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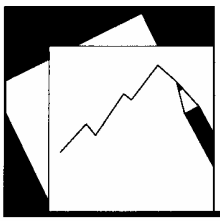

IMF Working Paper

China: Sources of Real Exchange Rate Fluctuations

Tao Wang

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China: Sources of Real Exchange Rate Fluctuations[1]

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Abstract

This paper reviews the evolution of China's real effective exchange rate between 1980 and 2002, and uses a structural vector autoregression model to study the relative importance of different types of macroeconomic shocks for fluctuations in the real exchange rate. The structural decomposition shows that relative real demand and supply shocks account for most of the variations in real exchange rate changes during the estimation period. The paper also finds that supply shocks are as important as nominal shocks in accounting for real exchange rate fluctuations, in contrast with other studies that show that, in industrial countries, nominal shocks are more important in explaining real exchange rate fluctuations.

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Keywords: China, real exchange rate, structural VAR

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I. INTRODUCTION

China's recent rapid export growth and accumulation of international reserves have generated considerable interest in modeling the determinants of the renminbi (RMB) exchange rate. Much of the existing literature has focused on the valuation of the exchange rate relative to its equilibrium. Chou and Shih (1998) estimate the equilibrium exchange rate of the RMB 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 RMB 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 (reduced-form equation). He finds that the RMB exchange rate was overvalued during most of the estimation period, but was close to its equilibrium in 1997. More recently, some observers and analysts (e.g., Anderson, 2003) have estimated partial equilibrium models centered around trade equations and find that the RMB is, at present, undervalued.

This paper contributes to the current discussion on the RMB exchange rate from a different angle. Instead of assessing the equilibrium exchange rate, this paper attempts to gain insights into the underlying forces driving the real exchange rate variations over the past two decades. According to economic theory (e.g., Balassa, 1964) and the experiences of many countries, an economy that goes through sustained rapid growth in its tradable goods sector, such as China, would expect an appreciation of its real exchange rate. However, economies, such as China, are often subject to many different types of shocks simultaneously, especially when they are undergoing major structural changes. Understanding the underlying sources of RMB fluctuations could help explain why the real exchange rate depreciated sharply during the boom of the mid-1980s while it appreciated during the output surge of the mid-1990s, and the forces that are behind the recent real exchange rate movements.

This paper constructs a structural vector autoregression (VAR) model, on the lines of Clarida and Gali (1994), to estimate the relative importance of different types of macroeconomic shocks to fluctuations in the real exchange rate. Three types of shocks are identified, which in the traditional IS-LM framework, could be referred to as the aggregate supply shocks, aggregate demand shocks, and nominal demand shocks (i.e., shocks affecting the money market).

Jin (2003) used an approach similar to the one used in this paper. He examined the relationship between the variation in the real exchange rate and two directly related determinants—real interest rate differential and official foreign exchange reserves. The structural decomposition approach used in the present paper has the benefit of identifying fundamental macroeconomic shocks that could simultaneously affect variables such as the real exchange rate and the interest rate differential.

The structural decomposition indicates that real demand and supply shocks accounted for most of the fluctuations in the real exchange rate movement during the estimation period, whereas nominal shocks were less important. During the mid-1990s, the contribution of the

real demand shocks increased, a key factor underlying the large real appreciation of the RMB. In the period after the Asian crisis, supply and nominal shocks were equally important as real demand factors in determining the real exchange rate movements of the RMB. Of course, these results should be interpreted with caution, given significant changes likely to have occurred in the structure of China's economy.

The paper is organized as follows. The next section reviews the evolution of China's exchange rate regime and the real effective exchange rate since 1980; Section III describes the theoretical background and econometric framework; Section IV presents preliminary data analysis; Section V discusses the main empirical results from the estimation; and Section VI concludes.

II. Exchange Rate Regime and 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 in which 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 foreign exchange markets—these markets had emerged in the early 1980s as a result of a foreign exchange retention scheme. In the swap centers, exporters, importers, and other parties with foreign exchange supply or needs could transact under 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 based on the consumer price index (CPI) has had sharp swings.[2] This real effective exchange rate will be used as *the* real exchange rate in the rest of the paper. Alternative measures of the real effective exchange rate are presented in the Appendix. Both the unit labor costs (ULC)-based real effective exchange rate and the relative producer price index show a trend similar to the CPI-based real effective exchange rate—depreciating sharply in the 1980s and early 1990s before rising during the mid-1990s. However, the magnitude of depreciation was much larger and that of the subsequent appreciation more modest in the case of ULC-based real effective exchange rate.

[2] 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.

Throughout the 1980s and early 1990s, the CPI-based real effective exchange rate depreciated drastically through large devaluations of the nominal exchange rate as China steadily abandoned its planning for foreign trade and opened up its economy (Figure 1). Subsequently, although the renminbi was more or less fixed to the U.S. dollar, the real effective exchange rate 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 yen and the currencies of the crisis countries. This latter 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 in 2002 largely reflects the U.S. dollar's move against other currencies. In 2002, the index for the CPI-based real effective exchange rate is roughly at the same level as in mid-1997.

Figure 1. CPI-Based Real Effective Exchange Rate
(1990 = 100)

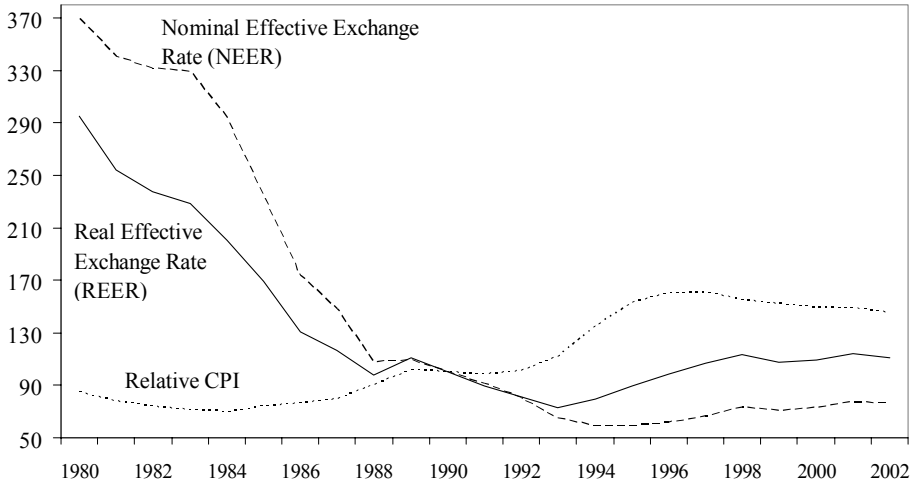
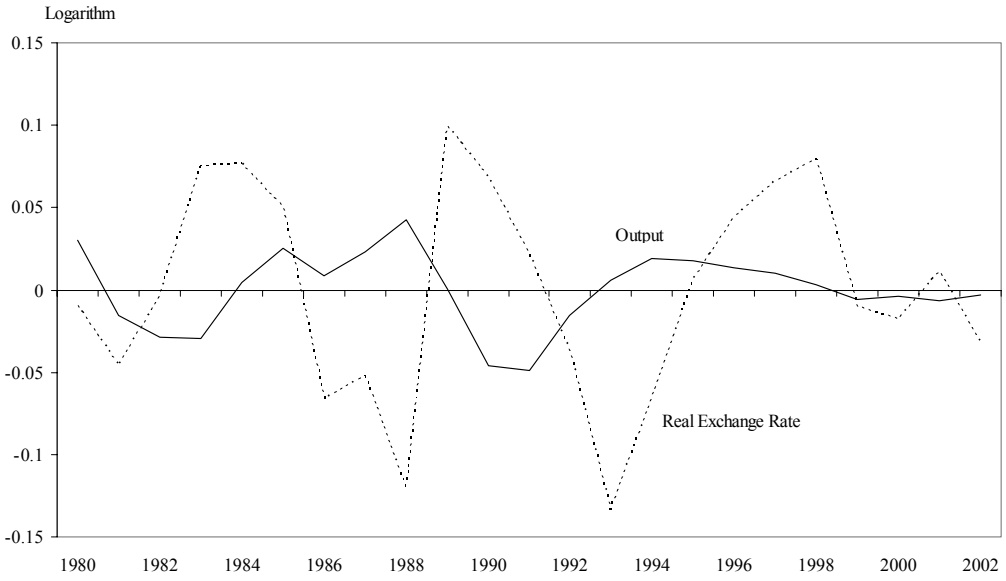


Figure 2 plots the stationary components of the CPI-based real effective exchange rate and output, which are obtained using the Hodrick-Prescott filter applied to annual data in 1980–2002.[3] It shows that the real exchange rate of the renminbi moved differently across business cycles—the movement was procyclical at times and countercyclical at other times. For example, the rapid output expansion during the mid-1980s was accompanied by a depreciating (relative to trend) real effective exchange rate, while the rapid growth in the

[3] In this calculation, λ is set to 100.

mid-1990s was accompanied by an appreciating exchange rate. Since the relationship between output and real exchange rate is affected by the sources of shocks, the joint dynamics of the endogenous variables, such as output, real exchange rate, and prices, in response to macroeconomic shocks need to be modeled.

Figure 2. Hodrick-Prescott (HP)-Filtered Output and Real Exchange Rate



III. Theoretical Background and Econometric Framework

Following the pioneering work of Blanchard and Quah (1989), there has been a growing body of literature in which long-run relationships from theory are used to identify structural shocks (e.g., Bayoumi and Eichengreen, 1992; Lastrapes, 1992; and Prasad, 1999) in an open economy setting. Clarida and Gali (1994) construct a three-variable—relative output, relative prices, and the real exchange rate—structural VAR and identify three types of macroeconomic shocks: supply, real demand, and nominal shocks. The contribution of each type of shock to the variability of each variable is then assessed. Canzoneri, Valles, and Vinals (1996), Chadha and Prasad (1997), and Thomas (1997) use a similar approach to study sources of exchange rate and output fluctuations in industrial countries.

To motivate their identification restrictions, Clarida and Gali (1994) derive a stochastic version of the Obstfeld (1985) open economy macromodel where output is supply determined over the long run. Their representation illustrates how the Mundell-Fleming-Dornbusch model can provide theoretical foundations for the restrictions used in their analysis to identify three separate types of "fundamental" shocks in the economy. The key assumptions of the model include (i) prices and output adjustments are sticky and (ii) foreign and domestic goods are imperfect substitutes in consumption. Shocks in the model can be categorized into aggregate supply shocks, such as changes in the relative productivity of

home to foreign countries; aggregate demand or absorption shocks, such as changes in relative government spending and relative market access for home versus foreign products; and nominal shocks (monetary and financial shocks), such as monetary policy shocks, money demand shocks (e.g., velocity shifts), and effects of financial liberalization.

A positive supply shock, such as a higher productivity growth in the home country, raises the aggregate supply of domestic goods and the rate of return to capital and, in a traditional Mundell-Fleming model in which capital is mobile, leads to a capital inflow and an appreciation of the exchange rate on impact (Obstfeld, 1994). Over the long run, domestic output increases to its higher potential level, domestic price declines, and the real exchange rate depreciates in order to generate trade surpluses to pay down the accumulated stock of net foreign liabilities. A positive demand shock increases demand for home goods, pushes up prices of home products and leads to an appreciation of the real exchange rate and an increase in output in the short run. Over time, output returns to the long-run trend, but the price level remains higher and the real exchange rate remains above its trend. A positive nominal shock lowers home interest rates. In the short run, both the nominal and real exchange rates depreciate, the relative price rises, and the domestic output increases. Over time, output and the real exchange rate return to their long-run trends. The long-run relationships described here are used in this paper as restrictions to identify the fundamental shocks in the model.[4]

Questions may arise as to whether this type of 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 opened up its trade and become more market oriented. Price controls have been all but eliminated. Even when the RMB 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 water-tight, 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 2–3 years. While China is still far from full employment, output capacity cannot be easily expanded in the short run. Given these considerations, this model is used to illustrate various types of shocks in the economy and examine whether its predictions apply in the case of China.

[4] The long-run neutrality of nominal shocks can also be derived in virtually all other modern macroeconomic models; real demand shocks have no long-run impact on output in most Keynesian-type models, although they do in some endogenous growth models.

A number of recent studies have applied similar structural VAR models to developing economies to gain insight into the sources of fluctuations in output and real exchange rates. Hoffmaister and Roldós (2001) extend the Clarida and Gali type of structural VAR approach to Brazil and Korea in a small open economy setting where there is no capital mobility.[5] Also, they incorporate the nominal variable in a very general way—the price level is determined by the response of the monetary authority to external shocks and fiscal and other policies—to accommodate both flexible and fixed exchange rate regimes. They find that supply factors are the dominant contributors to macroeconomic fluctuations in Korea while real demand factors are important in Brazil. Other works applying a structural VAR approach to developing and transition economies include Chen and Wu (1997) on Korea, Taiwan Province of China, and the Philippines; Borda and Montauban (2000) on the Caribbean countries; and Dibooglu and Kutan (2001) on Poland and Hungary.

In this paper, the three variables in the VAR are relative output, the real effective exchange rate, and the relative price level. The variables are relative to trade partner countries because both domestic and external macroeconomic conditions should affect the real exchange rate. Relative real output is measured as the log of real GDP of China minus the log of a trade-weighted measure of partner countries' real GDP; the relative price level (CPI) is similarly measured.

To implement the econometric methodology, the first step is to estimate the following reduced-form VAR:

$$\Delta X_t = A(L)u_t, \qquad (1)$$

where ΔX_t is a vector containing the first differences of relative output, the real exchange rate, and relative CPI; $A(L)$ is a lag polynomial; and u_t is a vector of disturbances. It has an estimated covariance matrix Σ.

To uncover the impact of various structural shocks, the coefficients in the following structural VAR model need to be estimated:

$$\Delta X_t = C(L)\varepsilon_t, \qquad (2)$$

where ε_t is a vector containing (unobserved) mutually uncorrelated shocks that could be interpreted as the (relative) supply shocks, (relative) real demand shocks, and (relative) nominal shocks.

Equations (1) and (2) imply a linear relationship:

$$u_t = C_0\varepsilon_t.,$$

[5] The paper shows that the relaxation of this assumption does not yield qualitatively different results.

where C_0 is the 3 × 3 matrix that defines the contemporaneous structural relationship among the three variables, and it would have to be identified for the vector structural shocks ε_t to be recovered from the estimated disturbances u_t. The symmetric matrix $\Sigma = C_0 C_0'$ imposes six of the nine restrictions that are necessary to identify C_0. Following Clarida and Gali (1994), three additional restrictions on the long-run multipliers are imposed while the short-run dynamics are freely determined. The three restrictions are nominal (monetary) shocks have no long-run impact on the levels of output and the real exchange rate, and real demand shocks have no long-run impact on the level of output.

The long-run multipliers of the structural VAR are denoted by the matrix $C(1) = [C_0 + C_1 + C_2 + \ldots]$. The three long-run restrictions make the (1, 2), (1, 3), and (2,3) elements of $C(1)$ matrix equal to zero, and hence the $C(1)$ matrix lower triangular. This is then used to recover C_0.

IV. Preliminary Data Analysis

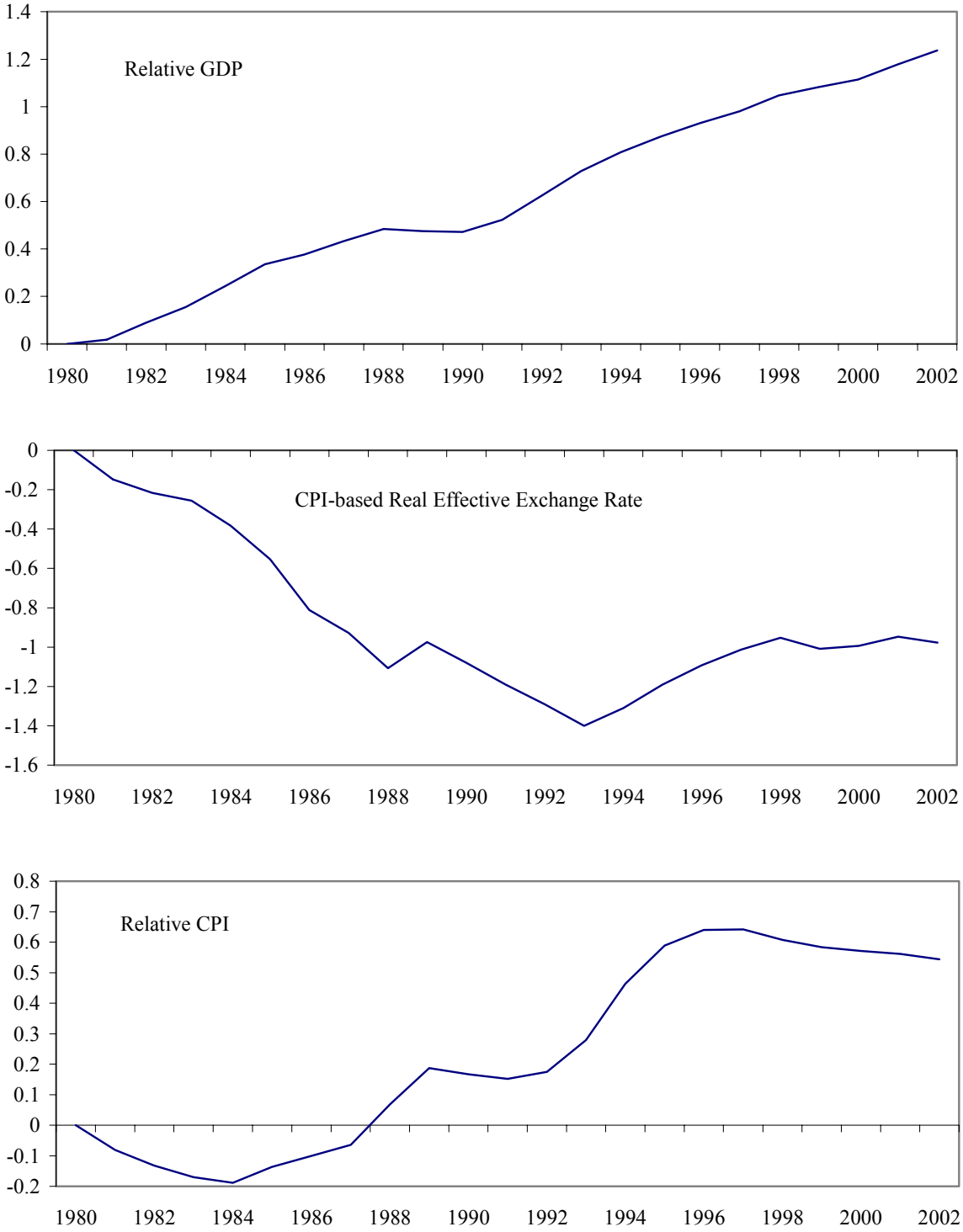
This section examines the time-series properties of the variables in the analysis. Figure 3 plots the three variables used in the VAR: China's relative output has risen almost continuously over the past two decades; the relative CPI shows a trend rise except in two periods—early 1980s and over the past few years—as China's CPI inflation has risen faster than in partner countries; all three variables show trends. Formal stationary tests are conducted and the results from the Augmented Dickey Fuller unit root tests are reported in Table 1. The null hypothesis of a unit root cannot be rejected for the levels of all three variables, while the first differences are confirmed to be stationary with only one exception. The null hypothesis of a unit root cannot be rejected for the first difference of the real effective exchange rate at the 5 percent critical value, although it can be rejected at the 10 percent level. In this paper, we accept the real exchange rate to be first difference stationary, both because standard economy theory does not predict otherwise and because other studies have typically found it to be so.

Table 1. Tests for Stationarity

	Level	First Difference	
Relative output	-3.63	-3.13	**
Real effective exchange rate	-1.13	-1.77	*
Relative price level	-2.56	-3.02	**
5 percent critical value	-3.64	-3.02	

Note: The regressions were run with 1 lag, and with a constant and a time trend for the levels and only a constant for the first differences.
* Test statistic significant at 10 percent level.
** Test statistic significant at 5 percent level.

Figure 3. Variables in the VAR Model



Next, we check whether the variables are cointegrated, although there is no economic reason to expect them to be cointegrated. However, if the variables were cointegrated, the VAR in first differences would be wrongly-specified, and the long-run relationship could be used to help obtain more efficient estimates of the short-run dynamics. Table 2 presents cointegration test results based on Johansen's maximum-likelihood procedure. Test results indicate that there is no evidence of cointegration among the three variables in consideration.

Table 2. Tests for Cointegration

	Null	Alternative	Test Statistics	95 Percent Critical Value
Johansen's likelihood ratio trace statistic test	H = 0	H = 1	33.45**	29.68
	H ≤ 1	H = 2	13.79	15.41
	H ≤ 2	H = 3	0.15	3.76
Johansen's maximal eigenvalue test	H = 0	H = 1	19.65**	20.97
	H ≤ 1	H = 2	13.64	14.07
	H ≤ 2	H = 3	0.15	3.76

Note: The letter h indicates the number of cointegrating relations under different hypothesis. An intercept is included in the fitted regressions.
**Test statistics is significant at 5 percent level.

V. Estimation Results

The unrestricted reduced-form VARs were estimated using annual data from 1980 to 2002 with two lags of each variable in each of the three equations, since quarterly data for China are available only after 1994.[6] VAR estimation with annual data may not pick up some short-run interactions that occur among the variables within a year since only the average of the reactions over four quarters is identified. While macroeconomic variables typically take much longer than one quarter to adjust to shocks, the use of annual data only approximately identifies the short-run impact. To the extent the impact in the first one to two quarters differ qualitatively from the impact in later quarters (e.g., with different signs), then the true short-

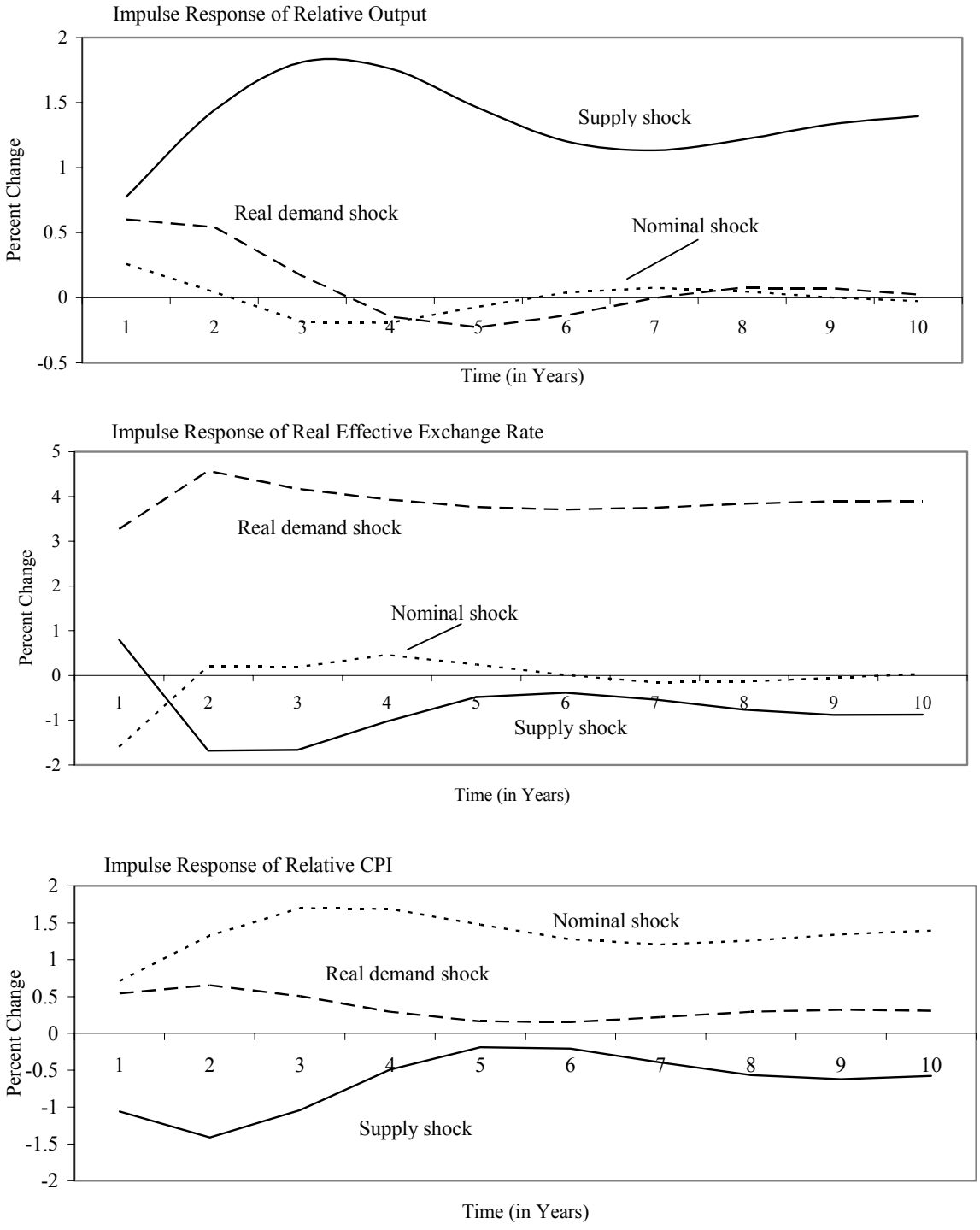
[6] An index of grain prices and the share of foreign direct investment (FDI) in investment are used as exogenous variables. Since grain prices have been administratively controlled by the government until recently, their effect on the CPI and the real exchange rate are removed by regressing the latter on the index of grain price. The resulting residual are then used in the VAR model. The share of FDI is included in the system, as a proxy for market orientation of the economy.

run impact may be misidentified. Nevertheless, using annual data would not affect the dynamics over the longer time horizon and the long-run effects of the shocks.

Figure 4 displays the impulse response functions of the log levels of relative output, the real exchange rate, and the relative price level to one standard deviation structural shocks. Since the variables were entered in first differences in the VAR, the resulting impulse responses were cumulated in order to obtain the impulse responses reported in Figure 4. These impulse response functions are in line with the theoretical priors discussed above. A positive supply shock leads to an increase in output that takes some time to peak before it declines to a lesser rise over the long run, and a positive real or nominal demand shock triggers a short-term rise in output while the long-run output level is unaffected, as imposed by the identifying restrictions. 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 relative price level drops immediately and then recovers somewhat to a lesser permanent decline over the longer time horizon in response to a positive supply shock. Both a positive real and nominal shock result in a permanent rise in the relative price level.

It is interesting that the responses of the real exchange rate to nominal shocks in the case of China are consistent not with the standard theoretical prior of a fixed exchange rate system, but with a flexible one. Under a fixed exchange rate, since the nominal exchange rate is (at least initially) fixed, as the price level goes up in response to a positive nominal shock, the real exchange rate would *appreciate*. Subsequently, capital outflows due to lower domestic interest rates and/or a worsening of the external current account caused by the initial real appreciation could then lead to a devaluation of the nominal exchange rate and a depreciation of the real rate. Under a flexible exchange rate arrangement, a positive nominal shock is expected to lower domestic interest rates relative to foreign rates, leading to a capital outflow and a *depreciation* of both nominal and real exchange rates while the price level and output rise in the short run. The estimation result here shows that, although China has been under a fixed exchange rate arrangement for much of the estimation period, the real exchange rate *depreciates* immediately in response to a positive nominal shock. This result could be driven by earlier episodes of frequent devaluations and is not totally unexpected given that annual data are used in the analysis. With annual data, the initial appreciation impact of a positive nominal shock on the real exchange rate is not identified. Instead, the subsequent depreciation of the real exchange rate due to a nominal devaluation was identified as the short-term impact. However, the contribution of nominal shocks to the variation in changes of the real exchange rate is quite small, as discussed below.

Figure 4. Accumulated Impulse Response Function of Relative Output, Real Exchange Rate, and Relative Price Level



Source: IMF Staff estimates.

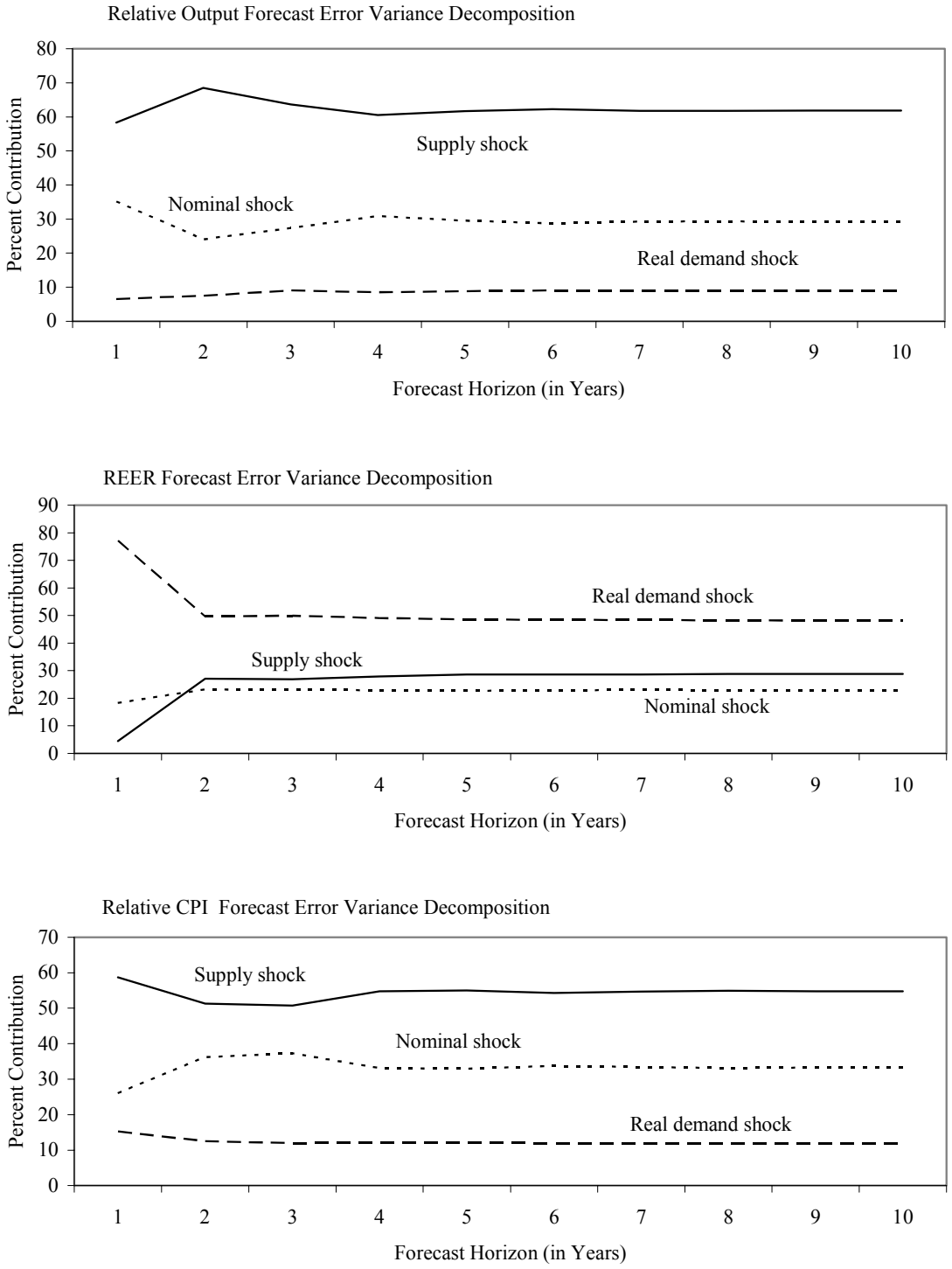
While impulse responses are useful in assessing the signs and magnitudes of responses to specific shocks, the relative importance of different shocks for a particular variable's fluctuations can really be gauged only through the forecast error variance decompositions (Figure 5). Panel 1 plots the share of the forecast error variance of output at different forecast horizon that can be attributed to each type of shocks in the model. Supply shocks account for two-thirds of the variance in output growth throughout the estimation horizon, while relative real demand shocks account for around 10 percent of the variance. Nominal shocks account for close to 30 percent of the variation in the changes of output. In summary, real shocks account for the bulk of the output growth variation, while the impact of nominal shocks is relatively small. The dominance of supply shocks in the fluctuations of output growth found here is consistent with the findings of Ahmed (2003) for Latin American economies, and Hoffmaister and Roldós (2001) for Korea.

Relative real demand and supply shocks account for most of the fluctuations in the real exchange rate changes during the estimation period, as shown in the middle panel of Figure 5. Real demand shocks are the most important factors, especially in the short run, and account for about half of the variance in exchange rate movement even in the long run; supply shocks also have a significant contribution that rises over longer horizons. The overall importance of real shocks to the variations of real exchange rate changes is consistent with findings on other developing countries (e.g., Chen and Wu, 1997; Ahmed, 2003). Compared with studies on industrial countries with flexible exchange rate systems (Eichenbaum and Evans, 1993; Clarida and Gali, 1994), 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.

Most of the variation in changes of relative prices seems to come from supply shocks, which explain more than half of the total forecast error in relative prices. This is consistent with the finding of Agénor, McDermott, and Prasad (1999) that supply shocks are key determinants of fluctuations in inflation in many developing countries. It is also consistent with the empirical findings in studies on determinants of China's price dynamics (Kumar and others, 2003). Nominal shocks account for about one-third of the variations in relative price changes, while real demand shocks account for the rest.

Using the estimated VAR, a historical decomposition can be derived to examine whether or not the supply, demand, and nominal shocks that have been identified can plausibly explain the time path followed by the renminbi real exchange rate over the last two decades. For example, we can verify whether episodes of tight money or positive real demand shocks are associated with real appreciation of the renminbi. Figure 6 plots the unconditional forecast error for the real exchange rate and shows the decomposition of this forecast error into the components that can be attributed to supply, real demand, and nominal shocks.

Figure 5. Forecast Error Variance Decomposition

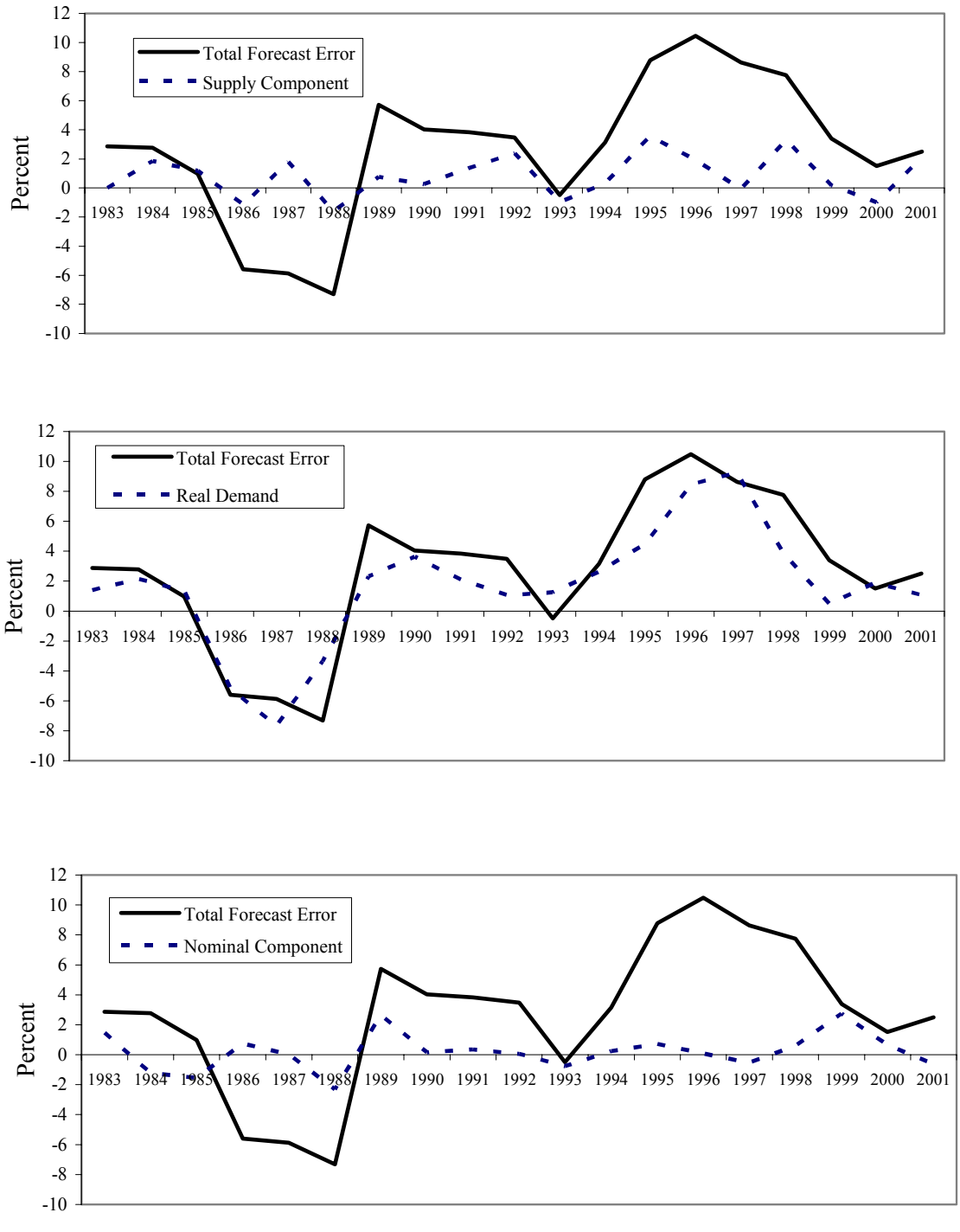


Source: IMF Staff estimates.

The solid line in each of the panels is the total forecast error, which depicts the difference between the actual (log level of the) real exchange rate and the level that would have been forecast from the VAR based on the history of the system up through 1982. In other words, the solid line reflects the cumulative impact of the three types of structural shocks between 1983 and 2002. The dashed line in each panel plots the contribution of each type of shocks to the total forecast error, or the forecast error that would have resulted if only one particular source of shocks had hit the system. As shown in the figure, unexpected movements in the real exchange rate have been driven mainly by real shocks.

Relative real demand factors were the main forces underlying the real depreciation in the mid-1980s when fiscal spending was reined in (Figure 6, middle panel). The real demand components then rose in the late 1980s as another boom was led by fiscal expansion and rapid investment growth. Money growth was also tightened during the 1988–89 period. Both these factors contributed to the appreciation of the real exchange rate. During the mid-1990s, real demand components rose sharply, as would be suggested by the rapid growth of both domestic and external demand during those years. It is interesting to note that nominal shocks appear not to have contributed significantly to unexpected movements in the real exchange rate during this period when monetary policy was first very loose between 1992–95 and then tightened gradually. Since the Asian crisis, real exchange rate movements can be attributed to all three components. As the onset of the Asian crisis crushed external demand, relative demand components declined drastically starting in 1998. However, nominal and supply factors (major SOE restructuring that started in 1997 could have had a temporary disruptive impact on production) apparently kept the real exchange rate from depreciating more than it did. More recently, supply side factors (for example, productivity gains related to WTO accession and resulting lowering of trade barriers) could have contributed to the depreciation of the real exchange rate.

Figure 6. Decomposition of Forecast Errors of Real Exchange Rate



Note: Supply, demand, and nominal components sum to total forecast error.

VI. Concluding Remarks

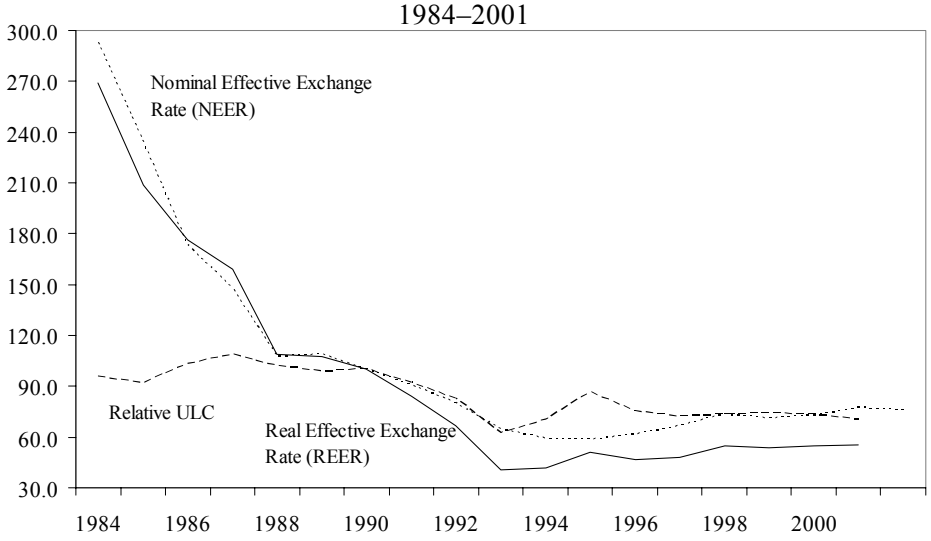
This paper studied the sources of real exchange rate fluctuations in China since 1980 using a structural vector autoregression model. Three types of macroeconomic shocks—supply, real demand, and nominal shocks—and their impact on output, the real exchange rate, and relative price were identified. The estimation results are generally in line with theoretical priors.

The structural decomposition shows that real relative demand shocks have been the most important sources of fluctuations in the real exchange rate over the period 1980–2002; while supply shocks have been the main factors accounting for variations in relative output and relative prices. It also shows that supply shocks were at least as important as nominal shocks in contributing to real exchange rate variations in China. These findings are consistent with the results of similar techniques applied by other authors to other developing countries, but differ from most studies on real exchange rate movements of industrial countries where real demand and nominal shocks are typically found to be important. One possible explanation is that China has been subject to many more supply-side shocks such as structural reforms and productivity shocks, relative to industrial countries. In addition, having a fixed exchange rate arrangement (de facto in recent years) with a relatively closed capital account could conceivably limit the role of nominal shocks.

I. ALTERNATIVE MEASURE OF THE REAL EFFECTIVE EXCHANGE RATE

This appendix briefly summarizes historical developments in alternative measures of the real effective exchange rate for China. Figure A1 plots data on the real value of the renminbi based on relative unit labor costs (ULC) in the manufacturing sector. Following a sharp depreciation in the 1980s and early 1990s, ULC-based real effective exchange rate experienced a modest appreciation since 1993. Between 1984 and 1993, the manufacturing ULC-based real effective exchange rate depreciated by about 85 percent, as the nominal exchange rate depreciated and wage growth generally fell short of the rise in labor productivity (with the exception of between 1985 and 1987). The rise and fall of the ULC-based real effective exchange rate in the mid-1990s was mainly driven by movements in the relative ULC, as wages rose sharply in a period of high inflation in China and subsequently slowed as inflation came down. Since 1998, the ULC-based real effective exchange rate has been relatively stable, partly reflecting that wage growth has been in line with productivity during this period (it is likely to have depreciated since then due to the depreciation of the nominal effective exchange rate. Data on ULCs are not yet available for 2002).

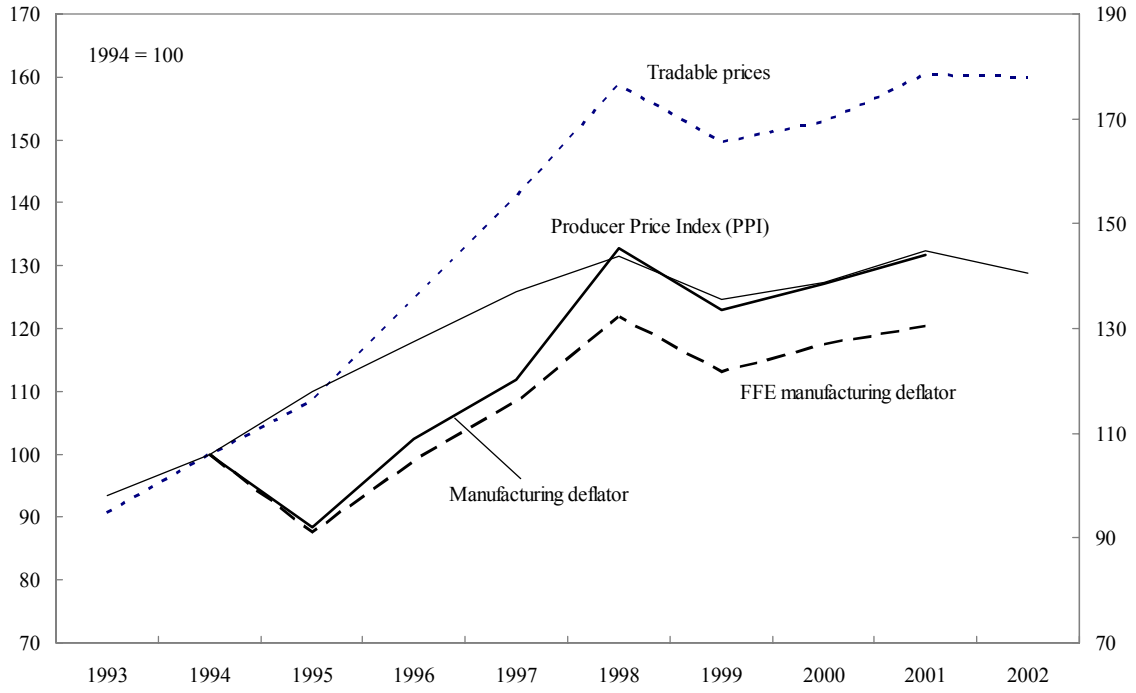
Figure A1. ULC-Based Real Effective Exchange Rate, 1984–2001



Trends and developments in measures of real effective exchange rate using the producer price index (PPI) and measures of relative export prices are presented in Figure A2. The PPI-based real effective exchange rate is constructed using relative producer price index of China and trade partner countries. As to the relative export price indices, export deflator or unit values are used for China's trade partners, and three proxies are used in the case of China—since China does not report export deflators or export unit values, its export price is proxied by (i) deflator of manufacturing sector gross output; (ii) deflator of manufacturing output in foreign-funded enterprises (since FFEs concentrate in producing manufacturing exports); and

(iii) tradable goods prices in the CPI basket. Much of the underlying data used for calculating the proxies were only available since 1993. Consistent with the trend of the CPI- and ULC-based real effective exchange rate, PPI-based real effective exchange rate and proxies of relative export prices have also risen since the mid-1990s, with much of the upward movements occurring before 1998.

Figure A2. Proxies of Relative Export Prices, 1993–2002



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