IV Exchange Rate Dynamics

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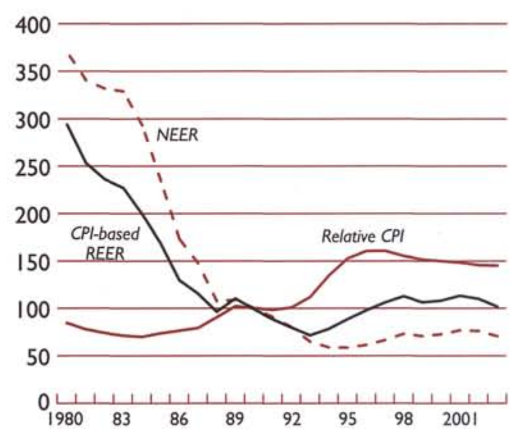
China's rapid export growth and accumulation of international reserves have generated considerable interest in analyzing the renminbi exchange rate. This section examines China's real exchange rate developments between 1980 and 2003 and the factors underlying these developments from three different angles. First, various measures of the real effective exchange rate are constructed to study its evolution over the past two decades. Second, results from different approaches to estimating equilibrium exchange rates are summarized. Reflecting the extreme difficulties of this exercise for a developing country, existing methodologies provide a wide range of estimates with a great deal of uncertainty attached to each of them. Finally, a structural vector autoregression approach is used to study the underlying forces driving real exchange rate variations. This analysis shows how the medium-term path of the exchange rate depends on the types of shocks hitting the economy.

Figure 4.1. CPI-Based Real Effective Exchange Rate and Its Components
(1990 = 100)



Source: IMF staff calculations.

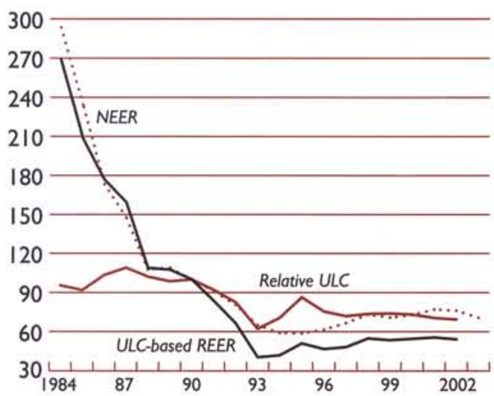
Exchange Rate Developments: A Historical Overview

During much of the 1980s, China had a fixed exchange rate system although the renminbi was devalued frequently, reflecting economic developments and waves of opening up of the economy. Between 1988 and 1993, China had a dual exchange rate system where the official fixed exchange rate coexisted with the market-determined rate in the swap centers. The swap centers were established in 1988 as an expansion and centralization of the fragmented markets that had emerged since the early 1980s. In the swap centers, exporters, importers, and other parties with foreign exchange supply or needs could transact at a market-determined exchange rate. The swap market rate depreciated sharply in the early 1990s, while the fixed official rate became increasingly overvalued. In 1994, the official rate was devalued and unified with the exchange rate at the swap centers (which accounted for an estimated 80 percent of current account foreign exchange transactions at the time), and the exchange rate system was officially changed into a managed float. Since then, China has officially had a managed floating exchange rate system although the currency has been de facto fixed to the U.S. dollar since 1995.

Although China has had either a de jure or de facto fixed exchange rate regime over the past two decades, the real effective exchange rate (REER) based on the consumer price index (CPI) has experienced sharp swings.[1] Throughout the 1980s and early 1990s, the CPI-based REER depreciated drastically through large devaluations of the nominal exchange rate as China steadily abandoned its annual quantitative plans for foreign trade and opened up its economy (Figure 4.1). Subsequently, when the renminbi was more or less fixed to the U.S. dollar, the

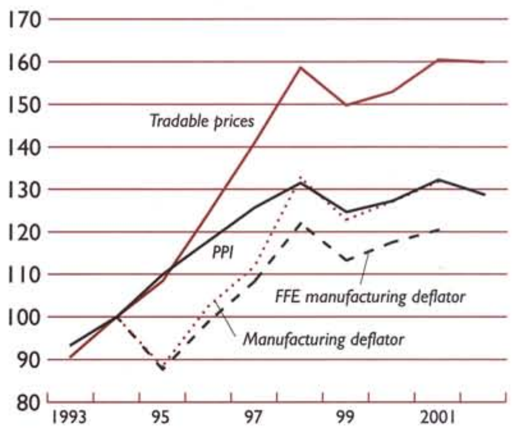
[1]REER data are annual averages. For the period that a dual exchange rate system existed, the nominal exchange rate used in the calculation is a combination of both the official and swap center exchange rates, weighted by the transaction volumes.

Figure 4.2. Unit-Labor-Cost-Based Real Effective Exchange Rate and Its Components
(1990 = 100)



Source: IMF staff calculations.

Figure 4.3. Proxies for Relative Export Prices
(1994 = 100)



Source: IMF staff calculations.

REER appreciated steadily until the onset of the Asian crisis in mid-1997, mainly reflecting the faster CPI growth in China than in partner countries.

Between mid-1997 and mid-1998, with the renminbi being held stable against the U.S. dollar, China's real effective exchange rate appreciated, mostly on account of the depreciation against the U.S. dollar of the Japanese yen and the currencies of the countries hit by the Asian crisis. This appreciation was soon reversed as Asian currencies rebounded and inflation in China was much lower than in its trading partners. Since 1999, China's CPI inflation has continued to be low relative to partner countries, and the modest appreciation of the nominal effective exchange rate until 2001 and the depreciation since then largely reflect the U.S. dollar's movements against other currencies. The average index for the CPI-based REER in 2003 is depreciated relative to its level in 1997 by roughly 4 percent.

Alternative measures of the REER show a similar trend. Figure 4.2 plots data on the real value of the renminbi based on relative unit labor costs (ULC) in the manufacturing sector. Between 1984 and 1993, the ULC-based REER depreciated by about 85 percent, much more sharply than the CPI-based REER, partly because wage growth generally fell short of the rise in labor productivity (with the exception of the period between 1985 and 1987). Between 1998 and 2002, wage growth has been in line with productivity and the ULC-based REER has been relatively stable. Figure 4.3 presents the producer price index (PPI)-based REER and measures of relative export prices, and they have also risen since the mid-1990s, with much of the upward movement occurring before 1998.[2]

Determinants of the Medium-Term Path of the Real Exchange Rate

Modeling exchange rate dynamics is a daunting task because of the complexity of the forces determining exchange rates. Determining "equilibrium" exchange rates is even more of a challenge. These difficulties are further exacerbated in the case of developing economies where substantial structural changes can make the underlying relationships unstable. In the case of China, existing methodologies provide a wide range of estimates with a great deal of uncertainty attached to each of them. This subsection illustrates, on the basis of some commonly used techniques, how wide and imprecise the range of estimates of China's equilibrium exchange rate tends to be.

A number of recent studies have used a variety of methods to estimate the equilibrium exchange rate of

[2]Since China does not report export deflators or export unit values, three proxies are used: (1) deflator of manufacturing sector gross output; (2) deflator of manufacturing output in foreign-funded enterprises (FFEs), (since FFEs are concentrated in producing manufacturing exports); and (3) tradable goods prices in the CPI basket. Much of the underlying data used for calculating the proxies was only available since 1993.

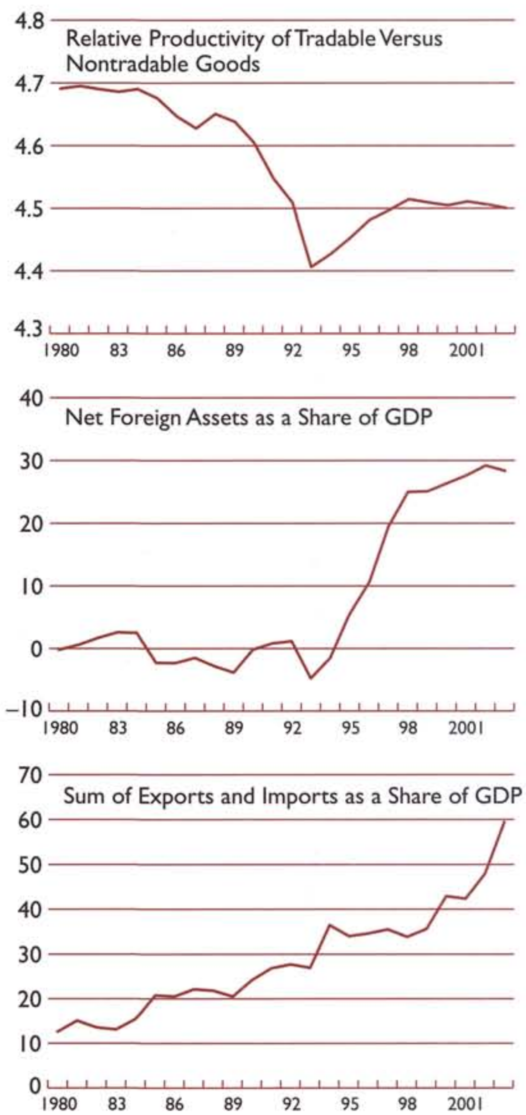
the renminbi. Chou and Shih (1998) estimate the equilibrium exchange rate between 1978 and 1994 using both a purchasing power parity (PPP) approach and an approach based on the shadow price of foreign exchange, and find that the renminbi was overvalued for much of this period, but came close to equilibrium between 1990 and 1994. Zhang (2001) estimates a behavioral equilibrium exchange rate between 1952 and 1997 by using a set of fundamental determinants of the actual real exchange rate. He finds that the renminbi exchange rate was overvalued during most of the estimation period, but was close to its equilibrium in 1997. More recently, Funke and Rahn (2004) estimate a behavioral equilibrium exchange rate with quarterly data between 1985 and 2002 using a set of variables similar to the ones used in the present paper, and conclude that the renminbi was not substantially undervalued as of end-2002. Numerous market analysts have also estimated partial equilibrium models centered around trade equations and argue that the renminbi is currently undervalued, but the range of their estimates of the undervaluation is very wide.

We first use an extended relative PPP approach to explain movements in the real exchange rate, as measured by the CPI-based REER (Alberola and others (1999) use a similar approach). This approach incorporates the impact of relative productivity gains in the tradable and nontradable goods sectors (Balassa-Samuelson effects), as well as other fundamentals, on the real exchange rate (Bayoumi, Faruque, and Lee, 2003).

The model specifies the real effective exchange rate as a function of:

- *Relative productivity gains,* proxied by changes in the CPI to PPI ratio in China relative to partner countries.[3] As described in Balassa (1964), faster productivity growth in the tradable goods sector relative to the nontradable goods sector compared to partner countries typically leads to an increase in nontradable goods prices relative to tradable goods prices in the home country and, hence, an appreciation of the real exchange rate.
- *Net foreign assets (NFAs).* A long-run decline in the NFA position (or a rise in the home country's indebtedness to the rest of the world) would require a larger trade surplus over the medium term to match the higher level of debt servicing, which, in turn, requires a more depreciated real exchange rate, and vice versa (Lane and Milesi-Ferretti, 2000).

Figure 4.4. Variables Used in the Estimation of the Medium-Term Exchange Rate



Source: IMF staff calculations.

- *Openness of the trade regime,* measured by the ratio of the sum of imports and exports to GDP. A more restrictive trade regime tends to be linked to a more appreciated currency.

Using a nonlinear least squares estimator approach, we estimate the above model using annual average data between 1980 and 2003. The variables in the model are plotted in Figure 4.4 and the key

[3]Direct measures of relative productivity are not available. Since PPI contains mainly tradable goods prices and CPI contains a substantial portion of nontradables, the CPI/PPI ratio is a function of relative prices of nontradable versus tradable goods.

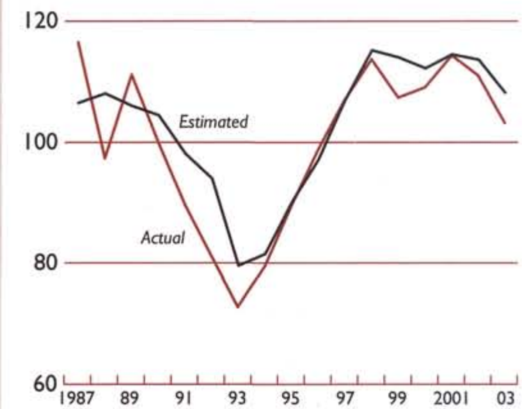
Table 4.1. Medium-Term Determinants of the Real Exchange Rate: Extended Relative PPP Method

Variable	(1)	(2)	(3)
Constant	–0.42	–0.38	–1.82
	(0.28)	(0.28)	(0.86)
TNT	1.12	1.11	1.43
	(3.46)	(3.92)	(3.26)
NFA	0.90	0.91	1.01
	(3.03)	(3.2)	(2.33)
Open	–0.30	–0.30	–0.36
	(0.75)	(0.82)	(0.52)
dum	–37.28	–37.40	–38.19
	(2.55)	(2.7)	(2.81)
*dum * TNT*	8.30	8.33	8.44
	(2.67)	(2.8)	(2.92)
*dum * NFA*	–7.03	–7.03	–5.64
	(1.57)	(1.65)	(1.28)
*dum * Open*	–6.24	–6.23	–4.84
	(2.2)	(2.31)	(1.64)
Number of observations	24	24	24
Adjusted *R*-squared	0.96	0.97	0.97
S.E. of regression	0.06	0.06	0.05
F-statistic	51.20	61.91	54.63

Note: Absolute *t*-statistics are reported in parentheses below the coefficient estimates. Results in column (1) are from a nonlinear least squares specification, which adds lags of the first differences of the variables used in the ordinary least squares estimation and the lag of the equilibrium error to modify the OLS results. Column (2) represents results from a dynamic OLS specification, which adds leads and lags of the first differences of the explanatory variables to the OLS estimation. Column (3) is a modified version of column (2), omitting some leads that are not statistically significant.

results are summarized in Table 4.1, column (1). *REER* is the CPI-based real effective exchange rate; *TNT* is the relative productivity of tradable versus nontradable goods; *NFA* is the stock of net foreign assets (expressed as a ratio to GDP); *Open* is a measure of openness of the trade regime; and *d* is a dummy variable equal to 1 for 1980–86 and 0 otherwise.[4] *T*-statistics are in parentheses. The signs of the coefficients are in line with predictions of standard economic theories.[5] The estimated coefficients imply that a 1 percent increase in *TNT* would lead to a slightly more than 1 percent real appreciation, while a 1 percentage point increase in the *NFA* to GDP ratio is associated with a 0.9 percent higher real exchange rate. On the other hand, a 1 percentage point increase in the measure of trade openness would be associated with a 0.3 percent decline in the real value of the currency.

Figure 4.5. Actual and Estimated CPI-Based REER
(1990 = 100)



Source: IMF staff calculations.

Alternative estimation methods generally confirmed the above results. Columns (2) and (3) in Table 4.1 display the results from two specifications of dynamic OLS estimators. In addition, various stability tests confirmed that the parameters of the estimated models are generally stable over the period 1987–2003. Nevertheless, the estimation results need to be interpreted with caution. The use of the relative CPI/PPI ratio as a proxy for relative productivity has some drawbacks. A better proxy might have been the ratio of the GDP deflator to the manufacturing deflator, but these data are not available. In addition, liberalization of price controls, which may have affected CPI and PPI at different times, could be misinterpreted in this methodology as changes in relative productivity.

A medium-term path of the real exchange rate is calculated using the coefficients from the nonlinear least square estimates and the realized values of the explanatory variables. This estimated path is plotted against the actual CPI-based REER in Figure 4.5.[6] While movements of the two series are generally in line, there are episodes during which there have been

[4]The *NFA* is calculated by adding accumulated current account surpluses to the estimated value of *NFA* in 1979. The dummy variable is used to capture the effects of major structural reforms and trade liberalization starting in 1987.

[5]Based on estimation results for the period 1987–2003.

[6]Results for the other equations estimated are qualitatively similar.

persistent differences between actual and estimated values. However, the differences in the past few years have not been large, which could be interpreted as an indication that the exchange rate may not be substantially undervalued. One should, of course, bear in mind that interpreting fitted values from estimation of such reduced-form equations as indicators of equilibrium exchange rates is fraught with conceptual problems.

An alternative approach to assessing real exchange rate levels that is commonly used is the macroeconomic balance approach (see Isard and Faruqee, 1998; and Isard and others, 2001). This approach examines the exchange rate from an equilibrium saving-investment balance point of view. It compares the "underlying" current account position (the position that would emerge at prevailing market exchange rates if all countries were producing at their potential output levels and the effects of past exchange rate changes have fed through) with an estimated "equilibrium" or "normal" position based on the medium-term determinants of saving and investment. The difference is then used to derive an estimate of how much the exchange rate would have to move (based on estimates of trade elasticities) to shift the underlying current account balance toward its medium-term norms.

Given the difficulties in estimating the underlying current account balance and an equilibrium saving-investment balance, especially for developing countries, some proxies have to be used for these concepts. In the case of China, the underlying current account is proxied by its recent average value, and two proxies are used for the equilibrium saving-investment balance. A norm for the equilibrium saving investment balance is derived from a panel data estimate of the determinants of the saving-investment balance using a set of structural and macroeconomic variables (norm A).[7] Another norm (norm B), is derived by estimating the current account balance that would stabilize the *NFA* to GDP ratio at the 2001 level.

As shown in Table 4.2, contrasting results come from comparing the underlying current account balance with two alternative norms. Norm A suggests that, given the current high saving rate, China should run larger current account surpluses than in the past, indicating a need for a real exchange rate depreciation. On the other hand, norm B would require China to run lower current account surpluses (1 percent of GDP) than in the past, suggesting the need for a real exchange rate appreciation.

Table 4.2. Measures of Underlying Current Account Balances and Norms
(In percent of GDP)

Underlying Current Account Balance	Current Account Balance "Norms"	
Average for 2000–2002	Norm A	Norm B
2.10	3.10	0.98

Sources: State Administration of Foreign Exchange; and IMF staff estimates.

The basic conclusion to be drawn from these alternative methodologies is that it is difficult to arrive at any firm and robust conclusion about the equilibrium level of the renminbi using existing techniques. Furthermore, as discussed below, the medium-term path of the exchange rate is crucially dependent on the sources of shocks hitting the economy.

Sources of Real Exchange Rate Fluctuations

A different approach to understanding the dynamics of the real exchange rate is to study its long-run and short-run movements in a unified framework, where it is modeled as an endogenous variable that responds to various structural shocks. This could provide a better understanding of the evolution of real exchange rates. To this end, a structural vector autoregression (VAR) model following Clarida and Gali (1994) is used to estimate the relative importance of different macroeconomic shocks to real exchange rate movements in China. This approach has the benefit of allowing all variables to be simultaneously determined by structural shocks in the short run while, in order to successfully estimate the model, a few of the long-run relationships are pinned down on the basis of specific theoretical models.

Questions may arise as to whether this type of empirical model is applicable to a developing economy such as China. For example, the model assumes an open economy with a flexible exchange rate and capital mobility, and full employment in the long run. While China may not fully satisfy these assumptions, fundamental changes in the economy over the past two decades have made the model increasingly more relevant. Starting from a closed, centrally planned economy in the early 1980s, China has

[7]Norm A is derived using coefficients obtained from an econometric study of medium-term determinants of current accounts using a panel dataset for an extensive group of developing countries (Chinn and Prasad, 2003). The variables in the estimated equation include stage of development, *NFA* position, dependency ratio, and financial deepening.

Box 4.1. Identification of Shocks in a Structural VAR Model

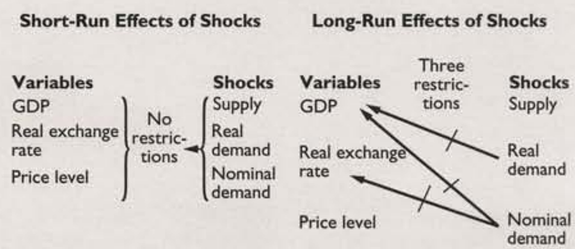
Vector autoregressions (VARs) have become a popular empirical tool for modeling various macroeconomic relationships. However, achieving statistical identification in these models requires strong restrictions on the short-run relationships among the variables in the system. This poses a problem when modeling relationships where it is difficult to plausibly argue that one variable is "exogenous" relative to another in the short run. For instance, output and prices jointly respond to different shocks and viewing either of these as "predetermined" relative to the other makes little sense in most contexts. Furthermore, when including the exchange rate in such a system, the notion of shocks such as an "exchange rate shock" has little meaning since, in principle, it is the exchange rate that responds to different underlying shocks.

The structural VAR approach, originally developed by Blanchard and Quah (1989) to study the joint dynamics of output and prices, provides a way around these problems. This technique allows a VAR to be identified using a minimal set of long-run restrictions that are derived from economic theory. The variables in the model are then allowed to respond to underlying ("structural") shocks in a completely unrestricted manner in the short run.

Clarida and Gali (1994) extended the Blanchard-Quah approach to one that allows for an analysis of real exchange rate dynamics in an open economy setting based on the Mundell-Fleming-Dornbusch analytical framework. The basic VAR includes three variables—log differences of (1) relative output, (2) relative CPI, and (3) the real exchange rate. Since both domestic and foreign macroeconomic conditions affect the real exchange rate, the output growth and inflation variables for the home country are measured relative to the corresponding partner country variables (in a manner consistent with the construction of the real exchange rate variable). Three structural shocks are then identified by the model—relative supply shocks, relative real demand shocks, and relative nominal demand shocks. Each of these shocks affects all of the variables in the short and long run.

The short-run relationships among the three variables are unconstrained. In order to identify the model, however, three of the nine long-run relationships between the shocks and the variables need to be restricted. These restrictions, derived from a stochastic open economy macroeconomic model, are that:

- The relative nominal demand shock has no long-run effect on the *level* of the real exchange rate.
- The relative nominal and real demand shocks have no long-run effects on the *level* of relative output.



Thus, in this setup, there are no restrictions on the short-run responses of the real exchange rate to the three structural shocks. Of the three possible long-run responses of the real exchange rate, only one is restricted to be zero, and this is an entirely plausibl restriction since it is hard to imagine that nominal shocks (e.g., money supply shocks) could permanently alter the *level* of the real exchange rate.

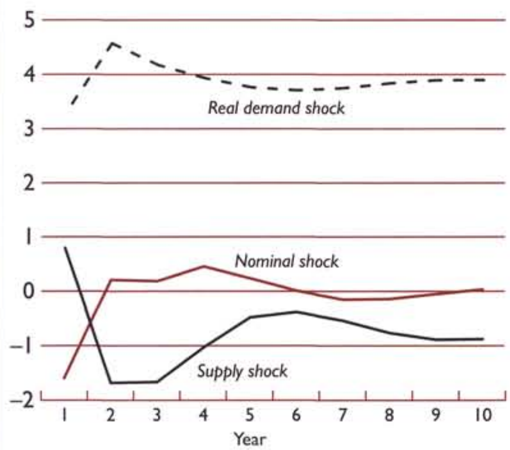
opened up its trade and become more market oriented. Price controls have been all but eliminated. Even when the renminbi was officially fixed, the nominal exchange rate moved frequently to reflect the economic developments and the rate prevailing in the black market or swap market. Capital controls were never watertight, and flows in the form of foreign direct investment and external borrowing were significant through much of the estimation period. In recent years, capital movements have become increasingly large, as reflected in the large outflow during the Asian crisis and the sharp reversal in the last two-three years. While China is still far from full employment, output capacity cannot be easily expanded in the short run. Given these considerations, it is not unreasonable to use this model to disentangle various sources of shocks and to examine whether the model's predictions apply in the case of China.[8]

A three-variable structural VAR is estimated using annual data for the period 1980–2002. The variables in the VAR are relative output, the real effective exchange rate, and the relative price level.[9] The variables are expressed relative to those in trading part-

[8]A number of recent studies have applied similar structural VAR models to developing economies, including Chen and Wu (1997) on Korea, Taiwan Province of China, and the Philippines; Borda, Manioc, and Montauban (2000) on the Caribbean countries; Hoffmaister and Roldós (2001) on Brazil and Korea; and Dibooglu and Kutan (2001) on Poland and Hungary.

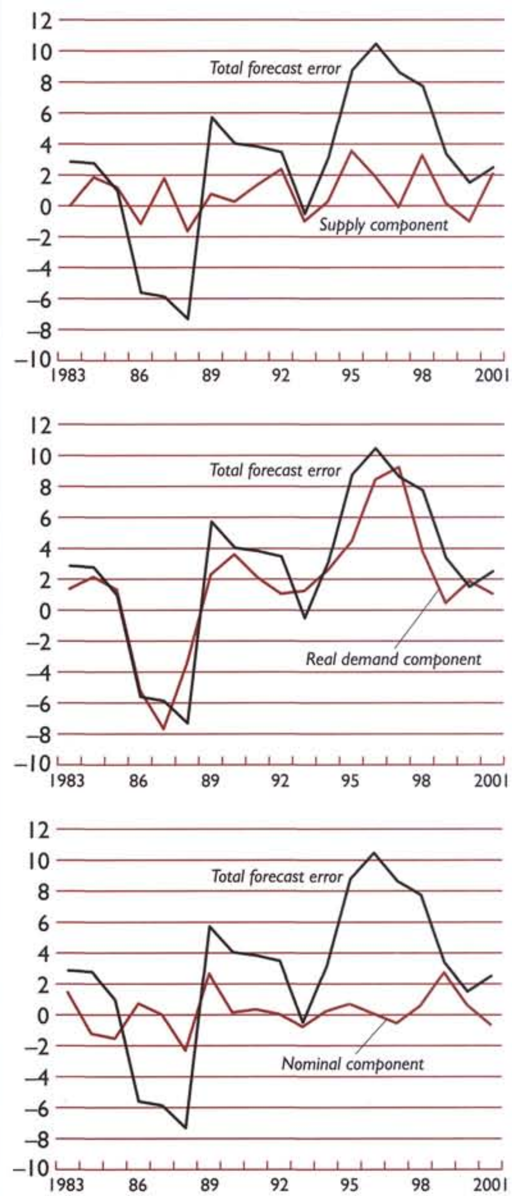
[9]For a description of the SVAR methodology, model specification, data calculations, and more detailed estimation results, see Wang (2004).

Figure 4.6. Accumulated Impulse Response Functions for the Real Effective Exchange Rate
(In percent)



Source: IMF staff calculations.
Note: Since the model is estimated in first differences, the resulting impulse responses were cumulated in order to derive the effects of the structural shocks on the level of the REER. The long-run level response of the REER to a nominal shock is restricted to be zero. There are no other restrictions on the short-run and long-run responses of the REER to different shocks.

Figure 4.7. Decomposition of Forecast Errors of Real Exchange Rate
(In percent)



Source: IMF staff estimates.
Note: Total forecast error is the difference between the actual real exchange rate and forecasts based on history up to 1983 and cumulated effects of the various shocks thereafter. Supply, demand, and nominal components sum to total forecast error.

ner countries because both domestic and external macroeconomic conditions affect the real exchange rate. Three types of shocks are identified, and in the traditional IS-LM framework, these could be referred to as aggregate supply shocks, aggregate demand shocks, and nominal demand shocks (shocks affecting the money market). More details on the methodology are provided in Box 4.1 (also see Wang, 2004).

Figure 4.6 displays the impulse response functions of the level of the real effective exchange rate to one standard deviation structural shocks. As predicted by standard economic theory, a positive supply shock leads to a short-term appreciation followed by a decline in the real exchange rate in the long run, while a positive real demand shock is associated with a permanent appreciation of the real exchange rate. A nominal shock has a temporary (depreciating) impact on the real exchange rate with no long-run effects—as imposed by the long-run restriction.

The structural decomposition indicates that real shocks accounted for most of the variation in real exchange rate changes during the estimation period, whereas nominal shocks were less important. Real demand shocks are the most important factor, especially in the short run, and account for about half of the variance in exchange rate changes even in the

long run; supply shocks also have a significant contribution that rises over longer horizons. Of course, these results should be interpreted with caution, given significant changes that are likely to have occurred in the structure of the economy.

Nevertheless, the overall importance of real shocks to the variations of real exchange rate changes is consistent with findings for other developing countries (for example, Ahmed, 2003). Compared with studies on industrial countries with flexible exchange rate systems (Clarida and Gali, 1994; and Chadha and Prasad, 1997), supply shocks here play a more important role, maybe because China has been going through rather major supply-side changes such as structural reforms and productivity shocks. Moreover, nominal shocks appear not to have played as large a role as in other countries in explaining the fluctuations in either output growth or real exchange rate movements, possibly because China has a de facto fixed exchange rate system with a relatively closed capital account. Hoffmaister and Roldós (2001) also find that supply shocks contribute more than nominal shocks to the fluctuations of changes in the real exchange rate in the case of Korea.

Using the estimated VAR, a historical decomposition was derived to examine whether or not the supply, demand, and nominal shocks that had bee identified could plausibly explain the time path followed by the renminbi real exchange rate over the last two decades. Figure 4.7 displays the "historical" decomposition of forecast errors of the real exchange rate. The solid line in each panel is the total forecast error—the difference between the actual real exchange rate and forecasts based on history up to 1983 and cumulated effects of the various shocks thereafter. The dotted lines are contributions of individual shocks to the total forecast error.

It seems that we can indeed verify that episodes of tight money or positive real demand shocks were associated with real appreciations of the renminbi. For example, real demand factors rose sharply between 1993 and 1997, coinciding with the sharp appreciation of the renminbi. As the onset of the Asian crisis sharply reduced external demand for China's products, relative demand factors declined starting in 1998. However, nominal factors (relatively tight monetary conditions) and supply factors (major restructuring of state-owned enterprises that started in 1997 and could have had a temporary disruptive impact on production) kept the real exchange rate from depreciating more than it did. More recently, supply-side factors pushed up the real exchange rate in 2001; these are probably linked with strong inflows of foreign direct investment on account of productivity gains in China.

This analysis indicates that it is possible to reasonably model fluctuations in China's real exchange rate using a conventional framework. But it also shows the importance of properly accounting for the sources of shocks in trying to understand short-run and medium-run exchange rate dynamics.