Real Exchange Rate Fluctuations in Indian Currency: 
Role of Real and Nominal Factors

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ABSTRACT

This paper analyzes the role of real and nominal disturbances in explaining the movement of Indian exchange rate using a structural vector-autoregressive model. Using monthly data, we document the evidence that real shocks are important both in explaining real as well as nominal exchange rate fluctuations. The empirical findings are robust in terms of effective as well as bilateral exchange rates. The results are consistent with ‘equilibrium approach’ offered by Stockman (1987) in analyzing the behavior of exchange rates.

Key Words: Structural VAR Model, Exchange Rates, India

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Introduction

A major goal in the study of flexible exchange rates is to find an acceptable model that explains the movement of exchange rates in terms of other macroeconomic variables. A purpose of this study is to examine the efficacy of established theoretical models in explaining the volatility of exchange rates in India after the breakdown of the Bretton-Woods era, especially after the liberalization of Indian economy in 1991.

Substantial variations in real exchange rates, i.e., deviations from purchasing power parity (PPP), which closely mirror movements in nominal rates, have been one of the most important features of the floating rate period. The overshooting model of Dornbusch (1976) offers the explanation for temporary deviations from PPP only. Models assuming PPP as a long-run relationship have not been successful in interpreting the movements in real exchange rates. A short list of recent studies on PPP includes McNown and Wallace (1989), Abuaf and Jorion (1990), Kim (1990), Layton and Stark (1990), Mark (1990), Diebold, Husted and Rush (1991), Flynn and Boucher (1993) etc. Studies focusing on high or hyperinflation countries find evidence in favor of PPP (see McNown and Wallace (1989), and Mahdavi and Zhou (1993) among others). This is in line with the notion that PPP may hold well in high-inflation countries where the disturbances to their economies are mostly monetary in origin. However, India cannot be viewed as a high inflation or hyperinflation economy.

Identifying the sources of exchange rate fluctuations is important not only to establish the validity of PPP but also for achieving successful exchange rate stabilization. Attempts to stabilize exchange rate changes that are due to economic fundamentals could be futile and even harmful to the economy. In addition, measuring the relative importance of permanent and transitory shocks on exchange rate is essential for exchange rate modeling. If exchange rates are dominated by real shocks then the 'equilibrium approach' offered by Stockman (1987) is appropriate in analyzing the behavior of exchange rates. Conversely, if the evidence suggests the contrary, then the 'disequilibrium approach' of Dornbusch (1976) should be considered as an alternative.

Two explanations can be offered to explain real exchange rate changes in response to real disturbances. On the one hand, permanent exogenous shocks to the tradable sector of the economy call for changes in competitiveness. For example, an increase in the price of oil will worsen the balance of trade position of a net oil-importing country like India and, therefore, lead to a real depreciation of the Indian rupee in order to improve the country's
competitive position in the world market. On the other hand, when countries experience 'productivity bias', real exchange rates of the faster-growing country's could appreciate. Other than these two, fiscal variables might be important in explaining the fluctuations in real exchange rates. Changes in government spending may affect the real exchange rate, but the sign depends on whether the rise is in the spending on tradable or non-tradable goods. High spending on non-traded goods and services may increase the relative price of non-traded goods and thus has the same effect of a rise in tradable goods productivity, i.e., an appreciation of the real exchange rate.

Although, it is clear that real factors have an impact on real exchange rate fluctuations, it would be interesting to investigate the significance of these factors and in addition whether these influences persist in the long run. On the other hand, the importance of nominal or monetary or the demand-side factors in case of nominal variables (such as nominal exchange rate) is also worth addressing.

1. Methodology

Several significant developments in time series econometrics have strongly influenced research in applied economics over the last decade. Vector autoregression (VAR) methodology has been widely applied to address the questions of elasticity or responsiveness by means of variance decomposition or impulse response analysis. In this analysis, we apply the long-run structural VAR approach to examine the importance of shocks on the fluctuations of real as well as nominal exchange rates, following Blanchard and Quah (1989). Here we assume that the economic system is driven by two structural shocks: real and monetary disturbances and that monetary shock has no impact on real exchange rates in the long run.

Let $s_t$ denotes the real exchange rate and $e_t$ the nominal exchange rate. Let

$$\Delta s_t = \begin{bmatrix} \Delta s_t \\ \Delta e_t \end{bmatrix},$$

where $\Delta$ denotes the first-difference operator. $\Delta x_t$ can be represented by

$$\Delta x_t = \sum_{k=0}^{p} A_k \Phi_t - k = A(L) \Phi_t$$

where $\Phi_t = (\phi_{r t}, \phi_{m t})$, where $\phi_{r t}$ and $\phi_{m t}$ denote for real and monetary innovations. Furthermore, we assume that selection of lag-length $p$ ensures the white-noise property of $\Phi_t$. As $\Delta x_t$ is stationary, it has a unique Wold-moving average representation:

$$\Delta x_t = C(L) V_t, \quad \text{Var}(V_t) = \Omega, \quad C_0 = I$$

After estimating equation (1), we can invert the estimated coefficients to obtain $C_i$'s. Next, comparing equation (1) and (2), we can get

$$V_t = A_0 U_t \quad A_i = C_i A_0 \quad i = 1,2,\ldots,k$$

Since $C_i$ is obtained by inverting VAR's estimated coefficients, once we know $A_0$, we can solve for $A_i$. One of the crucial features for solving the system is the identification of $A_0$. The variance-covariance matrix $\Omega = A_0 A'_0$ provides three restrictions needed for identification. We obtain one more restriction following Lastrapes (1993). We assume that monetary shocks have no impact on real exchange rates in the long run. This restriction along with the three restrictions that are obtained from the variance-covariance matrix are sufficient to determine the $A_0$ matrix and hence all the $A_i$ matrices. Finally, the impulse response functions and variance decompositions are used to show the important dynamic character of the empirical model.

However, one may think of two potential problems that are associated with the interpretation of these shocks as both nominal and real shocks. First, as Baldwin pointed out that if market-entry costs are sunk, nominal shocks may have permanent effect on real exchange rates by altering the domestic market structure. But if this impact is small relative to the one of real shocks, the identification scheme used is approximately correct as shown by Blanchard and Quah (1989). Second, the assumption that exchange rates are sensitive to only two structural disturbances can be misleading. There may exist many other disturbances, which may affect the fluctuations in real and nominal exchange rates. Blanchard and Quah (1989) derived reasonable conditions under which the existence of multiple shocks does not destroy our identification scheme. But, as the neutrality restriction is just sufficient to identify these structural disturbances from the reduced form, the restriction can not be testable.
3. Empirical Results

Data

In this paper, we examine the role of real and nominal disturbances for affecting the real Indian Rupee after 1991. Instead of using bilateral exchange rates, we use the real and nominal effective exchange rates for Indian currency. One limitation of such bilateral exchange rates is that they do not incorporate the full range of economies involved in the domestic country's trade and payments. For a given country, real effective exchange rate is defined as the geometric weighted average of exchange rates for the currencies of its major partners in trade and payments, adjusted for relative movements in national price or cost indicators of the home country and its partner countries. The data is collected form various issues of Economic Survey, Government of India. Our data is monthly and from January 1991 to December 1997. We have used the ten-country\(^1\) index of real and nominal effective exchange rates. All variables are expressed in natural logarithm.

Integration and Co-integration Properties of the Data

In order to justify the reliability of the structural VAR, we have to show that individual series is integrated of order one and there exist no co-integration between real and nominal exchange rates. We apply the Augmented Dickey-Fuller and Phillips-Perron unit-root test to examine the integration property of real and nominal effective exchange rates. In order to perform the Augmented Dickey-Fuller unit-root test we run the following regression:

\[
\Delta s_t = \alpha + \beta s_t - 1 + \sum_{j=1}^{k} \gamma_j \Delta s_{t-j} + \epsilon_t
\]  

(4)

In order to select the lag length, we follow the procedure suggested by Campbell and Perron (1991), and Ng and Perron (1995). We start with k = k\(_{\text{max}}\) = 13 and use the 10 percent critical value of the t-distribution, to assess the significance of the last lag. If the last lag is significant, then we choose, k = k\(_{\text{max}}\).

Table 1: Results from the Unit Root Test

<table>
<thead>
<tr>
<th>Variable</th>
<th>Augmented Dickey-Fuller</th>
<th>Phillips-Perron</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>-2.582</td>
<td>-3.073</td>
</tr>
<tr>
<td>(\Delta s)</td>
<td>-8.877***</td>
<td>-8.875***</td>
</tr>
<tr>
<td>E</td>
<td>-2.965</td>
<td>-3.097</td>
</tr>
<tr>
<td>(\Delta e)</td>
<td>-8.339***</td>
<td>-8.420***</td>
</tr>
</tbody>
</table>

*** denotes the rejection of null hypothesis of presence of unit root at one percent level of significance.

From table 1, we can infer that real and nominal effective exchange rates are non-stationary in levels, but stationary in first-differences by both test-statistics. We then test for the presence of cointegration between real and nominal effective exchange rates. Here we apply the Engle-Granger (1987) two-step procedure as well as Johansen (1988) and Johansen and Juselius (1990) multivariate cointegration procedure. The superior property of Johansen's cointegration technique relative to several other procedures has been established by Gonzalo (1995) using a Monte-Carlo Study. Table 2 reports the results from the cointegration test. The optimal lag length for Johansen procedure is selected by a likelihood ratio test (Sims, 1980). We choose a lag-length of nine and estimate a model where the constant is restricted to the cointegrating space.

Table 2: Results from Co-integration Test

<table>
<thead>
<tr>
<th>Engle-Granger Test</th>
<th>Johansen Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1.90</td>
<td>Lambda - Max</td>
</tr>
<tr>
<td></td>
<td>Trace</td>
</tr>
<tr>
<td>H(_0): r = 0</td>
<td>H(_0): r &lt;= 1</td>
</tr>
<tr>
<td>10.240</td>
<td>7.080</td>
</tr>
<tr>
<td>H(_1): r &lt;= 1</td>
<td>H(_1): r &lt;= 1</td>
</tr>
<tr>
<td>17.320</td>
<td>7.080</td>
</tr>
</tbody>
</table>

r denotes the number of co-integrating vector, Lambda- Max is the maximum eigenvalue statistics

\(^1\) The ten countries are Australia, Belgium, France, Germany, Italy, Japan, Netherlands, Switzerland, United Kingdom and United States.
Both the statistics from Table 2 provide evidence in support of the absence of co-integration between real and nominal effective exchange rates. Hence, the structural VAR model can be applied to examine sources of real and nominal effective exchange rates fluctuations.

4. Impulse Response and Variance Decompositions

We first estimate a bivariate VAR system with first-differenced real and nominal effective exchange rates. In order to select the lag-length of the VAR model, we again follow Sims (1980) likelihood ratio test. We select a model with a lag-length of eight. The residual diagnostics statistics are reported in Table 3 along with p-values of significance in parenthesis.

<table>
<thead>
<tr>
<th>Real Effective Exchange Rates</th>
<th>Nominal Effective Exchange Rates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normality 0.04 (0.98)</td>
<td>Normality 7.97 (0.02)</td>
</tr>
<tr>
<td>LB 6.90 (0.22)</td>
<td>LB (16) 9.06 (0.11)</td>
</tr>
<tr>
<td>ARCH 12.97 (0.67)</td>
<td>ARCH (16) 3.94 (0.99)</td>
</tr>
</tbody>
</table>

Table 3: Residual Diagnostic Statistics

Normality: Jarque-Bera Normality Test, LB: Ljung-Box test for residual autocorrelation
ARCH: Lagrange multiplier test for residual ARCH.

From Table 3, all the residual diagnostics show absence of autocorrelation and autoregressive conditional heteroskedasticity. Hence, we proceed with a lag length of eight for our VAR model.

Impulse response functions can be used to illustrate the dynamic characteristics of the empirical model. We generate the impulse response functions by accumulating the effects of Ai coefficients. This can be done as follows:

Equation (1) gives us $y_1 = y_0 + a_1\phi_1$ and $y_2 = y_1 + a_2\phi_2 + a_1\phi_1$. Replacing the expression for $y_1$ into that of $y_2$ gives $y_2 = y_0 + a_2\phi_2 + (a_0 + a_1)\phi_1$. Repeating this process, one can get the following expression:

$$y_t = y_0 + a_0\phi_1 + (a_0 + a_1)\phi_{t-1} + \sum_{i=0}^{t-1} a_i\phi_1$$  \hspace{1cm} (5)

Figures 1a and 1b plot the response of real effective exchange rate to real and nominal disturbances respectively along with 95 percent standard error confidence interval that indicates the precision of the impulse-response functions. Using a bootstrap simulation on reduced form errors with 1000 replications generates these standard-errors confidence interval.
The result shows that the responses of real effective exchange rates to real disturbances keep a constant level in the long run. Figure 1b illustrates that due to a nominal disturbance the real effective exchange rate of Indian currency rises immediately. However, the response of real effective exchange rate goes to zero in about 30 months or even less. This result is consistent with our assumptions that a nominal shock has an impact on real effective rates in the long run.

The responses of nominal effective exchange rates due to real and nominal shocks are represented in Figures 2a and 2b respectively. It is clear from Figure 2a that the response of nominal effective exchange rate to real disturbance is quite similar to that of the real rate. This infers that the permanent changes in real effective exchange rate due to real shocks mainly happens through nominal exchange rate changes instead of changes in price levels.

Variance decompositions are a different way of measuring the average relative contribution to forecast error variance of each shock as a function of forecast horizon. While the impulse response shows the impact of a one-time shock, the variance decompositions measure the relative importance of such shocks to the system. Table 4 reports the variance decompositions of real and nominal exchange rates at selected horizon. Estimated bootstrap standard errors are given in parenthesis.

Table 4: Variance Decomposition of Real and Nominal Effective Exchange Rates

<table>
<thead>
<tr>
<th>Forecast Horizon</th>
<th>Real Effective Exchange Rate</th>
<th>Nominal Effective Exchange Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Real Shock</td>
<td>Nominal Shock</td>
</tr>
<tr>
<td></td>
<td>Real Shock</td>
<td>Nominal Shock</td>
</tr>
<tr>
<td>4</td>
<td>0.96 (0.16, 0.96)</td>
<td>0.05 (0.05, 0.84)</td>
</tr>
<tr>
<td>12</td>
<td>0.82 (0.25, 0.88)</td>
<td>0.18 (0.12, 0.75)</td>
</tr>
<tr>
<td>20</td>
<td>0.81 (0.25, 0.86)</td>
<td>0.19 (0.14, 0.74)</td>
</tr>
<tr>
<td>32</td>
<td>0.81 (0.26, 0.86)</td>
<td>0.19 (0.14, 0.74)</td>
</tr>
<tr>
<td>48</td>
<td>0.81 (0.25, 0.86)</td>
<td>0.19 (0.14, 0.74)</td>
</tr>
</tbody>
</table>
From table 4, it is clear that the real shock is the driving force behind real and nominal exchange rate movements. The real innovation causes a 96 percent of variation in real rate at four months, and the percent of variation falls to 82 percent in twelve months. More than 80 percent of variation in real effective exchange rate is due to real shocks at all time horizons. For nominal rates, the role of real shocks is also important. However, the importance of real shocks in explaining the nominal rates is less important than in the case of real rates.2

Conclusion

In this paper, we have used vector autoregressive model to explain the movements in real and nominal effective exchange rates for Indian currency in terms of real and nominal disturbances. The results indicate predominance of real shocks in explaining the variations in both real and nominal exchange rates. These results are consistent with Lastrapes (1993), Meese and Rogoff (1988), Stein (1990), Yoshikawa (1990) and support the equilibrium model of Stockman (1987). With regard to exchange rate policy, the results presented in this study imply that the variation in nominal effective exchange rates is mostly necessary to allow for changes in relative prices across countries and efficient allocation of resources.

2 The results are similar with analysis covering July 1991 to December 1997. Also, we have tried to see the robustness of our results with Indian real exchange rates with respect to United States. The results are almost identical with the one presented here.
References


