intercountry price of tradables, as $q_{T,t}$ and the intercountry relative price of nontradables as $\omega_t \equiv (p_{N,t} - p_{T,t}) - (p_{N,t}^* - p_{T,t}^*)$, leads to the following rewriting of equation (2):

(2′) $$q_t = q_{T,t} - \alpha\omega_t$$

This expression indicates that the real exchange rate can appreciate as changes occur in the relative price of traded goods between countries or as the relative price of nontradables rises in one country, *relative to another.* In principle, economic factors can affect one or both.

Models that center on the relative price of nontradables include the well-known approaches of Balassa (1964) and Samuelson (1964). In those instances, the relative price of nontradables depends upon sectoral productivity differentials, as in Hsieh (1982), Canzoneri, Cumby and Diba (1999), and Chinn (2000b). They also include those approaches that include demand-side determinants of the relative price, such as that of De Gregorio and Wolf (1994), who observe that if consumption preferences are not homothetic and factors are not perfectly free to move intersectorally, changes in per capita income may result in shifts in the relative price of nontradables.

This perspective provides the key rationale for the well-known positive cross-sectional relationship between relative price (the inverse of q, i.e., $-q$) and relative per capita income levels. We exploit this relationship to determine whether the Chinese currency is undervalued. Obviously, this approach is not novel; it has been implemented recently by Frankel (2006) and Coudert and Couharde (2005). However, we will expand this approach along several dimensions. First, we augment the approach by incorporating the time series dimension.[7] Second, we explicitly characterize the uncertainty surrounding our determinations of currency misalignment. Third, we examine the stability of the relative price and relative per capita income relationship using (a) subsamples of certain country groups and time periods, and (b) control variables.

7.3.3 The Basic Bivariate Results: Using the 2007 Vintage Data

We compile a large data set encompassing up to 160 countries over the 1975 to 2005 period. Most of the data are drawn from the World Bank's *World Development Indicators (WDI).* Because some data are missing, the panel is unbalanced. The data appendix provides greater detail on the data used.

Extending Frankel's (2006) cross-section approach, we estimate the real exchange rate-income relationship using a pooled time series cross-section ordinary least squares (OLS) regression, where all variables are expressed in terms relative to the United States;

$$r_{it} = \beta_0 + \beta_1 y_{it} + u_{it}, \qquad (3)$$

where $r = -q$ is expressed in real terms relative to the U.S. price level, y is per capita income also relative to the United States.[8] The results are reported in the first two columns of table 7.2, for cases in which we measure relative per capita income in either USD exchange rates or PPP-based exchange rates.

One characteristic of estimating a pooled OLS regression is that it forces the intercept term to be the same across countries and assumes that the error term is distributed identically over the entire sample. Because this is something that should be tested, rather than assumed, we also estimated random effects and fixed effects regressions. The former assumes that the individual specific error is uncorrelated with the right-hand-side variables, while the latter is efficient when this correlation is nonzero.[9]

Random effects regressions do not yield substantially different results from those obtained using pooled OLS. Interestingly, when allowing the within and between coefficients to differ, we do find differing effects. In particular, with USD-based per capita GDP, the within effect is much stronger than the between. This divergence is likely picking up short-term effects,

7. 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 indexes.

8. β_0 can take on currency specific values if a fixed effects specification is implemented. Similarly, the error term is composed of a currency specific and aggregate error if the pooled OLS specification is dropped. Note that this analysis differs from that in Cheung, Chinn, and Fujii (2007b), in that we use an updated and revised data set and exclude China from the regression.

9. Because the price levels being used are comparable across countries, in principle there is no need to incorporate country-specific constants as in fixed effects or random effects regressions. In addition, fixed effects estimates are biased in the presence of serial correlation, which is documented in the subsequent analysis.

Table 7.2 **The panel estimation results of the real exchange rate-income relationship: 2006 vintage data**

	U.S.$-based GDP				PPP-based GDP			
	Pooled OLS (1)	Between (2)	Fixed effects (within) (3)	Random effects (4)	Pooled OLS (5)	Between (6)	Fixed effects (within) (7)	Random effects (8)
GDP per capita	0.259***	0.259***	0.387***	0.309***	0.317***	0.309***	0.386***	0.361***
	(0.003)	(0.013)	(0.020)	(0.012)	(0.005)	(0.025)	(0.020)	(0.013)
Constant	–.023***	–.040	—	.099***	–.147***	–.184***	—	–.084**
	(0.008)	(0.044)		(0.036)	(0.010)	(0.055)		(0.037)
Adjusted R^2	0.564	0.677	0.800	0.564	0.413	0.467	0.800	0.413
F-test statistic			33.557***				54.362***	
Hausman test statistic				19.013*				0.167
No. of observations	4,600				4,600			

Notes: GDP = gross domestic product; PPP = purchasing power parity; OLS = ordinary least squares. The data covers 168 countries over the maximum of a thirty-one-year period from 1975 to 2005. The panel is unbalanced due to some missing observations. Heteroskedasticity-robust standard errors are given in parentheses underneath coefficient estimates. For the fixed effects models, the *F*-test statistics are reported for the null hypothesis of the equality of the constants across all countries in the sample. For the random effects models, the Hausman test statistics test for the independence between the time-invariant country-specific effects and the regressor.

***Significant at the 1 percent level.

**Significant at the 5 percent level.

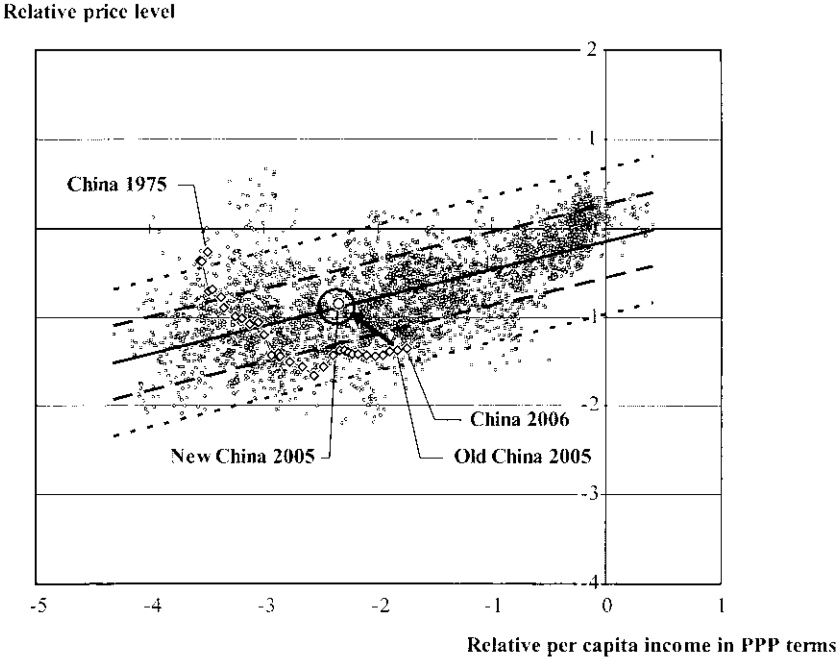

Fig. 7.7 The rate of RMB misalignment based on the pooled OLS estimates with the PPP-based per capita income, 1975–2005

Sources: Chinese 2006 data are from *World Economic Outlook.* "New China 2005" observation is based upon 2007 International Comparison Program data.

where output growth is correlated with other variables pushing up currency values. This pattern, however, is not present in results derived from the PPP-based output data.

Interestingly, the estimated elasticity of the price level with respect to per capita income does not appear to be particularly sensitive to measurements of per capita income. In all cases, the elasticity estimate is always around 0.26 to 0.39, which compares favorably with Frankel's (2006) 1990 and 2000 year cross-section estimates of 0.38 and 0.32, respectively.[10]

One of the key emphases of our analysis is the central role accorded the quantification of the uncertainty surrounding the estimates. That is, in addition to estimating the economic magnitude of the implied misalignments, we also assess whether the implied misalignments are statistically different from zero. In figure 7.7, we plot the actual and resulting predicted (inverse) rates and standard error bands derived from the PPP-based data. The results

10. Note that, in addition to differences 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 United States rather than in absolute terms.

pertaining to USD-based per capita GDP data are qualitatively similar and, thus, are not reported for brevity.

It is interesting to consider the path that the RMB has traced out figure 7.7. It begins the sample as overvalued, and over the next three decades, it moves toward the predicted equilibrium value and then overshoots, so that by 2005 to 2006, it is substantially undervalued by about 60 percent in log terms (50 percent in absolute terms).[11] It is indeed a puzzle that the RMB path is different from the one predicted by the Balassa-Samuelson hypothesis. In comparing the observations at 1975 and 2004, we found that countries including Indonesia, Malaysia, and Singapore also experienced an increase in their income but a decrease in their relative price level. On the other hand, Japan—a country typically used to illustrate the Balassa-Samuelson effect, has a positive relative price level—income relationship. We reserve further analysis for future study.

In this context, we make two observations about these estimated misalignments. First, the RMB has been persistently undervalued by this criterion since the mid-1980s, even in 1997 and 1998, when China was lauded for its refusal to devalue its currency despite the threat to its competitive position.

Second, and perhaps most important, in 2005, the RMB was more than 1 standard error—but less than 2 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 2005) in a statistically significant sense. Similarly, we could not assert that the estimated degree of undervaluation is statistically significant in 2006. The wide dispersion of observations in the scatter plots should give pause to those who would make strong statements regarding the exact degree of misalignment.

In Cheung, Chinn, and Fujii (2007b), we extended this analysis to allow for heterogeneity across country groupings (industrial versus less-developed, high versus low, and regional) and time periods. After conducting various robustness checks, we conclude that although the point estimates indicate the RMB is undervalued in almost all samples, in almost no case is the deviation statistically significant, and indeed, when serial correlation is accounted for, the extent of misalignment is not even statistically significant at the 50 percent level. These findings highlight the great degree of uncertainty surrounding empirical estimates of equilibrium real exchange rates, thereby underscoring the difficulty in accurately assessing the degree of RMB undervaluation.

Notice that the deviations from the conditional mean are persistent; that is, deviations from the real exchange rate-income relationship identified by

11. The deviations when using per capita income in USD, rather than PPP, terms are somewhat smaller—55 percent in log terms (42 percent in absolute terms).

the regression are persistent or exhibit serial correlation. This has an important implication for interpreting the degree of uncertainty surrounding these measures of misalignment. Frankel (2006) 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 0.95 (derived from PPP-based per capita income figures) 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 $[1/(1-\hat{\rho}^2)]^{0.5} \approx 3$. After controlling for serial correlation, the actual value of the RMB is always within 1 standard error prediction interval surrounding the (predicted) equilibrium value in the last twenty plus years! Combining this result and the large data dispersion observed in figure 7.7, it is clear that the data are not sufficiently informative for making a sharp inferences regarding misalignment—not just for the recent period but for the entire sample period.[12]

7.3.4 The Basic Specification Updated: The 2008 Vintage Data

Recently, the World Bank reported new estimates of China's GDP and price level in 2005, measured in PPP terms. These estimates, based on the International Comparison Project's work, incorporated new benchmark data on prices. The end result was to reduce China's estimated GDP per capita by about 40 percent and increase the estimated price level by the same amount.[13] Using the updated data, one finds that China's 2005 observation lying essentially on the regression line, highlighted as "New China 2005" in figure 7.7. In other words, the new estimates erase our estimated undervaluation.

However, taking proper account of this issue involves a slightly more involved approach. This is because data for *many* other countries were substantially revised as well. This means that we need to reestimate the regressions. We report these results in table 7.3.

Focusing on the PPP-based data, one finds that the pooled OLS results indicate a smaller impact of income on relative price levels than obtained using the earlier data. The coefficient drops from 0.3 to 0.2. In fixed effects regressions, the between coefficient drops, while the within rises. Given the change in the sample period and the change in the estimated coefficients, one would not be too surprised to find the estimated misalignments change. However, the *magnitude* of the change in the implied misalignment for the RMB is surprising. Essentially, as of 2006, there is no significant misalignment, in

12. The discussant, Jeffrey Frankel, has observed that the 5 percent significance level might be too high a hurdle to jump for policy purposes. Even when reducing the significance levels to 40 percent, we would not reject the no-undervalation null hypothesis, after accounting for serial correlation.

13. Statistics are from Asian Development Bank (2007). See also Elekdag and Lall (2008) and International Comparison Program (2007) for discussion.

Table 7.3 **The panel estimation results of the real exchange rate-income relationship: 2008 vintage data**

	U.S.$-based GDP				PPP-based GDP			
	Pooled OLS	Between	Fixed effects	Random effects	Pooled OLS	Between	Fixed effects	Random effects
GDP per capita	.211***	.196***	.552***	.482***	.194***	.188***	.415***	.302***
	(.002)	(.012)	(.008)	(.006)	(.004)	(.019)	(.023)	(.013)
Constant	–.099***	–.157***	—	0.623***	–.276***	–.310***	—	–.078**
	(.008)	(.040)		(.026)	(.010)	(.045)		(.035)
Adjusted R^2	.541	.585	.894	.541	.300	.365	.740	.300
F-test statistic			82.484***				42.765***	
Hausman test statistic				112.50***				35.122***
No. of observations	3,946				4,031			

Notes: GDP = gross domestic product; PPP = purchasing power parity; OLS = ordinary least squares. The data covers 168 countries over the maximum of a twenty-seven-year period from 1980 to 2006. The panel is unbalanced due to some missing observations. Heteroskedasticity-robust standard errors are given in parentheses underneath coefficient estimates. For the fixed effects models, the *F*-test statistics are reported for the null hypothesis of the equality of the constants across all countries in the sample. For the random effects models, the Hausman test statistics test for the independence between the time-invariant country-specific effects and the regressor.

***Significant at the 1 percent level.

**Significant at the 5 percent level.

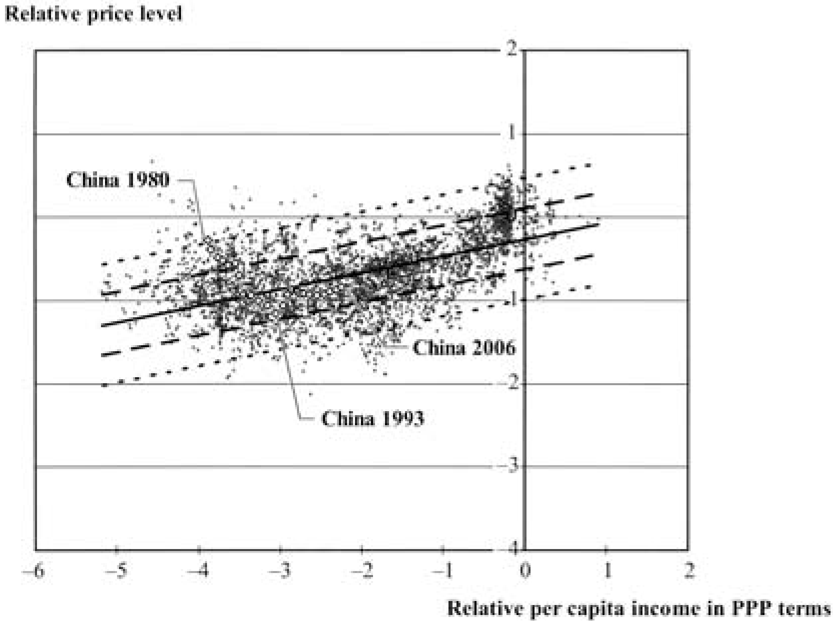

Fig. 7.8 The rate of RMB misalignment based on the pooled OLS estimates with the PPP-based per capita income, 2008 vintage data

either the economic or statistical sense. The undervaluation is on the order of 10 percent in log terms, and the maximal undervaluation is in 1993.[14]

This outcome is clearly illustrated in figure 7.8, where we present the scatterplot of the price level against per capita income but utilizing the most recent data. These figures summarize our basic finding: namely that the substantial misalignment—on the order of 40 percent—detected in our previous analysis disappears in this analysis.[15]

14. We also estimated equation (3) using the year-by-year cross-section regression method. The implied pattern of RMB misalignment is comparable with the one discussed in the preceding. For instance, RMB is found to be overvalued before the 1980s, display a large amount of undervaluation from the late 1980s to 2004, and be slightly overvalued in 2005. All these year-by-year cross-section estimates of the degree of undervaluation are not statistically significant. The average of these year-by-year undervaluation estimates from 1975 to 2005 is 15.5 percent. The value is similar to the undervaluation estimate of 16 percent reported in Arvind Subramanian (2008), who obtains his estimate based upon the methodology outlined in Johnson, Ostry, and Subramanian (2007). We believe utilizing panel regression—as we do—and focusing specifically on the most recent period provides a more accurate assessment of the current degree of currency misalignment.

15. We have not controlled for additional effects in these regressions. However, our basic results do not change with the inclusion of other variables including demographics and institutional factors. See Cheung, Chinn, and Fujii (2009b).

One might take this development as justification for our earlier conclusions that the statistical evidence for undervaluation was misplaced. However, our confidence bands were drawn based upon sampling uncertainty. The revision in China's position reflects measurement error, which we did not take into account in our previous analysis.

The seemingly ephemeral nature of our undervaluation estimate reinforces the point that we have only investigated one approach of the several laid out in table 7.1. Our discussant has observed that other indicators also inform the debate over whether the RMB is misaligned. The burgeoning trade surplus and reserves accumulation, as well as the rapid growth rate (exceeding what is widely perceived as the sustainable rate), point to an undervalued currency, at least conditional upon the level of other policy variables.

We would not disagree with the view that multiple approaches should be used to assess currency misalignment. In that respect, we have somewhat more evidence for RMB undervaluation than one would gain from merely looking at the Penn effect, especially as the revised PPP data have cast into doubt our estimates of misalignment.

Nonetheless, to the extent that almost all such estimates indicate quantitatively substantial undervaluation, and sustained deviation from the price line, we are willing to consider the possibility that the real rate can be controlled for sustained periods of time. Taking the real exchange rate as somewhat exogenous, we can then plausibly consider the effects of changes in the RMB's value on Chinese trade flows.

7.4 A Closer Look at Trade Elasticities

7.4.1 Survey of Trade Elasticity Estimates

The extant literature documenting the price and income responsiveness of Chinese trade flows is relatively small, and given the rapid pace of structural transformation, some of the earlier studies spanning the transition period is of limited relevance.

With respect to Chinese multilateral trade elasticities, there are few academic studies. One widely cited estimate from Goldman Sachs is for a Chinese export price elasticity of 0.2 and an import price elasticity of 0.5.[16] Presumably, similar estimates underlie Goldstein's (2004) calculations although they are not reported.

Kwack et al. (2007) uses a gravity model augmented with a Consumer Price Index (CPI)-deflated real exchange rate to estimate elasticities over the 1984 to 2003 period. Using a panel of twenty-nine developed and developing

16. O'Neill and Wilson (2003) as cited in Morrison and Labonte (2006).

countries, they obtain a Chinese multilateral import price elasticity of 0.50 and an income elasticity of 1.57.[17]

Thorbecke and Smith (forthcoming) do not directly examine the implications for both imports and exports, but do focus on the impact of RMB appreciation on exports, taking into account the integration of the production chain in the region. Using a sample of thirty-three countries over the 1994 to 2005 period and a trade-weighted exchange rate that measures the impact of how bilateral exchange rates affect imported input prices, they find that a 10 percent RMB appreciation in the absence of changes in other East Asian currencies would result in a 3 percent decline in processed exports and an 11 percent decline in ordinary exports. If other East Asian currencies appreciated in line with the RMB, then the resulting change in the processed exports would be 9 percent.

Marquez and Schindler (2007) argue that the absence of useful price indexes for Chinese imports and exports requires the adoption of an alternative model specification. They treat the variable of interest as world (import or export) trade shares, broken down into "ordinary" and "parts and components." Using monthly Chinese imports data from 1997 to July 2006, they find ordinary trade-share income elasticities ranging from –0.021 to –0.001 (i.e., the coefficients are *in the wrong direction*), and price elasticities from 0.013 to 0.021.[18] The parts and components price elasticities are in the wrong direction and statistically significantly so. Interestingly, the stock of foreign direct investment (FDI) matters in almost all cases. Because the FDI stock is a smooth trend, it is not clear whether to attribute the effect explicitly to the effect of FDI or to other variables that may be trending upward over time, including productive capacity.

For export shares (ordinary goods), they find income elasticities ranging from 0.08 to 0.09 and price elasticities ranging from 0.08 to 0.068. For parts and components export share, the income coefficient ranges from a 0.042 to 0.049. Their preferred specification implies that a 10 percent real appreciation of the Chinese RMB reduces the Chinese trade balance between $75 billion and $92 billion.

Garcia-Herrero and Koivu (2007) come closest to our approach. They examine data over the 1995 to 2005 period, breaking the data into ordinary and processing/parts imports and exports. They relate Chinese exports to the world imports and the real effective exchange rate, augmented by a proxy measure for the value added tax rebate on exports and a capacity utilization variable. In both import and export equations, the stock of FDI is included.

17. Wang and Ji (2006) adopt a related approach and find essentially zero effect of nominal exchange rates on Chinese imports and exports.

18. Marquez and Schindler (2007) conjecture that this counterintuitive result arises from the role of state-owned enterprises. They also observe that this result can occur under certain configurations of substitutability between imported and domestic goods.

One notable result they obtain is that for Chinese imports, the real exchange rate coefficient has a sign opposite of anticipated in the full sample.

Another particularly interesting result they obtain is that post-World Trade Organization (WTO) entry, Chinese income and price elasticities for exports rise considerably. On the import side, no such change is obvious with respect to the pre- and post-WTO period.

In the bilateral vein, Mann and Plück (2007) investigate China-U.S. trade. Using an error correction model specification applied to disaggregate bilateral data over the 1980 to 2004 period, they find extremely high income elasticities for U.S. imports from China: for capital and consumer goods, the estimated long-run income elasticities are 10 and 4, respectively. The consumer good price elasticity is not statistically significant, while the capital good elasticity is implausibly high, around 10.[19] On the other hand, U.S. exports to China have a relatively low income elasticity of 0.74 and 2.25 for capital and consumer goods, respectively. The price elasticity estimates are not statistically significant. In general, they have difficulty obtaining sensible coefficient estimates.

Thorbecke (2006) examines aggregate bilateral U.S.-China data over the 1988 to 2005 period. Using both the Johansen maximum likelihood method as well as Stock and Watson's (1993) dynamic OLS methodology, he finds statistically significant evidence of cointegration between incomes, real exchange rates, and CPI-deflated trade flows.

U.S. imports from China have a real exchange rate elasticity ranging from 0.4 to 1.28 (depending upon the number of leads and lags in the dynamic ordinary least squares [DOLS] specification). The income elasticity ranges between 0.26 to 4.98. In all instances, substitution with Association of Southeast Asian Nations (ASEAN) trade flows is accounted for by the inclusion of an ASEAN/dollar real exchange rate. Interestingly, the income elasticities are not statistically significant, even when quantitatively large. For U.S. exports to China, he obtains exchange rate elasticities ranging from 0.42 to 2.04, and income elasticities ranging from 1.05 to 1.21.

7.4.2 Multilateral Trade Elasticities

First, let us consider Chinese trade flows with respect to the rest of the world. We estimate the following equations, where the designations import and export are from the Chinese perspective,

$$\mathrm{ex}_t = \beta_0 + \beta_1 y_t^* + \beta_2 q_t + \beta_3 z_t + u_{1,t}, \tag{4}$$

and

19. Mann and Plück (2007) use disaggregate U.S. trade flow and price index data from the Bureau of Economic Analysis (BEA). The reported income elasticities are for matched expenditure series, for example, investment activity as the income variable in a regression involving capital goods.

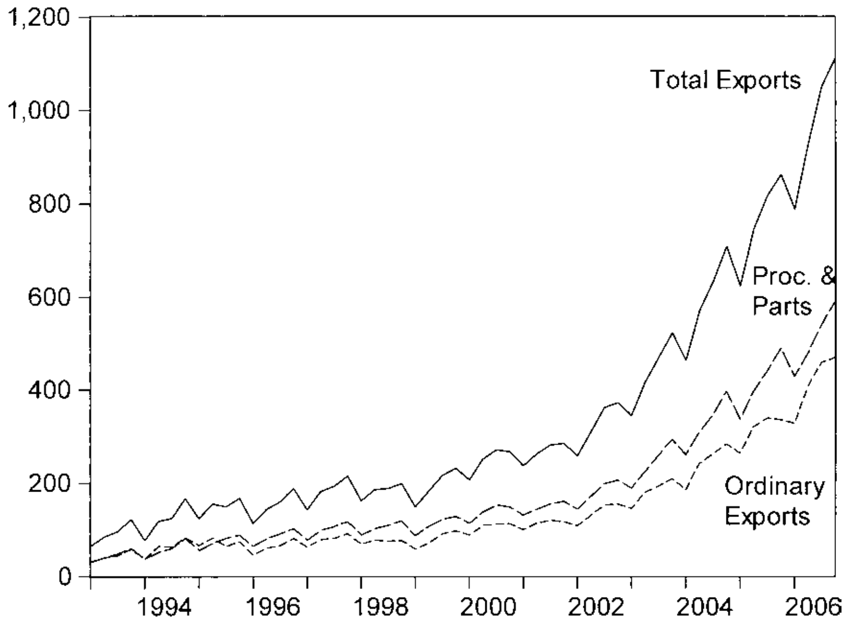

Fig. 7.9 Chinese total, ordinary, and processing and parts exports, in billions of U.S. dollars, at annual rates

(5) $$\text{im}_t = \gamma_0 + \gamma_1 y_t + \gamma_2 q_t + \gamma_3 w_t + u_{2,t},$$

where y is an activity variable, q is a real exchange rate (defined conventionally, so that a rise is a depreciation), and z is a supply-side variable. The variable w is a shift variable accounting for other factors that might increase import demand. The equations are estimated using the Stock-Watson (1993) dynamic OLS regression method with two leads and lags of first differences of the right-hand-side variables.

For the dependent variables, we have collected data on Chinese exports and imports from as early as 1980, to 2006, on a monthly basis. These data are in turn broken into ordinary and processing and parts trade flows. The multilateral data is sourced from Chinese Customs via CEIC. Import data are on a cost, insurance, and freight (c.i.f.) basis, while export data are free on board (f.o.b.). We convert the monthly data into quarterly by simple averaging. These series are depicted in figures 7.9 and 7.10.

One particularly difficult issue involves price deflators. Until 2005, the Chinese did not report price indexes for imports and exports. This limitation explains Marquez and Schindler's (2007) reliance on a trade share variable. We attempt to circumvent this difficulty in a different manner, by relying on several proxy measures. Because the trade flows are reported in U.S. dollars,

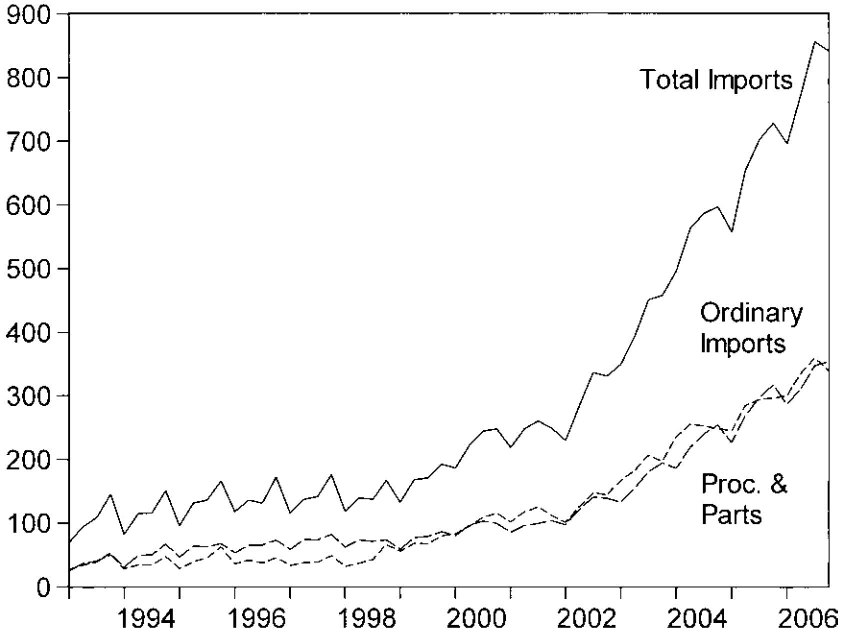

Fig. 7.10 Chinese total, ordinary, and processing and parts imports, in billions of U.S. dollars, at annual rates

the price measures we consider include the U.S. CPI-all, the PPI for finished goods, the price indexes reported by Gaulier, Lemoine, and Ünal-Kesenci (2006, hereafter GLÜ-K), both at the aggregate level, and by stage of production, and, finally, using the Hong Kong reexport indexes.

In the following, we report only the results based upon the PPI, the category-specific GLÜ-K indexes, and the Hong Kong unit value indexes; the remaining results are available upon request. We select these indexes (shown in figures 7.11 and 7.12) mostly on the grounds of pragmatism. The PPI appears to be a good proxy for tradable goods prices, while the GLÜ-K indexes are carefully constructed and documented.

The Hong Kong unit value indexes have typically been used in empirical analyses as proxy measures for Chinese trade (see Cheung 2005). We use the Hong Kong to China reexport unit value indexes to deflate Chinese imports and the Hong Kong to U.S. reexport unit value indexes to deflate Chinese exports.

The GLÜ-K indexes have the drawback of being available only at the annual frequency, and then only up to 2004. We have used quadratic interpolation to translate the annual data into quarterly.

Our measure of the real exchange rate, q, is the IMF's CPI-deflated trade-

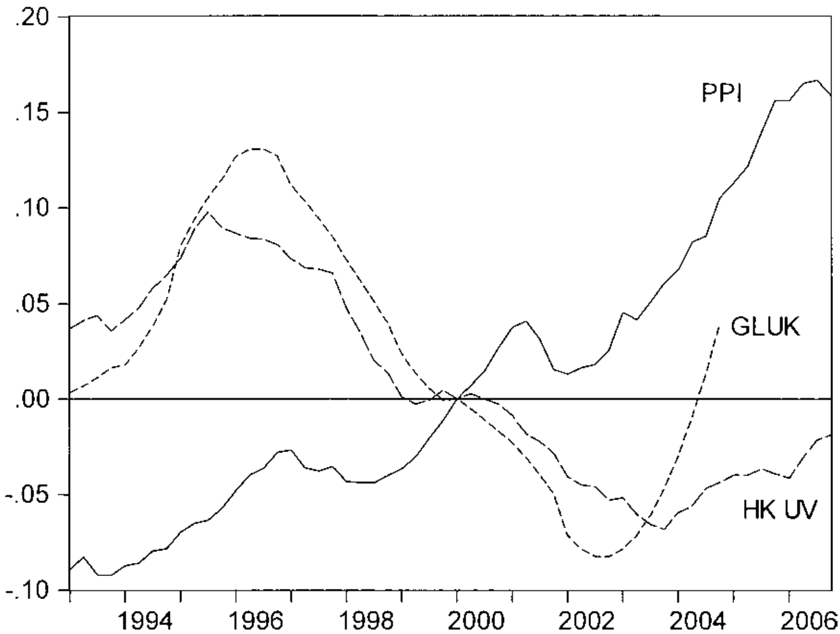

Fig. 7.11 Deflators for Chinese exports

Sources: U.S. PPI, consumption good-based price index from Gaulier, Lemoine, and Ünal-Kesenci (2006) and Hong Kong reexport to world unit value index.

Note: All series in logs, rescaled to 2000Q1 = 0.

weighted index. For y^*, we use rest-of-the-world GDP evaluated in current U.S. dollars, deflated into real terms using the U.S. GDP deflator, while y is measured using real GDP (production based) expressed in real 1990 RMB. For z, we assume that supply shifts out with the capital stock in manufacturing (Chinn 2005). This capital stock measure was calculated by Bai, Hsieh, and Qian (2006). This series is extended by assuming a 12 percent growth rate in 2005 and 2006, and interpolated to quarterly frequency using quadratic match averaging.

In table 7.4, we present the results for Chinese exports, with panel A for aggregate flows, panel B for ordinary exports, and panel C for parts and processing. For each flow, we present coefficient estimates pertaining to real trade flows calculated using alternative deflators. The results in column (1) pertain to PPI-deflated series, while those in column (2) pertain to that obtained when deflating with the GLÜ-K price series, and column (3) pertains to Hong Kong reexport unit value index-deflated series. For now, the z term is suppressed.

There are two uniformly consistent results in all the regression results reported in table 7.4. First, the income variable enters in with a very high (perhaps implausibly high) and statistically significant coefficient. Second,

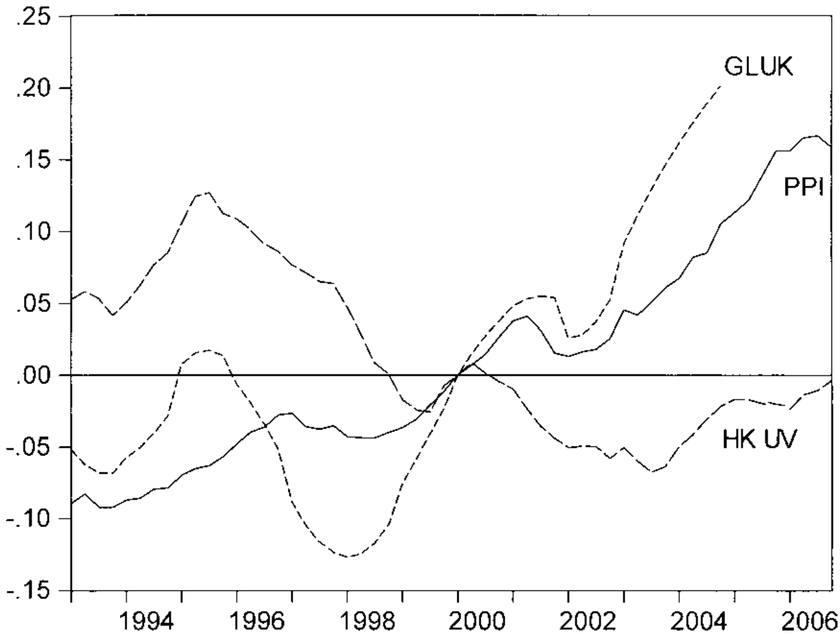

Fig. 7.12 Deflators for Chinese imports

Sources: U.S. PPI, capital good-based price index from Gaulier, Lemoine, and Ünal-Kesenci (2006) and Hong Kong reexport to China unit value index.

Note: All series in logs, rescaled to 2000Q1 = 0.

the real exchange rate enters in with a strongly negative sign—that is, greater RMB depreciation induces less exports.[20]

Because these results seem so counterintuitive, we appeal to a supply shift variable. The standard imperfect goods model of imports and exports typically relies upon the real exchange rate index measuring the relative price of traded goods well. However, our exchange rate measure is the CPI-deflated exchange rate, which may or may not be a good measure of relative traded goods prices.[21] Hence, we add in a measure of the supply side. In line with the approach adopted in Helkie and Hooper (1988), we use a measure of the Chinese capital stock in manufacturing.

The results using this supply variable are quite interesting. As reported in table 7.5, the supply variable coefficient is now the only one that is consistently significant. In addition, the income and price coefficients now take

20. In these, and subsequent, estimates, the inclusion of a time trend often results in substantially different point estimates for the income elasticity. This outcome occurs because Chinese GDP and rest-of-the-world GDP look similar to a deterministic time trend.

21. Here we have adjusted the official rate to reflect the fact that many transactions took place through swap centers during the period leading up to 1994. See Fernald, Edison, and Loungani (1999).

Table 7.4 **Chinese export elasticities**

	PPI (1)	GLÜ-K (2)	HK UV (3)
	A. Aggregate exports		
y^*	5.23***	5.30***	6.01***
	(0.29)	(1.42)	(0.35)
q	–1.63***	–2.14***	–1.69***
	(0.39)	(0.68)	(0.47)
z			
Adjusted R^2	0.89	0.76	0.88
Standard error	0.186	0.272	0.223
Sample	93Q3–06Q2	93Q3–04Q2	93Q3–06Q2
	B. Ordinary exports		
y^*	4.98***	4.82***	5.76***
	(0.32)	(1.52)	(0.38)
q	–1.46***	–2.00***	–1.51***
	(0.42)	(0.73)	(0.50)
z			
Adjusted R^2	0.85	0.68	0.84
Standard error	0.209	0.293	0.244
Sample	93Q3–06Q2	93Q3–04Q2	93Q3–06Q2
	C. Processing and parts exports		
y^*	5.35***	5.14***	6.13***
	(0.27)	(1.15)	(0.33)
q	–1.86***	–2.68***	–1.92***
	(0.37)	(0.56)	(0.45)
z			
Adjusted R^2	0.92	0.84	0.90
Standard error	0.171	0.220	0.208
Sample	93Q3–06Q2	93Q3–04Q2	93Q3–06Q2

Notes: Point estimates are obtained from dynamic ordinary least squares (2,2). Robust standard errors are given in parentheses. The price elasticity estimate should be positive for Chinese exports. PPI indicates U.S. producer price index-finished goods is used as the deflator; GLÜ-K indicates the Gaulier, Lemoine, and Ünal-Kesenci (2006) consumer good index is used as the deflator; HK UV indicates the Hong Kong unit value index for reexports to the world is used as the deflator.

***Significant at the 1 percent level.

on more plausible coefficients, even though they are often not statistically significant.

In panel A, overall exports are examined. The only statistically significant coefficients are on the supply variable. Of course, as suggested by Marquez and Schindler (2007), the differing behavior of ordinary and processing exports suggests that aggregation is inappropriate. Panel B reports the results for ordinary exports. Here, one finds that the rest-of-the-world activity is not a good predictor of exports, while the price variable is an important determinant. Using either GLÜ-K or Hong Kong indexes, one

Table 7.5 **Chinese export elasticities in the presence of Chinese capital stock**

	PPI (1)	GLÜ-K (2)	HK UV (3)
	A. Aggregate exports		
y^*	0.57	–0.56	0.31
	(0.40)	(0.53)	(0.40)
q	–0.06	0.26	0.27
	(0.23)	(0.22)	(0.22)
z	1.68***	2.35***	2.06***
	(0.16)	(0.16)	(0.15)
Adjusted R^2	0.98	0.98	0.99
Standard error	0.077	0.080	0.076
Sample	93Q3–06Q2	93Q3–04Q2	93Q3–06Q2
	B. Ordinary exports		
y^*	0.04	–1.26	–0.22
	(0.55)	(0.75)	(0.55)
q	0.31	0.61*	0.64*
	(0.32)	(0.31)	(0.32)
z	1.83***	2.51***	2.22***
	(0.22)	(0.22)	(0.22)
Adjusted R^2	0.96	0.96	0.97
Standard error	0.106	0.108	0.105
Sample	93Q3–06Q2	93Q3–04Q2	93Q3–06Q2
	C. Processing and parts exports		
y^*	0.98***	0.26	0.72**
	(0.30)	(0.32)	(0.31)
q	–0.47**	–0.62***	–0.14
	(0.19)	(0.16)	(0.18)
z	1.52***	1.99***	1.91***
	(0.11)	(0.10)	(0.11)
Adjusted R^2	0.92	0.99	0.99
Standard error	0.065	0.060	0.062
Sample	93Q3–06Q2	93Q3–04Q2	93Q3–06Q2

Notes: Point estimates are obtained from dynamic ordinary least squares (2,2). Robust standard errors are given in parentheses. The price elasticity estimate should be positive for Chinese exports. PPI indicates U.S. producer price index-finished goods is used as the deflator; GLÜ-K indicates the Gaulier, Lemoine, and Ünal-Kesenci (2006) consumer good index is used as the deflator; HK UV indicates the Hong Kong unit value index for reexports to the world is used as the deflator. Supply is the Bai, Hsieh, and Qian (2006) measure of the Chinese capital stock in manufacturing.

***Significant at the 1 percent level.

**Significant at the 5 percent level.

*Significant at the 10 percent level.

finds an export elasticity of approximately 0.6. At the same time, a 1 percent increase in the Chinese manufacturing capital stock induces between a 2.2 and 2.5 percent increase in real exports.

Strangely, the rest-of-the-world GDP does affect positively processing output. Thorbecke and Smith (forthcoming) argue that Chinese processing output is fairly sophisticated in nature; if so, that might explain the greater income sensitivity of such exports.

In table 7.6, we turn to examining Chinese imports. We rely upon the same breakdown, with panel A pertaining to aggregate imports, panel B to ordinary imports, and panel C to processing and parts imports.

Aggregate imports appear to respond strongly to income, and in the expected direction. On the other hand, we replicate Marquez and Schindler's (2007) results with regard to the price elasticity. A weaker RMB induces greater imports, rather than less. This is true also for ordinary imports. Only when moving to parts and processing imports does one obtain some mixed evidence, and there the results are still toward finding a wrong-signed coefficient.

The Marquez and Schindler (2007) results suggest including a role for FDI as our w variable. However, inclusion of a cumulative FDI variable is insufficient to overturn this result on a consistent basis.

In panel D of table 7.6, we interpret w as real total exports, in the specification involving parts and processing imports. Then we obtain a negative estimated elasticity for the real exchange rate although the results can hardly be considered robust.

Given these mixed results, we have to be very careful in interpreting the estimated elasticities until such time as we have a long time series on Chinese trade prices.

7.4.3 China-U.S. Trade Elasticities

In order to examine the behavior of the bilateral China-U.S. trade balance, it is necessary to modify equations (4) and (5) to take into account the substitutability between Chinese goods and goods from competing countries. The resulting specifications are given by:

$$\text{ex}_t = \beta_0 + \beta_1 y_t^* + \beta_2 q_t + \beta_3 z_t + \beta_4 \tilde{q}_t + u_{3,t}, \tag{6}$$

and

$$\text{im}_t = \gamma_0 + \gamma_1 y_t + \gamma_2 q_t + \gamma_3 w_t + \gamma_4 \tilde{q}_t + u_{4,t}, \tag{7}$$

where q_t is the bilateral real exchange rate, and $\tilde{q}_t$ is an effective real exchange rate relative to China's other trading partners.

Two sets of bilateral data are obtained; the first is sourced from the People's Republic of China Customs agency, and the second from U.S. Customs. The valuation conventions differ between the Chinese and U.S. data as does the

Table 7.6 Chinese import elasticities

	PPI (1)	GLÜ-K (2)	HK UV (3)
	A. Aggregate imports		
y	1.78***	1.41***	2.16***
	(0.06)	(0.04)	(0.06)
q	1.48***	0.39**	1.54***
	(0.38)	(0.19)	(0.32)
Adjusted R^2	0.99	0.98	0.99
Standard error	0.056	0.050	0.055
Sample	94Q4–06Q2	94Q4–04Q2	94Q4–06Q2
	B. Ordinary imports		
y	2.16***	2.40***	2.54***
	(0.26)	(0.32)	(0.27)
q	2.75**	2.25**	2.80**
	(1.18)	(1.06)	(1.19)
Adjusted R^2	0.85	0.94	0.94
Standard error	0.209	0.152	0.196
Sample	94Q4–06Q2	94Q4–04Q2	94Q4–06Q2
	C. Processing and parts imports		
y	1.68***	0.85***	2.06***
	(0.08)	(0.13)	(0.06)
q	1.15***	–0.25	1.20***
	(0.35)	(0.34)	(0.28)
R^2	0.98	0.88	0.99
Standard error	0.072	0.080	0.060
Sample	94Q4–06Q2	94Q4–04Q2	94Q4–06Q2
	D. Processing and parts imports		
y	–0.40*	–1.86*	–0.04
	(0.20)	(0.93)	(0.25)
q	–0.13	–1.64***	–0.16
	(0.23)	(0.58)	(0.22)
w	1.10***	1.20***	0.96***
	(0.13)	(0.40)	(0.12)
Adjusted R^2	0.99	0.89	0.99
Standard error	0.037	0.074	0.035
Sample	94Q4–06Q2	94Q4–04Q2	94Q4–06Q2

Notes: Point estimates are obtained from dynamic ordinary least squares (2,2). Robust standard errors are given in parentheses. The price elasticity estimate should be negative for Chinese imports. PPI indicates U.S. producer price index-finished goods is used as the deflator; GLÜ-K indicates the Gaulier, Lemoine, and Ünal-Kesenci (2006) capital goods and parts index is used as the deflator for aggregate, capital goods for ordinary and parts for processing and parts; HK UV indicates the Hong Kong unit value index for reexports is used as the deflator. The demand shift variable *w* is total real exports.

***Significant at the 1 percent level.

**Significant at the 5 percent level.

*Significant at the 10 percent level.

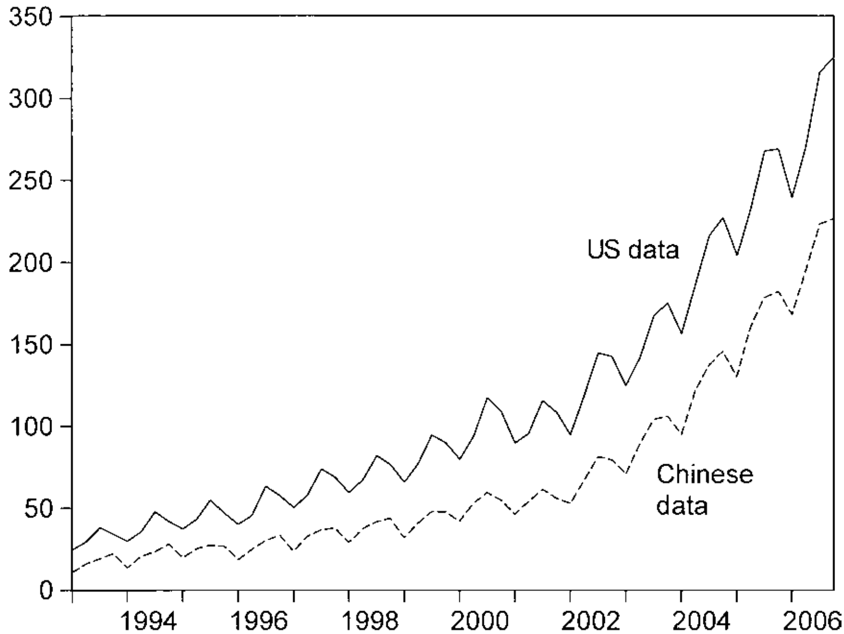

Fig. 7.13 Chinese exports to the United States, in billions of U.S. dollars, at annual rates

coverage. These differences are discussed in detail by Schindler and Beckett (2005). The relevant bilateral series are presented in figures 7.13 and 7.14.

Now y^* is measured using U.S. real GDP (in chained 2000 dollars). q_t is calculated by deflating the Chinese RMB (taking into account the transactions taking place at swap rates pre-1994) by the Chinese and U.S. CPI. $\tilde{q}_t$ is calculated using time-varying trade weights based on Chinese trade flows and bilateral real exchange rates calculated using CPIs. In the calculation of trade weights, we omitted Hong Kong, due to the difficulties in interpreting the trade with that economy.

Once again, our chief difficulty arises from the absence of an appropriate deflator. The Bureau of Labor Statistics (BLS) reports a price index for Chinese imports into the United States starting from 2004 onward, which affords a much too short time series for purposes of estimation. While the Chinese import price series has tracked the import price index for East Asian newly industrializing countries (NICs) over the period that we have Chinese statistics, it is clearly inappropriate to use the NICs series going back before June 1997 as China did not move its exchange rate with the other East Asian countries. Hence, for Chinese exports to the United States, we use a variety of proxy measures. The first is the U.S. PPI for all finished goods. The second is a composite measure, that is, the reported U.S. import series for Chinese

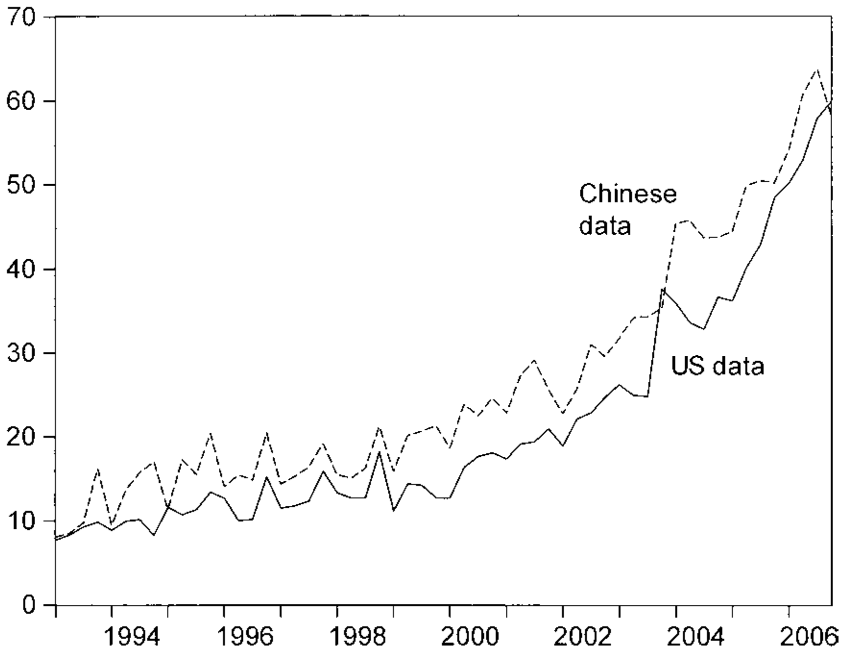

Fig. 7.14 Chinese imports from the United States, in billions of U.S. dollars, at annual rates

goods from January 2004 onward, the NICs series from January 2000 to end-2003, and the GLÜ-K consumer goods index from 1992 to end-1999. The third is the Hong Kong unit value index for reexports to the United States.

The BLS does not report a price index for U.S. exports to China. Because according to Chinese statistics, over half of Chinese imports from the United States are categorized as machinery and electrical equipment in 2006, we chose to use as one of our proxies for Chinese import prices, the U.S. capital goods export price index, in addition to the U.S. PPI. A final proxy measure is the Hong Kong unit value index for imports from the United States. This means there are three deflators for each trade flow measure.

The results for Chinese exports are reported in table 7.7. The three left-hand-side columns pertain to results obtained using U.S. data, while the three right-hand-side columns pertain to results obtained using Chinese data. We do not report results omitting the supply shift variable as this leads to implausibly high income elasticities.

The estimated income elasticities based on U.S. data are positive but not statistically significant. On the other hand, there is a strong, statistically significant coefficient on the bilateral real exchange rate. In other words, as the Chinese currency depreciates against the dollar, Chinese exports to the United States increase. In addition, as the Chinese currency depreci-

Table 7.7 **Chinese bilateral export elasticities (China-United States)**

	US data			Chinese data		
	PPI (1)	P (2)	HK UV (3)	PPI (4)	P (5)	HK UV (6)
y^*	0.03	0.59	0.56	–1.75*	–1.19	–0.62
	(0.80)	(0.73)	(0.75)	(0.99)	(0.92)	(0.99)
q	0.80***	1.27***	1.05***	1.55***	2.03***	1.65***
	(0.22)	(0.22)	(0.20)	(0.30)	(0.29)	(0.31)
$\tilde{q}$	0.47	0.68	1.04	1.31	1.52	1.08
	(0.72)	(0.67)	(0.71)	(0.88)	(0.89)	(0.80)
z	.82***	2.14***	2.04***	3.12***	3.45***	2.98***
	(0.32)	(0.31)	(0.33)	(0.47)	(0.45)	(0.46)
Adjusted R^2	0.99	0.99	0.99	0.99	0.99	0.99
Standard error	0.040	0.039	0.042	0.049	0.048	0.048
Sample	93Q4–06Q2	93Q4–06Q2	93Q4–06Q2	93Q4–06Q2	93Q4–06Q2	93Q4–06Q2

Notes: Point estimates are obtained from dynamic ordinary least squares (2,2). Robust standard errors are given in parentheses. PPI indicates that U.S. producer price index-finished goods is used as the deflator; P indicates that the composite import price deflator is used (see text); HK UV indicates that the Hong Kong unit value index for reexports to the United States is used. Supply is the Bai, Hsieh, and Qian (2006) measure of the Chinese capital stock in manufacturing.

***Significant at the 1 percent level.

**Significant at the 5 percent level.

*Significant at the 10 percent level.

ates against its trade partners, it gains a larger share of exports—vis-à-vis ASEAN and other economies—to the United States.[22] However, this estimated effect is not particularly large and is nowhere near statistical significance. Finally, the supply shift variable comes in with a large positive and statistically significant coefficient.

Interestingly, when we use Chinese data, we obtain a negative coefficient on U.S. income (significant in one instance). The other results remain intact, however. Hence, we can be reasonably confident that the bilateral real exchange rate does have an effect on bilateral trade flows.

Which set of estimates should we place more weight on? Because Schindler and Beckett (2005) argue that most of the error in calculating trade balances is attributable to China's inability to identify correctly the destination of Chinese exports transshipped through Hong Kong, we believe the results based on U.S. data are of greater reliability, at least insofar as Chinese exports are concerned. For Chinese imports of U.S. goods, Chinese data may be more reliable.[23]

In contrast to the results obtained for Chinese exports to the United States, Chinese imports from the United States are relatively well explained by Chinese income and—at least for U.S. data—the real exchange rate. Both elasticities are statistically significant and in the anticipated direction when using U.S. data. However, the Chinese exchange rate relative to other trading partners once again do not enter in with any sort of recognizable pattern. Despite the similarity in the time series behavior of the U.S. and Chinese data, when the latter are used, the coefficient on the bilateral real exchange rate is no longer statistically significant, nor is the sign negative.

7.4.4 Policy Implications of the Estimates

There are some complications in drawing out the policy implications of these regression estimates. First, it is clear that the estimates are not robust to specification. Second, some of the key point estimates are not statistically significant. Third, some of the point estimates—when statistically significant—are counterintuitive. In particular, the results pertaining to import elasticities are problematic.

For instance, consider a 10 percent appreciation. Using the point estimates from table 7.5, column three of panels B and C for exports, one finds that Chinese real exports (in 2000$) decline from 952.3 billion (recorded in 2006) to 927.4 in the long run. On the other hand, using column three estimates from panels B and D from table 7.6, one finds that Chinese imports also *decline,* from 581.6 billion to 510.5 billion. This means that the trade balance *increases* from 400.9 billion to 416.9 billion, in response to a 10

22. For a discussion of the complementary/substituting aspect of Chinese and ASEAN trade, see Ahearne et al. (2003).

23. See also the discussion in Fung and Lau (2001).

percent real appreciation. (Note that parts and processing imports fall as total exports rise.)

The ordinary goods import price elasticity estimate of +2.8 drives this result. Alternative econometric specifications lead to different estimates. For instance, using a single equation error correction model, allowing for coefficient shifts with Chinese accession to WTO, leads to a statistically insignificant estimate of the price elasticity. In the 2000 to 2006 period, the implied price elasticity is zero. Using this point estimate, then a 10 percent appreciation would actually lead to a shrinkage of the trade balance from 400.9 billion to 355.2 billion. This estimate of 45.7 billion (2000$) is somewhat less than the $88.6 billion current dollars reported in Marquez and Schindler (2007).

Although the China-U.S. trade balance is not, macroeconomically speaking, very interesting, for political reasons it has taken on heightened visibility.[24] We can apply our estimates to answering the question of what would happen in response to a 10 percent appreciation of the RMB against the USD. Because both export and import and price elasticities are approximately unity (see column three in tables 7.7 and 7.8), this implies the China-U.S. trade balance would respond fairly strongly to RMB appreciation. Assuming unitary elasticities, the 2006 trade balance of 229.3 billion (2000$) would fall to 195.9 billion, or by 33.4 billion. Of course, this does not mean that the overall U.S. trade deficit would shrink. In fact, the deficit could be reallocated to other countries, even as the Chinese surplus with the United States fell.

Interestingly, our estimate is not that far away from Thorbecke's (2006) estimate of a long-run decrease of 29 billion dollars in response to a 10 percent appreciation in 2005.

The ex-U.S. trade-weighted exchange rate ($\tilde{q}$) should capture the effect of the changes in the value of the RMB relative to the currencies of other countries that also export to the United States. Unfortunately, the point estimate is not statistically significant at conventional levels. Hence, one can take the foregoing calculation in either of two ways. First, it assumes that the RMB moves against the U.S. dollar, while holding its position relative to its trading partners constant—that is, other countries aside from the United States move their currencies in line with China's. Second, the other country effect is absent.

7.5 Concluding Thoughts

This study has aimed to illuminate some of the determinants of the Chinese exchange rate and China's external balance. In documenting the em-

24. See, for instance, Frankel and Wei's (2007) analysis of determinants of the Treasury's decisions regarding currency manipulators.

Table 7.8 Chinese bilateral import elasticities (China-United States)

	U.S. data			Chinese data		
	PPI (1)	P (2)	HK UV (3)	PPI (4)	P (5)	HK UV (6)
y	1.45***	2.02***	1.85***	1.24**	1.81***	1.65***
	(0.33)	(0.35)	(0.32)	(0.46)	(0.48)	(0.45)
q	–1.31***	–1.13***	–0.99***	0.25	0.43	0.57
	(0.33)	(0.32)	(0.32)	(0.39)	(0.42)	(0.45)
$\tilde{q}$	–0.26	0.69	–0.21	0.36	1.32	0.42
	(1.06)	(1.10)	(1.04)	(1.51)	(1.56)	(1.51)
Adjusted R^2	0.95	0.96	0.97	0.95	0.96	0.97
Standard error	0.101	0.101	0.100	0.087	0.091	0.087
Sample	94Q4–06Q2	94Q4–06Q2	94Q4–06Q2	94Q4–06Q2	94Q4–06Q2	94Q4–06Q2

Notes: Point estimates are obtained from dynamic ordinary least squares (2,2). Robust standard errors are given in parentheses. PPI indicates that U.S. producer price index-finished goods is used as the deflator; P indicates that the U.S. capital goods export price deflator is used (see text); HK UV indicates that the Hong Kong unit value index for imports from the United States is used.

***Significant at the 1 percent level.

**Significant at the 5 percent level.

pirical record, we have highlighted one particularly important fact: many of the empirical relationships that can be identified are of a tenuous nature.

Turning first to the real value of the RMB, we reiterate the findings of Cheung, Chinn, and Fujii (2007b)—namely that the relationship between real per capita income and the real value of a currency in PPP terms is quite diffuse. We can be quite certain that a relationship exists, but the exact magnitude of the slope coefficient is subject to substantial uncertainty. And this is even before one adds in model uncertainty and measurement error, the latter of which has been spectacularly demonstrated as being of consequence. Hence, we cannot reject the null hypothesis of no undervaluation at conventional levels of statistical significance. Of course, it is critical to remember that the failure to reject a null is *not* the same as acceptance of the null hypothesis.[25] Even now, with the benefit of updated Chinese price and income data, we could also not reject the null that the RMB was 40 percent undervalued.

The same characterization applies to our findings regarding trade elasticities, perhaps even more so than in the case of the exchange rate. That outcome occurs for a number of reasons, in our view. First, in the approach adopted, we rely solely upon a single country's data, rather than appealing to cross-country data. Second, the data pertain to an economy experiencing rapid structural changes. These structural changes include a rapid build up in the capital stock, motivating our use of a proxy measure of China's supply capacity.[26]

We also freely acknowledge that our approach, while fully in the spirit of conventional approach, may miss some important aspects of China's recent macroeconomic behavior. In particular, some observers have noted that the decline in import growth during the 2005 to 2006 period was associated with a decline in consumption, which, in turn, has been driven by a declining disposable income-GDP ratio and a rising saving-disposable income ratio (International Monetary Fund 2006). Because consumption behavior clear affects imports and exports, omission of this factor is something to be examined in subsequent work.

With these caveats in mind, we conclude that there is some evidence that Chinese trade flows respond to changes in real exchange rates—as well as income levels. However, the price elasticities do not appear reliably estimated, and some estimates are counterintuitive.

Our bottom line conclusion regarding the estimated elasticities is that the real exchange rate effect on overall trade flows—using typical point

25. This is cogently discussed in Frankel (1990).

26. Marquez observes that assuming a constant income elasticity of imports while the import-GDP ratio increases over time presupposes a very specific behavior for the marginal propensity to import. An alternative is to impose a constant marginal propensity to import and retrieve the implied time varying income elasticities.

estimates—is relatively small and sometimes goes in the direction opposite of anticipated. Using some plausible estimates and zeroing out perverse estimates, we obtain for a 10 percent RMB real appreciation a 46 billion (2000$) reduction in the Chinese trade balance, which, while not inconsequential, is still not tremendously large when measured against a 2006 balance of 401 billion (2000$).

These findings suggest that exchange rate policy alone will not be sufficient to reduce the Chinese trade surplus, especially when taken in the context of a trend increase in China's manufacturing capacity. Depending upon which specification is selected, slower growth in the rest of the world could have substantial impact on Chinese exports. With less circumspection, one can assert that slower growth in the United States would have a substantial impact on the U.S. trade deficit with China.

Appendix

Data Appendix

The data used for the real exchange rate portion of the paper (section 7.3) were drawn from a number of different sources. For most countries, data were available from 1971 through 2006 and drawn from the World Bank's *World Development Indicators* (2007 and 2008 editions). Taiwanese data are drawn from the Central Bank of China; International Center for the Study of East Asian Development (ICSEAD); and Asian Development Bank, *Key Indicators of Developing Asian and Pacific Countries* (through 2005).

The data used for the trade elasticities portion of the paper (section 7.4) are drawn from a variety of sources.

- Official exchange rates from IMF *International Financial Statistics* and "swap rates" from personal communication with John Fernald.
- Total Chinese exports and imports, from Chinese Customs, via CEIC.
- China-U.S. trade flows, from China Customs, via CEIC, and from U.S. BEA/Census via Haver.
- Price deflators from various sources.
  - U.S. CPI-all and PPI (finished goods), from U.S. Bureau of Labor Statistics, via Federal Reserve Economic Data (FRED) II.
  - Overall price indexes for Chinese exports and imports, and category-specific price indexes, in USD terms, as described in Gaulier, Lemoine, and Ünal-Kesenci (2006); personal communication from Guillaume Gaulier.
  - Price indexes for U.S. imports from China, East Asian Newly Industrializing Countries (NICs), from Bureau of Labor Statistics.

- Chinese real GDP seasonally adjusted (from CEIC). U.S. real GDP drawn from Bureau of Economic Analysis (June 28, 2007 release).
- The Chinese nominal and real trade-weighted exchange rates from IMF *International Financial Statistics.*
- The bilateral USD/RMB exchange rate adjusted for swap transactions was provided by John Fernald.
- Chinese CPI drawn from CEIC, updated using IMF *International Financial Statistics* year-on-year growth rates.
- The Chinese capital stock in manufacturing, as described in Bai, Hsieh, and Qian (2006), was provided by Chang-Tai Hsieh. This series is assumed to grow by 12 percent in 2005 and 2006, and is interpolated to a quarterly frequency using quadratic match averaging.

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Comment Jeffrey Frankel

When one reads in the second paragraph of this nice chapter, "there are very few studies that simultaneously assess the Chinese exchange rate and trade/current account balance," one's first reaction is: "That is true; I wonder why analysts haven't addressed them together. This will be a useful contribution." And the chapter does turn out to be a useful contribution; the authors do their usual careful job with the econometrics, while linking directly to some of the most important questions in international macroeconomic policy today.

One doesn't have to read much further, however, before being reminded why quantitative research on the Chinese exchange rate and trade balance has been stunted. There are reasons to be pessimistic about getting good results econometrically. First, as the authors say, "the data pertain to an economy experiencing rapid structural changes." Second, the exchange rate has usually been de facto fixed, in the past under a dual exchange rate system and even today supported by capital controls. Neither the domestic financial market, nor international capital flows, nor the exchange rate itself are determined by market forces. Flexibility in the nominal exchange rate has been so low and the current "misalignment" probably so high, that there is little hope in estimating an econometric equation to determine the exchange rate. According to some theories, one gets the same real exchange rate regardless of the regime: if nominal flexibility is suppressed, then fundamentals show up in the price level instead. But we know that, in practice, if a country like China holds the nominal exchange rate fixed at a time, it will prevent or at

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