WP/00/157

IMF Working Paper

What Caused the 1991 Currency Crisis in India?

Valerie Cerra and Sweta Chaman Saxena

INTERNATIONAL MONETARY FUND

 WP/00/157

IMF Working Paper

European I Department

What Caused the 1991 Currency Crisis in India?

Prepared by Valerie Cerra and Sweta Chaman Saxena[1]

Authorized for distribution by Sharmini Coorey

October 2000

Abstract

Did real overvaluation contribute to the 1991 currency crisis in India? This paper seeks an answer by constructing the equilibrium real exchange rate, using an error correction model and a technique developed by Gonzalo and Granger (1995). The results are affirmative and the evidence indicates that current account deficits and investor confidence also played significant roles in the sharp exchange rate depreciation. The ECM model is supported by superior out-of-sample forecast performance versus a random walk model.

JEL Classification Numbers: F41, F47, F31, F32, C32

Keywords: India, Currency Crisis, Equilibrium Exchange Rate, Error Correction Model, Gonzalo-Granger decomposition

Authors' E-Mail Addresses: vcerra@imf.org; ssaxena+@pitt.edu

---

[1] European I Department, IMF; and University of Pittsburgh, respectively. The authors would like to thank Timothy Callen, Charles Engel, David Goldsbrough, and Christopher Towe for helpful comments on this and earlier versions of this paper, and Janet Bungay for editorial suggestions. All errors are the responsibility of the authors.

Contents Page

I. Introduction

In mid-1991, India's exchange rate was subjected to a severe adjustment. This event began with a slide in the value of the rupee leading up to mid-1991. The authorities at the Reserve Bank of India took partial action, defending the currency by expending international reserves and slowing the decline in value. However, in mid-1991, with foreign reserves nearly depleted, the Indian government permitted a sharp depreciation that took place in two steps within three days (July 1 and July 3, 1991) against major foreign currencies: for example, 9½ percent and then another 23 percent against the U.S. dollar. With assistance from the IMF and after an initial stage of stabilization through administrative controls, the government embarked on an adjustment program featuring macroeconomic stabilization and structural reforms. Structural measures initially emphasized accelerating the process of industrial and import delicensing and then shifted to further trade liberalization, financial sector reform, and tax reform. However, despite progress in liberalizing trade and capital flows, India is still relatively closed and capital inflows have been well below those in other Asian economies. In this respect, India's 1991 currency crisis provides an interesting case study, contrasting against the recent Asian crisis, which mostly affected the very open Asian countries.

In official descriptions of the event, India's exchange rate crisis has been attributed to continued current account deficits leading up to the crisis, made worse by problems related to the Middle East crisis; high fiscal deficits; and a loss of confidence in the government. Some of these factors are consistent with the traditional Mundell-Fleming model. Alternatively, Edwards (1989) presents an extensive analysis of exchange rate misalignments and crises in developing countries, including those with restricted external regimes. He attributes crises to a correction of real exchange rate appreciation following expansive macroeconomic policies.

The paper will investigate the causes of India's currency crisis, using econometric evidence to select among alternative explanations. The paper proceeds by estimating the long-run (equilibrium) real exchange rate for India in order to determine whether the Indian rupee was overvalued at the time of the crisis in 1991. The aim is to find the macroeconomic factors that led to a misaligned exchange rate—if there was in fact any misalignment. Section II first provides a historical perspective on the external sector developments as background for the selection of some of the exogenous variables used in the analysis. Section III discusses the determinants of the equilibrium real exchange rate in the light of theoretical models. Section IV presents the econometric results from the estimation of error correction models and verifies how closely the results adhere to predictions of the theoretical models. Section V uses information from the econometric estimation to decompose the real exchange rate into its temporary and permanent (equilibrium) components. The forecasting performance of our model is contrasted against the random walk in Section VI, and Section VII concludes.

II. External Sector Performance

India's post-Independence development strategy was both inward-looking and highly interventionist, consisting of import protection, complex industrial licensing requirements, financial repression, and substantial public ownership of heavy industry. However, macroeconomic policy sought stability through low monetary growth and moderate public sector deficits. Consequently, inflation remained generally low except in response to unfavorable supply shocks (e.g., from oil price increases or poor weather conditions). The current account was in surplus for most years until 1980, and there was a reasonable cushion of official reserves.[2] Official aid dominated capital inflows.

During the first half of the 1980s, the current account deficit stayed below 1½ percent of GDP. While export growth was slow, the trade deficit was kept in check, as a rapid rise in domestic petroleum production permitted savings on energy imports. At the same time, the high proportion of concessional external financing kept debt service down.

In the second half of the 1980s, current account deficits widened. India's development policy emphasis shifted from import substitution toward export-led growth, supported by measures to promote exports and liberalize imports for exporters. The government began a process of gradual liberalization of trade, investment, and financial markets. Import and industrial licensing requirements were eased, and tariffs replaced some quantitative restrictions. Export growth was rapid, due to the initial measures of deregulation and improved competitiveness associated with the real depreciation of the rupee. However, the value of imports increased at a faster clip. The volume of petroleum imports increased by more than 40 percent from 1986/87 to 1989/90 with the growth of domestic petroleum production slowing and consumption growth remaining strong. A deterioration of the fiscal position stemming from rising expenditures contributed to the wider current account deficits. For instance, imports of aircraft and defense capital equipment rose sharply. The balance on invisibles also deteriorated as debt-service payments ballooned.

Current account deficits in the second half of the 1980s exceeded the availability of aid financing on concessional terms and consequently other sources of financing were tapped to a greater extent. In particular, the growing current account deficits were increasingly financed by borrowing on commercial terms and remittances of nonresident workers—which meant greater dependence on higher cost short maturity financing and heightened sensitivity to shifts in creditor confidence. India's external debt nearly doubled from some $35 billion at the end of 1984/85 to $69 billion by the end of 1990/91. Medium- and long-term commercial debt jumped from $3 billion at the end of 1984/85 to $13 billion at the end of 1990/91 and the stock of nonresident deposits rose from $3 billion to $10.5 billion over the same period. Short-term external debt grew sharply to $6 billion and the ratio of debt-service payments to current receipts widened close to 30 percent. By 1990/91, India was increasingly vulnerable to shocks as a result of its rising current account deficits and greater reliance on commercial external financing.

---

[2] For a review of the long-run external sector performance and other economic developments, see Chopra, et al. (1995).

Two sources of external shocks contributed the most to India's large current account deficit in 1990/91. The first shock came from events in the Middle East in 1990 and the consequent run-up in world oil prices, which helped precipitate the crisis in India. In 1990/91, the value of petroleum imports increased by $2 billion to $5.7 billion as a result of both the spike in world prices associated with the Middle East crisis and a surge in oil import volume, as domestic crude oil production was impaired by supply difficulties. In comparison, non-oil imports rose by only 5 percent in value (1 percent in volume terms). The rise in oil imports led to a sharp deterioration in the trade account, worsened further by a partial loss of export markets (as the Middle East crisis disturbed conditions in the Soviet Union, one of India's key trading partners). The Gulf crisis also resulted in a decline in workers' remittances, as well as an additional burden on repatriating and rehabilitating non-resident Indians from the affected zones.

Second, the deterioration of the current account was also induced by slow growth in important trading partners. Export markets were weak in the period leading up to India's crisis, as world growth declined steadily from 4½ percent in 1988 to 2¼ percent in 1991. The decline was even greater for U.S. growth, India's single largest export destination. U.S. growth fell from 3.9 percent in 1988 to 0.8 percent in 1990 and to –1 percent in 1991. Consequently, India's export volume growth slowed to 4 percent in 1990/91.

In addition to adverse shocks from external factors, there had been rising political uncertainty, which peaked in 1990 and 1991. After a poor performance in the 1989 elections, the previous ruling party (Congress), chaired by Rajiv Gandhi (the son of former Prime Minister Indira Gandhi), refused to form a coalition government. Instead, the next largest party, Janata Dal, formed a coalition government, headed by V.P. Singh. However, the coalition became embroiled in caste and religious disputes and riots spread throughout the country. Singh's government fell immediately after his forced resignation in December 1990. A caretaker government was set up until the new elections that were scheduled for May 1991. These events heightened political uncertainty, which came to a head when Rajiv Gandhi was assassinated on May 21, 1991, while campaigning for the elections.

India's balance of payments in 1990/91 also suffered from capital account problems due to a loss of investor confidence. The widening current account imbalances and reserve losses contributed to low investor confidence, which was further weakened by political uncertainties and finally by a downgrade of India's credit rating by the credit rating agencies. Commercial bank financing became hard to obtain, and outflows began to take place on short-term external debt, as creditors became reluctant to roll over maturing loans. Moreover, the previously strong inflows on nonresident Indian deposits shifted to net outflows.

III. Theoretical Explanations of Equilibrium Real Exchange Rates

Montiel (1997) and Edwards (1989) present theoretical models that provide real fundamental determinants of the long-run real exchange rate. Both works use intertemporal optimization techniques to determine how the equilibrium real exchange rate is affected by real variables. While Montiel's model is an infinite horizon one, Edwards uses a two-period optimization model. Intuitively, the equilibrium real exchange rate—associated with the steady state in Montiel and the second period in Edwards—is consistent with simultaneous internal and external balance. The predictions from the two models can be summarized as follows:[3]

- Changes in the **composition of government spending** affect the long-run equilibrium REER in different ways, depending on whether the spending is directed toward traded or non-traded goods. If government spending is directed mainly toward traded goods and services, the trade balance deteriorates. To bring the external balance in equilibrium, the REER must depreciate. The expected sign on the coefficient is negative. Conversely, spending directed mainly toward non-traded goods and services generates excess demand in the non-traded sector. To restore the sectoral balance, there must be an appreciation of the REER, which can be defined as the relative price of non-tradables to tradables (since an increase in the ratio is defined as an appreciation). The expected sign on the coefficient is positive.

- As the **terms of trade** improve, there is an increase in the real wage in the export sector, due to which labor from the non-tradable sector moves to the tradable sector, which leads to a trade surplus. To restore external balance, the REER must appreciate. Hence, a positive coefficient is expected.

- As **exchange and trade controls** in the economy decrease, the demand for imports leads to external and internal imbalances, which require real depreciation to correct them. The expected sign depends on the proxy used for exchange controls. Montiel uses the proxy openness (exports+imports/gdp) for a reduction in exchange controls, arguing that as trade barriers are reduced (including price and quantity controls), the total amount of trade will increase. Accordingly, an increase in openness should be associated with real depreciation, and the expected sign is negative. However, Edwards uses other proxies for exchange controls—import tariffs as a ratio of tariff revenues to imports and the spread between the parallel and official rates in the foreign exchange market. If these proxies are used, then the expected sign is positive, since a reduction in the values of each of these proxies implies a reduction in controls and depreciation.[4] Edwards stresses the limitations of his two proxies. While import tariffs ignore the role of non-tariff barriers, the spread between the parallel and official rates capture some other forces besides the trade controls.

---

[3] Following the convention used by the IMF, an increase in the real effective exchange rate (REER) is an appreciation.

[4] In this case, the parallel and official rates are in rupees per dollar and the spread is the difference between them. Therefore, a positive spread reflects a more depreciated parallel rate compared with the official rate.

- As **capital controls** decrease, private capital flows in and both the intertemporal substitution effect and the income effect operate to increase present consumption.[5] There is pressure on the real exchange rate to appreciate in the short run in order to induce greater production in the nontraded sector and to shift some of the increased consumption toward imports. However, the long-run effect of a reduction in capital controls is ambiguous. The reduction in capital controls is equivalent to a decrease in the tax on foreign borrowing that generates a positive wealth effect, which increases consumption in all periods. Hence, an appreciation is required (positive sign) for equilibrium to hold. On the other hand, by the intertemporal substitution effect, future consumption is lower than present consumption, which exerts a downward pressure on the future (long-run) price of non-tradables, and hence a depreciation of the REER is required (negative sign). The overall sign of the equilibrium depends on which effect dominates.

- **Balassa-Samuelson effect—technological progress**: Higher differential **productivity growth** in the traded goods sector leads to increased demand and higher real wages for labor in that sector. The traded goods sector expands, causing an incipient trade surplus. To restore both internal and external balance, the relative price of non-traded goods must rise (REER appreciation).

- **Investment** in the economy: According to Edwards, when investment is included in the theoretical model, the intertemporal analysis includes supply-side effects that depend on the relative ordering of factor intensities across sectors. Therefore, the sign on the exchange rate in response to increased investment is ambiguous.

Permanent changes in the fundamentals above bring about changes in the long-run equilibrium real exchange rate. In other words, strict purchasing power parity does not hold, as the equilibrium real exchange rate is time-varying. The real exchange rate therefore fluctuates around a time-varying equilibrium defined by its relationship with the long-run fundamental determinants.

In addition to the long-run relationship, Edwards considers macroeconomic policies that result in overvaluation of the domestic currency, that is, short-run misalignments. He uses excess supply of domestic credit and a measure of fiscal policy (ratio of fiscal deficit to lagged high-powered money) as proxies of "inconsistent" macroeconomic policies. As macroeconomic policies become highly expansive, the real exchange rate appreciates—reflecting a mounting disequilibrium or real exchange rate overvaluation. However, his analysis is based on a fixed exchange rate regime: inconsistent macroeconomic policies

[5] The lifting of capital controls is typically associated with inflows of capital in developing countries, as foreign investors seek new investment opportunities and as domestic industries resort to borrowing abroad. The reduction of capital controls could also conceivably lead to an outflow of capital, although this would most likely occur in response to a temporary loss of confidence in domestic policies or economic prospects.

generate a higher domestic price level which, with a fixed nominal exchange rate, leads to an appreciation of the real exchange rate. India's inflation was broadly similar to that of its trading partners while its trade-weighted nominal exchange rate declined steadily over the second half of the 1980s. Therefore, the conditions assumed by Edwards—high domestic inflation in combination with a nominal exchange rate fixed to a low inflation country—do not appear to have been met. Instead, nominal exchange rate adjustment outpaced adjustment through the price level.

Nonetheless, in connection with Edwards' theory of misalignment, variables for inconsistent macroeconomic policies are included in the short-run part of the specification. In addition, the 1991 crisis in India is believed to have been caused mainly by high fiscal deficits, the loss of confidence in the government, and mounting current account deficits. The next section attempts to verify these assertions through econometric investigation.

IV. Model Selection

This section estimates the intertemporal model discussed above, using an error correction model (ECM).[6] Before the cointegration technique was developed, researchers used partial adjustment or auto-regressive models. These models assume that the variables are stationary and try to capture the serial correlation in the endogenous variable by including lags of it or by including ARMA terms. These techniques do not account for the tendency of many economic variables to be integrated and therefore also do not account for the possibility that the economic variables share a common stochastic trend. Any equilibrium relationship among a set of non-stationary variables implies that their stochastic trends must be linked. Then, since these variables are linked in the long run, their dynamic paths should also depend on their current deviations from their equilibrium paths. The ECM has the advantage of capturing the common stochastic trend among the non-stationary series and the deviations of each variable from its equilibrium.

All of the fundamentals are examined for unit roots to suggest their stochastic behavior. Unit test results are reported in Table 1. Standard unit root tests reveal that the null hypothesis of a unit root cannot be rejected for any of the long-run fundamentals, but that it can be rejected for the current account, excess credit, and the fiscal balance to high powered money.[7] The unit root test cannot be rejected for the index of political confidence, but it can be rejected for

[6] For testable implications of the intertemporal model, refer to Saxena (1999).

[7] Of course, much research has shown that unit root tests of economic variables suffer from lack of power. That is, when a series is stationary, but highly autocorrelated, rejection of the unit root hypothesis requires a considerably longer sample period than the sample typically available. Nonetheless, the consequences of assuming that variables are stationary when they are not include finding spurious relationships. Hence, it is more conservative to assume that the variables are nonstationary even if they are not.

its first difference. The lag length for the error correction model is determined by backward selection, beginning at a lag length of four to economize on degrees of freedom. The likelihood ratio test indicates that ECM(2) is the most appropriate.

In accordance with the theory of error correction models, the series are tested for cointegration. The results from Johansen cointegration tests are reported in Table 2, including the number of cointegrating vectors. The results reported in Table 3 are obtained by estimating the ECM by imposing one cointegrating vector for ease of interpretation.[8] (However, the equilibrium real exchange rate and forecasting analysis discussed below are estimated with the number of cointegrating vectors stipulated from the cointegration test.)

We first estimate the ECM with all of the potential fundamental long-run variables suggested from the theory (Model 1). The results indicate that all the fundamentals are significant, except openness. The same model was estimated with Edwards' proxies for openness, namely parallel market spread and exchange controls. However, they were insignificant as well. Government consumption leads to a real depreciation, consistent with a higher proportion of government consumption directed toward traded goods relative to private consumption. An improvement in the terms of trade leads to an appreciation of the real exchange rate, while increases in openness and increases in investment lead to real depreciation. A decrease in capital controls leads to higher capital inflows, which appreciates the real exchange rate in the long run—indicating that the income effect dominates over the intertemporal substitution effect. Technological progress leads to an appreciated real exchange rate—a result consistent with the Balassa-Samuelson effect.

Next, a general-to-specific modeling procedure is employed. The insignificant variables from Model 1 are eliminated sequentially to arrive at the parsimonious specification, Model 2. The results remain the same as Model 1 in terms of signs, although the magnitudes change slightly.

Having arrived at a parsimonious specification involving significant fundamentals that affect the equilibrium exchange rate, we now examine the impact of short-run factors that can cause the exchange rate to deviate temporarily from equilibrium.[9] Model 3 is estimated with the same long-run fundamentals as in Model 2, with proxies for inconsistent macroeconomic policies as used by Edwards (1989). The results indicate that the signs on the long-run

[8] Note that this one cointegrating vector can also be obtained as a linear combination of the estimated multiple cointegrating vectors.

[9] Sensitivity tests indicated that there was no advantage in using the full specification of Model 1 when analyzing the effects of the exogenous variables, since the results were not significantly different from those reported from the parsimonious specification while several degrees of freedom were lost in the process of carrying around the insignificant variables and their lags.

fundamentals remain the same as before and are significant. The coefficients on the policy variables are insignificant—indicating that the empirical evidence does not provide support for Edwards' description of misalignment in the case of India.[10] Moreover, the signs of our results are inconsistent with Edwards' explanation of real exchange rate misalignment in response to lax macroeconomic policy. Our (insignificant) results indicate that an improvement in the government fiscal balance leads to an appreciation in the real exchange rate and conversely, that fiscal deficits correspond to a depreciation of the real exchange rate. Excessive domestic credit creation results in a depreciation of the real exchange rate. In Edwards' model, the nominal exchange rate is fixed and higher government deficits that are monetized give rise to a higher domestic price level and a corresponding appreciation of the real exchange rate. Given these assumptions, the lack of support for Edwards' model for India is not surprising: nominal depreciation of the rupee appears to have offset any domestic price pressures arising from monetary expansion. In addition, the data do not indicate that India monetized its deficits to any significant extent. The increasing fiscal deficits in the years leading up to the crisis were financed by borrowing, including from foreign sources. The effect of this was a misalignment in the external sector as a result of fiscal deficits which, at the prevailing levels, were inconsistent with an intertemporal budget constraint. Instead of Edwards' framework, the exchange rate depreciation resulting from fiscal deficits or high domestic credit creation is consistent with the classical Mundell-Fleming framework. Expansive fiscal or monetary policy—in the case of a country such as India, with limited capital mobility—causes a balance of payments deficit and nominal exchange rate depreciation. With sluggish prices, the real exchange rate also depreciates.

Having found that the Edwards model does not fit well for India, we now investigate whether the evidence supports the descriptions of the causes of India's balance of payments crisis: namely, large current account deficits, fiscal deficits, and loss of confidence in the government. Hence, to Model 2, we add the short-run factors: the current account balance, the government fiscal balance to high powered money (as above), and changes in political confidence.[11] The results are shown in column 4 of Tables 3 and 4. The long-run results do not change much as the fundamentals have the usual (significant) signs. Regarding the exogenous variables, both the current account and the change in political confidence are significant, with positive signs.[12] This indicates that as the current account balance improves and confidence in the government increases, the real exchange rate appreciates. The sign and significance of the political confidence indicator can be expected since this variable proxies for the confidence of India's creditors and their willingness to roll over debt or maintain

[10] The table shows the results for the most significant lag. The coefficients on other lags have the same sign as the third lag, with one negligible exception.

[11] Since we could not reject the hypothesis of a unit root for the level of political confidence, its first difference was taken in the specification.

[12] The insignificant lags were eliminated.

deposits. Similar to the result reported in Model 3, the government balance is positive but insignificant. The insignificance of the fiscal variable here may be due to collinearity. Confidence in the government is likely to decline as fiscal deficits grow and appear unsustainable. Moreover, the inclusion of the current account deficit in the equation, according to the Mundell-Fleming model described above, captures the external effects of the expansionary fiscal policy.

Through elimination of the insignificant fiscal variable, we arrive at the parsimonious Model 5. However, one difficulty with using this model for the analysis in the next sections is that data are available for political confidence only from 1985. The loss of several years of data in the early 1980s causes the problem that there are not enough degrees of freedom to estimate a restricted sample for the out-of-sample forecasting exercise discussed below. Therefore, for purposes of the remaining analysis, the political confidence variable is dropped and the **baseline specification** is shown as **Model 6**—which consists of the long-run variables from the parsimonious specification (Model 2) and the current account balance as the exogenous short-run variable.

As a sensitivity analysis, we estimate Model 7, where Edwards' variables for capital control and investment are ignored but openness and terms of trade are restored, consistent with Montiel's specification. The findings from Model 1 still hold—increases in government consumption and openness lead to a depreciation of the real exchange rate, while an improvement in the terms of trade results in an appreciation of the real exchange rate. An improvement in the current account balance brings about real exchange rate appreciation. The coefficient on technological progress, however, becomes insignificant.

One finding that emerges very clearly from the econometric investigation is that the current account plays a very significant role in explaining short-run movements in the real exchange rate for India during the period of analysis. This variable is robust to all specifications (a significant positive sign). This result is corroborated by Callen and Cashin (1999), who examine the sustainability of India's current account during the period 1952/53-1998/99 using three methods. They find that in the period prior to 1990/91, India's intertemporal budget constraint was not satisfied and that the return to smaller current account deficits following the crisis was needed to reestablish solvency.

In this section, the current account has been discussed as an exogenous short-run explanatory variable. In general, however, the real effective exchange rate could be expected to influence the current account. Indeed, the decline in the real exchange rate in the latter half of the 1980s was likely a contributing factor to rapid export growth in particular, although the initial liberalization measures implemented to spur export-led growth are also thought to have been important. However, since the key feature of the current account from the mid-1980s through the crisis in mid-1991 was its sharp deterioration, it seems that the simultaneous rapid decline in the real exchange rate over this same period had at most a mitigating influence. There were many other factors that jointly overwhelmed any beneficial influence of the real exchange rate and produced the substantial deterioration in the current account. As mentioned in the introductory section, some of these factors included: the increasing dependence on foreign oil imports and consequently the greater vulnerability to oil price shocks; strong domestic demand as a result of both the initial liberalization efforts and deteriorating fiscal balances, but weak foreign demand in the years leading up to and including 1991; shocks to workers' remittances; and higher interest payments on external debt due to its higher cost structure and growing size.

Moreover, these observations on the relationship between the real exchange rate and the current account in this period are borne out by evidence from Granger causation tests (Table 5). The results of Granger causation tests lend support to the idea that movements in the current account had a strong impact on the real exchange rate, but that the opposite did not hold.

The null hypothesis that the current account does *not* Granger cause changes in the real effective exchange rate *can be rejected* at the 10 percent confidence level for 4 and 8 quarter lags and (marginally) at the 5 percent confidence level for 12 quarter lags. In the other direction of causality, the hypothesis that changes in the real effective exchange rate do *not* Granger cause the current account *cannot be rejected* for 8 and 12 lags. This hypothesis *can* be (marginally) rejected at the 10 percent confidence level for 4 lags. However, in the latter case, the sum of the lagged exchange rate coefficients in the current account equation is positive, counter to theoretical predictions that decreases in the real exchange rate should lead to improved current account balances. This evidence is in line with the discussion above that the current account balances were deteriorating at the same time that the real exchange rate was declining substantially.

V. Estimating the Equilibrium Real Exchange Rate

In order to determine whether the Indian rupee was overvalued prior to the crisis in 1991, we estimate the equilibrium real exchange rate, using the error correction model estimated in Section IV.[13] Frequently, researchers construct the equilibrium real exchange rate by multiplying the cointegrating vector with the *actual* values of the fundamentals. However, the fundamentals may have their own temporary components and by using the *actual* values of the fundamentals, the construction of the equilibrium real exchange rate depends on these temporary components, when it should not. Edwards (1989) recognizes the problem with using actual values of the fundamentals to construct the equilibrium exchange rate. He tries to solve this by means of two methods. He does a Beveridge-Nelson decomposition of each fundamental series or alternatively he uses moving averages of each fundamental series. He then uses the constructed permanent component of each variable in his equilibrium equation. These are potential suggestions for finding the equilibrium fundamentals, as would be other methods of univariate decomposition into permanent and temporary components.

[13] We report only the equilibrium exchange rate estimated from the baseline ECM (Model 6).

This section estimates the equilibrium real effective exchange rate, using three different methods. First, the permanent components of the fundamentals are constructed, using a Hodrick-Prescott filter and a 13-quarter (centered) moving average process as representative smoothing methods.[14] These methods are used for illustrative purposes only. While these methods produce smooth fundamental series that are appealing to the eye, there is no sound theoretical basis for these procedures. If simple smoothing processes were enough to arrive at the equilibrium values for the fundamental series, then the same smoothing processes could be employed on the real exchange rate series to estimate the equilibrium real exchange rate. But doing so would be devoid of economic theory such as that which describes a relationship between the exchange rate and other economic variables, a relationship that is estimated through an error correction model in this paper. In addition, independently smoothing the fundamentals does not take advantage of information arising from the interaction of the variables.

Gonzalo and Granger (1995) propose a more appealing way of solving this econometric problem so that the permanent (equilibrium) component of the endogenous variable of interest—in our case, the exchange rate—could be constructed by means of the permanent components rather than the actual values of the fundamental determinants. It is done using the joint information in the error correction system rather than pre-constructing the equilibrium fundamental variables. Other procedures advanced in the literature to address this issue include those of Quah (1992) and Kasa (1992). However, these latter two decomposition methods present the undesirable property that the transitory component Granger causes the permanent component, leading a temporary shock to have permanent effects on the actual aggregated series. Gonzalo and Granger derive a P-T decomposition such that the transitory component does not Granger cause the permanent component in the long-run (i.e., the effects of transitory shocks die out over time). Their procedure is sketched below.[15]

Let X_t be a *(px1)* vector of *I(1)* time series with mean 0 and assume that there exists a matrix α_{pxr} of rank *r* such that $\alpha' X_t$ is I(0). Then, the vector X_t has the following ECM representation:

$$\Delta X = \underset{pxr}{\gamma} \underset{rxp}{\alpha'} X_{t-1} + \sum_{i=1}^{\infty} \Gamma_i \Delta X_{t-i} + \varepsilon_t , \qquad (1)$$

[14] Previous work with the Beveridge-Nelson decomposition has shown that since the method assumes that the permanent component is a random walk, the filtered series tends to closely replicate the actual data; very little smoothing tends to occur.

[15] This is drawn from Gonzalo and Granger (1995). This procedure was also used by Alberola et al. (1999) in their study of euro-area exchange rates.

where Δ is the lag operator. The elements of X_t consist of *(p-r) I(1)* variables, f_t, known as the common factors, plus some *I(0)* components.

$$\underset{px1}{X_t} = \underset{pxk}{A_1} \underset{kx1}{f_t} + \underset{px1}{\widetilde{X}_t}, \tag{2}$$

where $k = p\text{-}r$. Gonzalo and Granger define $A_1 f_t$ and $\widetilde{X}_t$ as the permanent and temporary components of X_t, respectively, such that only the innovations from the permanent component can affect the long run forecast of X_t. Innovations to the temporary components of all of the endogenous variables, including the fundamental determinants, do not affect the long-run, i.e., "equilibrium," forecast of X_t. So, for our purposes, cyclical deviations of the fundamentals will be removed in the construction of the equilibrium exchange rate. In addition, all of the information required to extract the permanent component is contained in the contemporaneous observations.

The only linear combination of X_t that precludes $\widetilde{X}_t$ from having any long-run impact on X (which constitutes the conditions sufficient to identify the common factor f_t) is given by:

$$f_t = \underset{kxp}{\gamma_\perp'} \underset{px1}{X_t}, \tag{3}$$

where $\gamma_\perp$ is the orthogonal complement of γ (i.e., $\gamma'_\perp \gamma = 0$) and $k = p\text{-}r$. Once the common factors f_t are identified, the matrix $(\gamma_\perp, \alpha)$' can be inverted to obtain the *P-T* decomposition as follows:

$$\underset{px1}{X_t} = \underset{pxk}{A_1} \underset{kxp}{\gamma_\perp'} X_t + \underset{pxr}{A_2} \underset{rxp}{\alpha'} X_t, \tag{4}$$

where $A_1 = (\gamma'_\perp \alpha_\perp)^{-1}$ and $A_2 = \gamma\,(\alpha'\gamma)^{-1}$. The first term on the right-hand side provides the permanent component at each point in time, *t*, for the vector of endogenous variables (in our case, the real exchange rate and all of its fundamental long-run determinants).

The equilibrium exchange rate is estimated for the baseline model (Model 6), using the three methods—the Hodrick-Prescott filter and a moving average process for illustrative purposes (Figure 1a), and the theoretically attractive Gonzalo-Granger method (Figure 1b). The equilibrium exchange rate constructed by means of the Hodrick-Prescott filtered series shows an overvalued exchange rate from 1985:2 through 1995:5, while the one estimated by smoothing the series using the moving average shows an overvaluation of the exchange rate from 1986:3 through 1994:4. As mentioned above, these findings carry no theoretical value.

In order to estimate the exchange rate consistent with the fundamentals, we construct the equilibrium using the method described by Gonzalo and Granger (1995). Figure 1b shows the result—the real effective exchange rate was overvalued for several years prior to and through the crisis (from 1985:3 through 1993:1). Indeed, the equilibrium path was below the actual path of the exchange rate for several years of a downward trend, suggesting that the actual depreciation was moving in the direction of restoring equilibrium, although the equilibrium itself continued to move to lower levels. In 1993, the equilibrium comes into line with the actual data for the first time since the mid-1980s. Thereafter, the equilibrium is periodically above or below the actual, but there is no clear trend. In summary, a strong result that emerges from all of these estimations is that the real exchange rate for India was overvalued at the time of crisis in 1991.

VI. Forecasting the Real Exchange Rate

In order to test the forecasting performance of the baseline model (Model 6), we make dynamic as well as static forecasts of the real exchange rate. For both types of forecasts, the model is estimated for the full sample period (through 1997:1) and for a restricted sample period that ends at a point sufficiently earlier than the crisis such that there would be time for adjustment (1989:4 is chosen as the end point). The parameters from the error correction model estimated over each of these two sample periods are used to form forecasts for the period 1990:1 through 1997:1. While the static forecasts for the exchange rate are formed using actual data for the lagged endogenous variables on the right-hand side of the ECM, dynamic forecasts use actual data for the endogenous variables only up to 1989:4 and thereafter use forecasted data for all of the right-hand side endogenous variables.

The series of real exchange rate forecasts are shown in Figures 2a (dynamic) and 2b (static). The static forecasts from full and restricted sample parameters follow the actual exchange rate exceptionally closely. More surprisingly, the dynamic forecasts also display trends and cycles that are similar to the actual data. The dynamic forecast using parameters from the restricted sample does a better job in prediction than the forecast using the full sample parameters in the initial part of the forecast period, but the latter provides a better forecast for the end of the period.

Dynamic forecasts are also constructed for Model 2 in Figure 2c (which is the same as the baseline Model 6, but without the current account). The exchange rate forecasts show a linear downward trend. Compared with this, the forecasts from Model 6 show a similar downward trend, but also show cyclical movements that mirror the actual exchange rate. The better comparative performance of the model containing the current account adds to the evidence that the current account has been an important determinant of short-run exchange rate movements for India.

The forecasting performance of our baseline model is compared with the forecasting performance of different random walk models—in terms of their respective Mean Squared Errors (MSE). The static random walk model is estimated as the usual random walk—the forecast for time t is the actual value of the exchange rate prevailing at time t-1. These forecasts are comparable to the static forecasts from the ECM, as they both use the actual data from the period immediately preceding the forecast.

Some "dynamic" random walk models are also estimated so that they can be compared with our dynamic forecasts—which do not use any new information after the period of estimation.[16] A simple dynamic random walk model forms a forecast for all future exchange rates based on the value of the exchange rate at the end of the estimation period (1989:4). The two dynamic random walk with trend models are comparable to our dynamic forecasts, where the trend is estimated over the full and the restricted sample periods. These trends are combined with the value of the exchange rate prevailing in 1989:4 to construct the dynamic random walk forecasts.

The MSE results from forecasting are reported in Table 6. The results provide striking evidence that the forecasts from the ECM perform better than the random walk models. The static forecasts from the ECM models outperform the static random walk while the dynamic forecasts from the ECM models, including those using parameters from the restricted sample, outperform all of the dynamic random walk models.

VII. Conclusions

This paper estimates the long-run equilibrium real exchange rate for India in order to determine whether the currency crisis in 1991 was due to the overvaluation of the Indian rupee. First, the fundamentals that affect the long-run equilibrium exchange rate are explained as predictions from intertemporal theoretical models. Then, the predictions of the theoretical models are estimated empirically, using error correction models. The results show that the Indian rupee appreciates in the long run in response to an improvement in terms of trade, technological progress, and a relaxation of capital controls. The real exchange rate depreciates when government spending (on tradable goods) increases, the economy opens up and investment increases. The short-run variable, the current account, is found to be significantly positive and robust to all specifications.

The equilibrium real exchange rate is constructed using the smoothing techniques for the fundamentals—the Hodrick-Prescott filter and moving average processes. Since these smoothing processes do not have any theoretical basis, the joint information from the error correction model is used to construct the equilibrium values of the fundamentals, using the technique illustrated by Gonzalo-Granger (1995). The estimates of the equilibrium real exchange rate show an overvaluation at the time of crisis in 1991. The econometric evidence supports the position that the current account deficits played a significant role in the crisis. Moreover, the forecasts from our ECM model outperform random walk models.

---

[16] Except for the exogenous variable, for which there is no forecast model in the ECM method, and the parameters of the full sample model, which rely on the complete data set.

Table 1: Unit Root Tests

Variable	K	ADF Statistic	PP Statistic
LREER	3	-0.70 *	-0.10 *
LTOT	5	-1.84 *	-1.12 *
LGCONGDP	5	-0.62 *	-3.02 *
LOPEN	4	-0.24 *	-0.61 *
TECHPRO	4	-1.00 *	-2.04 *
LINVGDP	1	-1.19 *	-0.44 *
CAPCONTROL	4	-1.76 *	-1.47 *
EXCHCONTROL	2	-1.24 *	-1.87 *
LPARALLEL	2	-2.42 *	-2.09 *
GBALHPM	2	-3.45	-6.73
EXCREDIT	3	-3.80	-12.47
CURRENTACC	0	-5.23	-5.16
POLCONF	1	-1.44 *	-1.38 *
DPOLCONF	1	-4.58	-5.32

Note: Variables are as defined above in Appendix 1. The value of k corresponds to the highest-order lag for which the corresponding t-statistic in the regression is significant. Asterisks * denote non-rejection of null hypothesis of a unit root at 1% significance level. Critical values are from MacKinnon. These are the results from Unit Root testing in levels. However, all non-stationary series were stationary in first differences.

Table 2: Johansen Cointegration Test

Model	Eigenvalue	Likelihood Ratio	Critical Value 5%	Critical Value 1%	Hypothesized No. of CE(s)
Model 1	0.50	172.23	124.24	133.57	None **
	0.43	124.18	94.15	103.18	At Most 1 **
	0.37	84.56	68.52	76.07	At Most 2 **
	0.26	51.68	47.21	54.46	At Most 3 *
	0.23	31.02	29.68	35.65	At Most 4 *
	0.13	13.16	15.41	20.04	At Most 5
Model 2	0.43	97.87	68.52	76.07	None **
	0.34	58.60	47.21	54.46	At Most 1 **
	0.19	29.21	29.68	35.65	At Most 2
Model 3	0.43	96.53	68.52	76.07	None **
	0.36	58.71	47.21	54.46	At Most 1 **
	0.19	27.98	29.68	35.65	At Most 2
Model 4	0.71	98.24	68.52	76.07	None **
	0.41	39.25	47.21	54.46	At Most 1
Model 5	0.73	115.20	68.52	76.07	None **
	0.42	50.67	47.21	54.46	At Most 1 *
	0.22	23.59	29.68	35.65	At Most 2
Model 6	0.41	95.92	68.52	76.07	None **
	0.38	59.55	47.21	54.46	At Most 1 **
	0.19	26.39	29.68	35.65	At Most 2
Model 7	0.41	94.25	68.52	76.07	None **
	0.29	55.27	47.21	54.46	At Most 1 **
	0.19	29.88	29.68	35.65	At Most 2 *
	0.10	14.14	15.41	20.04	At Most 3

Note: *(**) denotes rejection of the null hypothesis of cointegration at 5%(1%) level of significance

Table 3: Results from Cointegrating Equation 1/2/

VARIABLE	MODEL 1	MODEL 2	MODEL 3	MODEL 4	MODEL 5	MODEL 6	MODEL 7
LGCONGDP	-3.586 ***	-4.859 ***	-2.895 ***	-4.842 **	-4.641 ***	-6.011 **	-6.423 ***
LTOT	0.771 ***						2.291 ***
LOPEN	-0.174						-0.967 ***
TECHPRO	3.909 ***	6.167 ***	6.378 ***	3.183 **	4.119 ***	5.703 ***	-1.475
CAPCONTROL	16.180 ***	41.084 ***	21.754 ***	108.910 ***	95.502 ***	56.969 **	
LINVGDP	-3.859 ***	-6.259 ***	-5.482 ***	-5.112 ***	-5.739 ***	-6.816 ***	
Exogenous Variables: 3/							
EXCREDIT(-3)			-0.193				
GBALHPM(-3)			0.297	0.187			
DPOLCONF(-3)				0.003 *	0.003 **		
CURRENTACC(-4)				0.00002 ***	0.00002 ***	0.00002 ***	0.00002 ***

1/ The models differ in terms of long run and short run variables that are included in each.

2/ Asterisks ***, **, * denote significance of the variable at 1, 5 and 10 percent level of significance, respectively.

3/ These variables are included in the short run part of the error correction models.

Table 4: Results from Error Correction Models 1/

VARIABLE	MODEL 1	MODEL 2	MODEL 3	MODEL 4	MODEL 5	MODEL 6	MODEL 7
CointEq	-0.111 ***	-0.057 ***	-0.067 ***	-0.061 ***	-0.079 ***	-0.037 ***	-0.077 ***
d(LREER(-1))	0.165	0.104	0.074	-0.256 **	-0.204 *	-0.012	0.104
d(LREER(-2))	-0.155	-0.217 *	-0.180	-0.360 ***	-0.350 ***	-0.254 ***	-0.234 **
d(GCONGDP(-1))	-1.593 **	-1.520 **	-1.313 **	-2.632 **	-3.014 ***	-1.420 **	-1.031
d(GCONGDP(-2))	1.386 ***	1.167 **	1.143 **	1.010	1.332	0.876 *	0.582
d(LTOT(-1))	-0.211						0.069
d(LTOT(-2))	0.258						-0.327
d(LOPEN(-1))	0.112 *						0.106 *
d(LOPEN(-2))	0.059						0.048
d(TECHPRO(-1))	0.051	0.065	0.065	0.084	-0.030	0.143	0.301 ***
d(TECHPRO(-2))	-0.190	-0.257 *	-0.208	-0.219 *	-0.308 **	-0.216	-0.109
d(CAPCONTROL(-1))	3.913	5.473 **	5.866 **	5.846 *	6.922 **	5.279 **	
d(CAPCONTROL(-2))	-1.807	-1.623	-0.210	1.480	0.402	-0.956	
d(LINVGDP(-1))	-1.177 *	-1.078 *	-0.900	-1.425 ***	-1.470 ***	-1.415 ***	
d(LINVGDP(-2))	1.399 **	1.670 **	1.838 ***	2.342 ***	2.405 ***	1.564 **	
EXCREDIT(-3)			-0.193				
GBALHPM(-3)			0.297	0.187			
DPOLCONF(-3)				0.003 *	0.003 **		
CURRENTACC(-4)				0.00002 ***	0.00002 ***	0.00002 ***	0.00002 ***
Adjusted R-Squared	0.343	0.326	0.354	0.687	0.675	0.420	0.346

1/ The dependent variable is d(LREER).

Note: Asterisks ***, ** and * denote the significance of the variables at 1, 5 and 10 percent level of significance, respectively.

Table 5: Pairwise Granger Causality Tests
Period: 1979:1 to 1997:1

Null Hypothesis	Lags	F-Statistic	Probability
CA does not Granger Cause D(LREER)	4	2.43485	0.05713
D(LREER) does not Granger cause CA	4	2.07426	0.09561
CA does not Granger Cause D(LREER)	8	2.06296	0.05895
D(LREER) does not Granger cause CA	8	1.53289	0.17160
CA does not Granger Cause D(LREER)	12	2.04197	0.04990
D(LREER) does not Granger cause CA	12	1.22957	0.30279

Table 6: Mean Squared Forecasting Errors

Model	Mean Squared Error
Dynamic_Random Walk	0.1277
Dynamic_Random Walk with Drift_Full Sample	0.0183
Dynamic_Random Walk with Drift_Restricted Sample	0.0409
Dynamic_ECM_Full Sample	0.0057
Dynamic_ECM_Restricted Sample	0.0063
Static_Random Walk	0.0025
Static_ECM_Full Sample	0.0008
Static_ECM_Restricted Sample	0.0022

Note: The forecasts for the ECM are from Model 6. All MSEs are estimated over a common sample (1990:1 to 1997:1) with 29 observations.

Figure 1. India: Actual and Equilibrium Real Effective Exchange Rates

Figure 1a: Hodrick Prescott Filter and Moving Average Methods

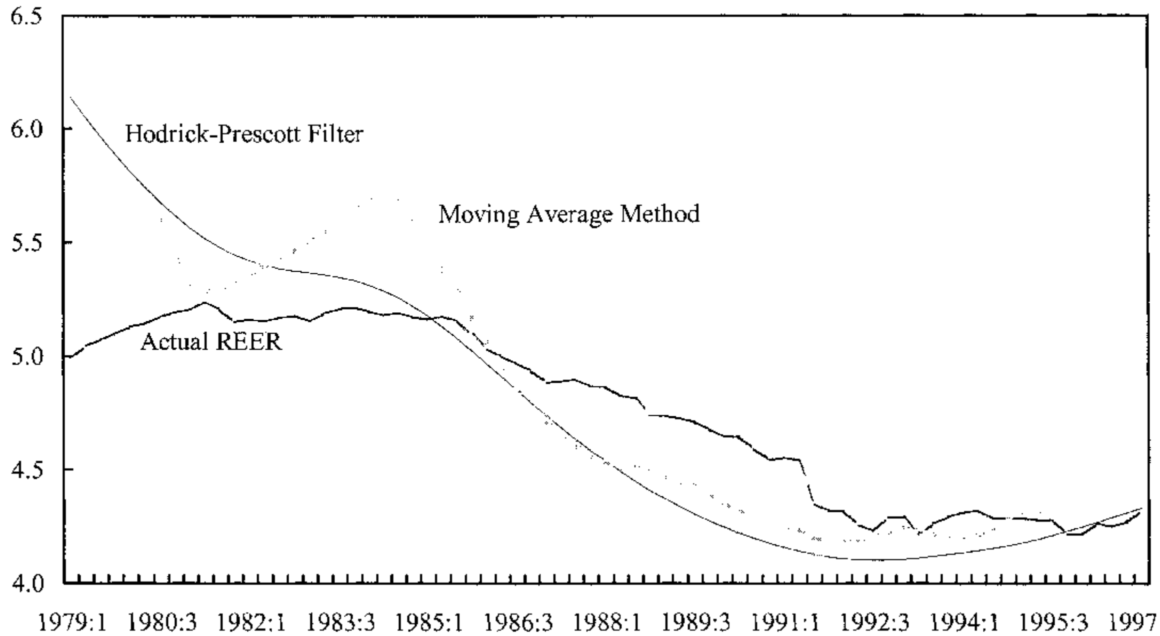
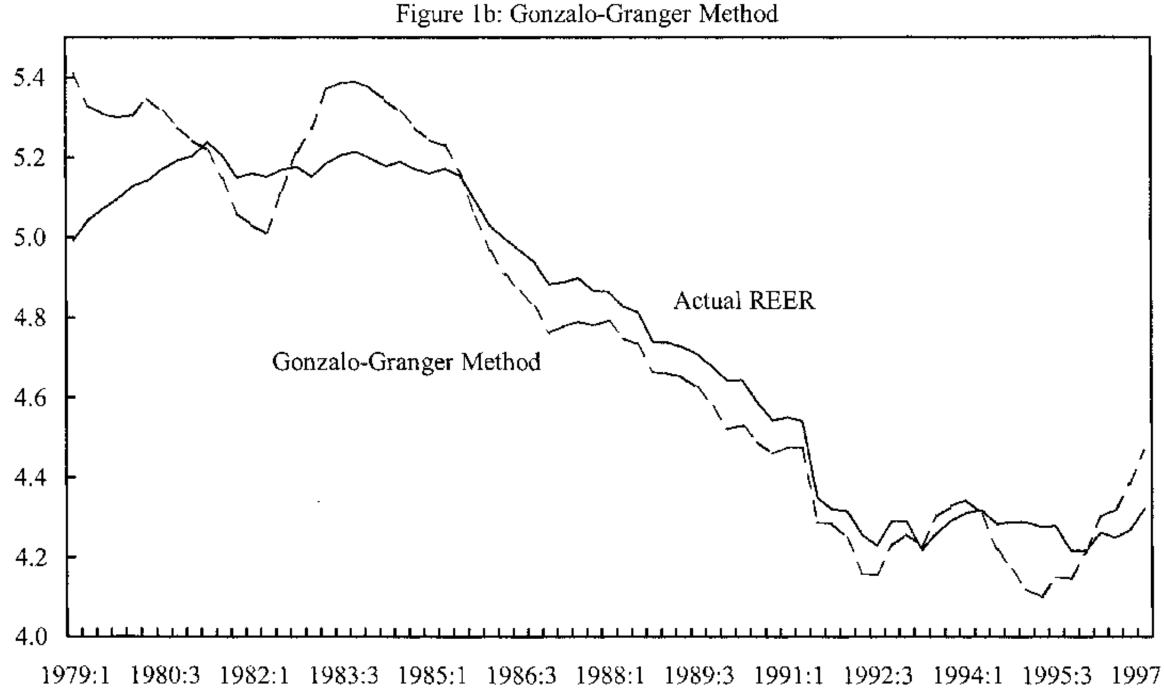


Figure 1b: Gonzalo-Granger Method



Source: IFS and authors' calculations

Figure 2. India: Forecasts of the Real Effective Exchange Rate

Figure 2a: Dynamic Forecast: Model 6

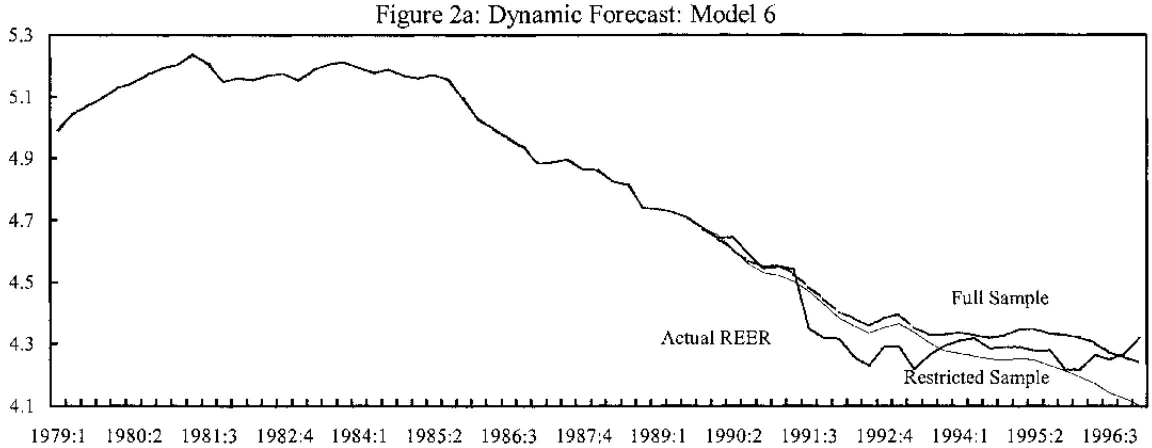


Figure 2b: Static Forecast: Model 6

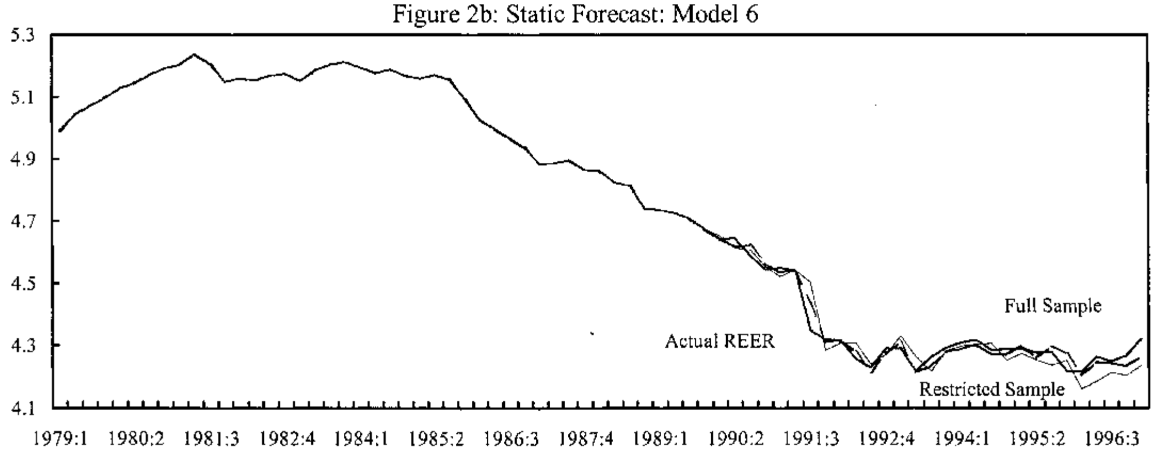
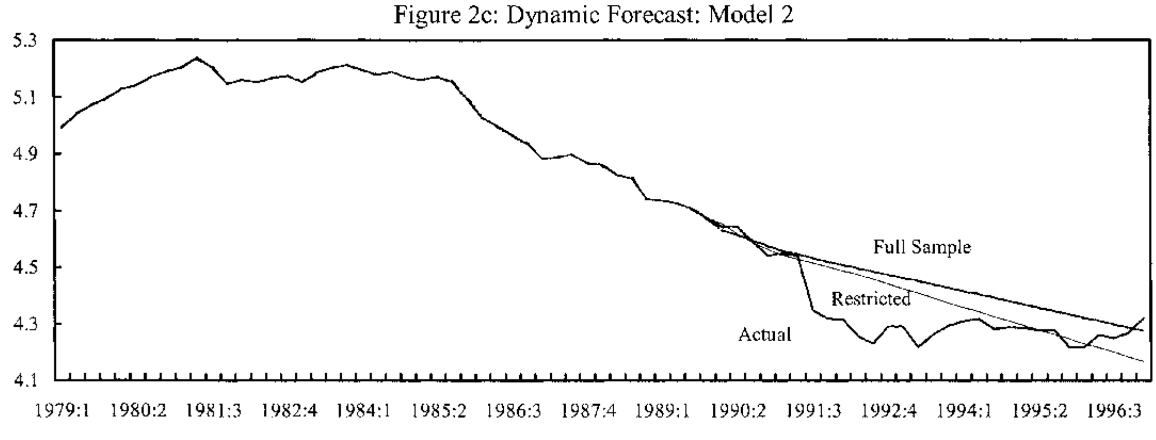


Figure 2c: Dynamic Forecast: Model 2



Source: IFS and authors' calculations

Data Source and Construction

Data Source:

Variable	Description of the Variable	Source
REER	Real Effective Exchange Rate	IMF Calculation
Rupper$	Period average nominal exchange rate	IFS line rf
GCON	Government consumption expenditure	IFS line 91
XVAL	Unit value of exports	IFS line 74
MVAL	Unit value of imports	IFS line 75
X	Exports	IFS line 70
M	Imports	IFS line 71
GDP	Gross Domestic Product	IFS line 99b
CAPINFLOW	Capital Inflows	IFS line 78bjd + 78cad
PARALLEL	Black market rate	Pick's World Currency Yearbook
IPI	Industrial Production Index	IFS line 66
INV	Gross Fixed Capital Formation	IFS line 93e
CURRENTACC	Current account balance	IFS line 78aldzf
POLCONF	Political Confidence	Ratings compiled by PRS group in the International Country Risk Guide
HPMONEY	High Powered Money	IFS line 14
DOMCREDIT	Domestic Credit	IFS line 32
CUSTREV	Custom revenues	Monthly Statistical Abstract of India, GOI Publication
GBAL	Government balance	IFS line 80

The data frequency is quarterly except the series GCON, GDP, INV, and GBAL were interpolated from annual data.

Data Construction:

1. LREER = Ln(REER)
2. LGCONGDP = Ln(GCON/GDP)
3. LTOT = Ln(XVAL/MVAL)
4. LOPEN = Ln (X + M/ GDP)
5. LINVGDP = Ln(INV/GDP)
6. TECHPRO = Ln(IPI/IPI_{-4})
7. LEXCHCONTROL = Ln(CUSTREV/M)
8. LPARALLEL = Ln(PARALLEL-Rupper$)
9. CAPCONTROL = $(CAPINFLOW/GDP)_{-1}$
10. GBALHPM = GBAL/$HPMONEY_{-1}$
11. EXCREDIT = $\Delta Ln(DOMCREDIT) - \Delta Ln(GDP)_{-1}$
12. DPOLCONF = POLCONF – $POLCONF_{-1}$

References

Agenor, P. R and A.W Hoffmaister, 1996, "Capital Inflows and the Real Exchange Rate: Analytical Framework and Econometric Evidence", *IMF Working Paper.*

Albcrola, E., S. G. Cervero, J. H. Lopez, and A. Ubide, 1999, "Global Equilibrium Exchange Rates-Euro, Dollar, "Ins," "Outs," and Other Major Currencies in a Panel Cointegration Framework," *IMF Working Paper* WP/99/175.

Callen, Tim, and Paul Cashin, 1999, "Assessing External Sustainability in India," *IMF Working Paper* WP/99/181.

Cerra, Valerie and Sweta C. Saxena, 1997, "Capital Inflows and the Real Exchange Rate: Econometric Evidence from India", *mimeo*, IMF.

Chinn, Menzie D., and Jeffrey A. Frankel, 1995, "Who Drives Real Interest Rates in the Pacific Rim: The U.S. or Japan?", *Journal of International Money and Finance*, Vol. 14, 801-821.

Chopra, Ajai, et al., 1995, "India: Economic Reforms and Growth", *Occasional Paper 134*, IMF, Washington DC.

Edwards, Sebastian, 1989, *Real Exchange Rates, Devaluations and Adjustments,* MIT Press, Cambridge, MA.

Enders, Walter, 1995, *Applied Econometric Time Series,* John Wiley and Sons Inc.

Fleming, J. Marcus, 1962, "Domestic Financial Policies under Fixed and under Floating Exchange Rates," *IMF Staff Papers*, 9, November, 369-79.

Gonzalo, Jesus and Clive Granger, 1995, "Estimation of Common Long Memory Components in Cointegrated Systems", *Journal of Business and Economic Statistics,* Vol. 13, No. 1, 27-35.

Hamilton, James D., 1994, *Time Series Analysis*, Princeton University Press.

International Monetary Fund, 1991, *India—Recent Economic Developments*, IMF Country Report No. 99/207.

Joshi, Vijay and I.M.D. Little, 1996, *India's Economic reforms 1991-2001*, Oxford University Press.

Kapila, Raj and Uma Kapila, 1996, "Recent Developments in External Sector", in *Understanding India's Economic Reforms*, edited by Raj Kapila and Uma Kapila, Academic Foundation, New Delhi.

Kasa, K., 1992, "Common Stochastic Trends in International Stock Market," *Journal of Monetary Economics*, 29, 95-124.

Montiel, Peter J, 1997, "The Theory of the Long-Run Equilibrium Real Exchange Rate", *Working Paper*, Department of Economics, Williams College.

Mundell, Robert A., 1963, "Capital Mobility and Stabilization Policy under Fixed and Flexible Exchange Rates," *Canadian Journal of Economics and Political Science*, 29, November, 475-85.

Mundell, Robert A., 1964, "A Reply: Capital Mobility and Size," *Canadian Journal of Economics and Political Science*, 30, August, 475-85.

Patriot, July 1991, New Delhi Edition.

Quah, D., 1992, "The Relative Importance of Permanent and Transitory Components: Identification and Some Theoretical Bounds," *Econometrica* 60, 107-118.

Rangarajan, C., July 1991, "Recent Monetary Policy Measures and the Balance of Payments," *Reserve Bank of India Bulletin*.

--------------------, September 1991, "Exchange Rate Adjustments—Causes and Consequences," *Reserve Bank of India Bulletin*.

--------------------, 1993, "India's Balance of Payments Problems", in *Indian Economy since Independence*, edited by Uma Kapila, 4th Edition, Academic Foundation, New Delhi.

--------------------, January 1994, "India's Balance of Payments: The Emerging Dimensions," Shri Govind Ballabh Memorial Lecture, *Reserve Bank of India Bulletin*.

--------------------, 1996, "Impact of liberalization on Foreign Direct Investment", in *Understanding India's Economic Reforms*, edited by Raj Kapila and Uma Kapila, Volume 5, Academic Foundation, New Delhi.

Saxena, Sweta C., 1999, "Exchange Rate Dynamics in Indonesia: 1980-1998", *mimeo,* University of Washington.

The Hindustan Times, March 1st 1997, New Delhi Edition.

Zai Naseem A., 1995, "External Capital Inflows and Structural Adjustment Program in India", *Indian Journal of Economics*.