India's policy stance on reserves and the currency

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Abstract

Over the last decade, India engaged in substantial liberalisation on the current account and the capital account. At the same time, a fully articulated policy framework defining the currency regime is not known in the public domain. In this paper, we seek to characterise the nature of the currency regime, in the period after the Asian crisis. This is closely linked to better understanding the phenomenon of reserves accumulation of the recent years. Our results suggest that the main focus of the currency regime has been to deliver a low volatility of the nominal exchange rate. The rupee appears to be a *de facto* peg to the USD. In the last one year, reserves accumulation cannot be explained by insurance motivations; it seems to be a passive side effect of maintaining the currency regime.

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Contents

1 Introduction

India has experienced a breathtaking increase in the stock of foreign exchange reserves, from a near-zero level in 1991 to $80 billion in May 2003. In particular, in the period after the Asian crisis, countries all over Asia have rapidly built up reserves. In this paper, we seek to obtain some insights on the factors shaping this accretion of reserves. This question is innately closely related to that of characterising the currency regime.

Reserves accretion can occur owing to a desire to hold reserves as 'insurance'. It is widely believed that the cost of holding reserves is a necessary 'insurance premium', that should be paid by a developing country that seeks to safely harness the benefits of globalisation. As an alternative hypothesis, reserves accretion or depletion can occur as a passive consequence of exchange rate policy.

We document a variety of metrics of reserves adequacy that have been proposed, in seeking to identify the level of reserves that are desirable in order to achieve insurance goals. We find that by March 2002, these metrics were substantially satisfied. Yet, India went on to add $25 billion in reserves in the period after March 2002. This suggests that 'reserves as insurance' is not a hypothesis that adequately explains the observed facts.

RBI has not released documents defining the rules through which the currency regime operates. Hence, we must make inferences based on data in order to understand the currency regime. Last year, two papers on this question highlighted the limited exchange rate flexibility of the INR-USD exchange rate (Calvo & Reinhart 2002, Reinhart & Rogoff 2002). Calvo & Reinhart observe that currency flexibility in India has not changed since 1979. Reinhart & Rogoff apply a data-driven algorithm for the classification of the *de facto* currency regime across a large database of countries. They classify India as a "*de facto* crawling peg to the US dollar".

In this paper, we exploit a broad range of empirical strategies, for obtaining insights into the nature of the currency regime. These include a measure of exchange rate flexibility, regression models based on multiple cross-currency exchange rates, measures of market efficiency, and testable propositions about cross-currency volatility. Our broad finding is that in the period following the Asian crisis, the rupee appears to be a *de facto* peg to the US dollar.

One competing hypothesis is that policies targeted the REER or the NEER. We argue that if the REER or the NEER were targeted, then they should exhibit low volatility. Instead, we find that they exhibit greater volatility than the nominal INR/USD rate. This suggests that REER targeting was not the goal of policy.

In summary, we find that India's policy stance on reserves and the currency is primarily one of exchange rate management on the INR/USD exchange rate which seeks to obtain low volatility of rate. Fluctuations of reserves appear to be a side effect caused by the pursuit of goals of currency policy.

The remainder of this paper is organised as follows. Section 2 shows the familiar empirical facts about India's experience with reserves accretion, and summarises the competing hypotheses which could serve as explanations. Section 3 explores the hypothesis that the reserves accretion of recent years was a consequence of policies focused on reserves adequacy. Section 4 describes the conceptual backdrop of 'characterising a currency regime'. Section 5 shows the methodologies that we will exploit in characterising the currency regime. Section 6 applies these methodologies to Indian data. Finally, Section 7 concludes the paper.

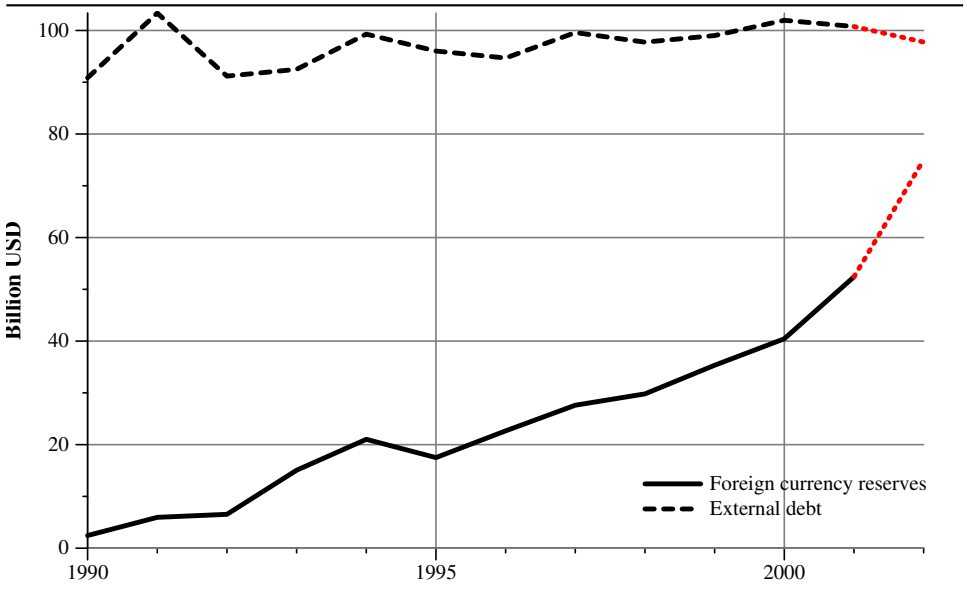

Figure 1: Growth of foreign exchange reserves

2 India's reserves buildup

The build-up of foreign exchange reserves in India has been a major phenomenon in the post-1991 period. Figure 1 shows the familiar time-series, which shows that reserves rose sharply from $20 billion in 1995 to $75 billion in 2002 - an increase of roughly 10% of GDP. Starting from near-zero levels in 1991, India is now the seventh largest holder of international reserves in the world. Figure 1 highlights the fact that while reserves accretion was occasionally done using debt inflows, for the major part, it was associated with stable external debt.

In 2002-03 alone, India added roughly $20 billion to her forex reserves. This scale of addition to reserves is a unique phenomenon when compared with India's historical experience, and invites further exploration (Ranade & Kapur 2003).

In general, growth in reserves can happen owing to asset management of the reserves portfolio, or owing to interventions by the central bank.[1] Intuitively, we may expect returns of a few percent in reserves management. If a country has $100 billion in reserves, then changes in reserves of a few billion dollars can occur owing to fluctuations in asset prices.

[1] In addition, reserves can also change owing to repayment of external debt. However, this has been relatively unimportant in explaining the time-series volatility of reserves in India.

In India's case, some of the increase in reserves during 2002-03 was the result of the appreciation of the Euro and the Japanese Yen against the USD. However, foreign exchange intervention by the RBI was the main cause of the build up of reserves during 2002-03. According to RBI data, out of $20.8 billion that were added to reserves during April-December 2002, $3.8 billion were added because of valuation changes, while $13.3 billion represent capital inflows and 3.7 the current account surplus.

There are broadly two competing explanations for a phenomenon of rapid addition to reserves:

Reserves as a goal of policy It could be the case that India added reserves as a consequence of reserves policy. That is, India had certain thought out targets for the minimum required level of 'reserves as insurance', and was trying to rapidly reach this target level.

Reserves as a side effect of currency policy Alternatively, buying and selling reserves could have been passive side effects of currency policy. Reserves would go up when RBI intervened to push the price of the INR down, and vice versa.

Thus, as an alternative to the hypothesis that India has followed a policy of achieving a desired level of reserves as 'insurance', the major competing explanation is one where RBI has been primarily focused on exchange rate management, and reserves have fluctuated passively as a response to the exigencies of RBI's trading on the currency market. In this paper, we seek to obtain some insights on the importance of these competing explanations in understanding India's post-1991 experience.

This is about disentangling cause and effect. The unambiguous stylised empirical fact is that reserves grew dramatically, and the INR was weak. We seek to understand whether reserves rose as a consequence of currency policy, or whether the INR was weak as a consequence of reserves policy.

The key intuition that we employ, in understanding variables which are targeted, as opposed to variables which are either instruments of policy or are side effects, is based on interpreting volatility. If reserves were targeted, then a country would experience first reserves volatility in getting to the target, but then experience low volatility of reserves. Other variables (such as external debt, exchange rates, money supply and interest rates) would be volatile in the process of achieving targets for reserves. Conversely, if the exchange rate were targeted, then other variables (such as reserves, money supply, interest rates) would be relatively volatile while exchange rates would be stable.

3.1 Conceptual issues

If reserves are held as insurance, how large do they need to be? What is an appropriate 'target' for reserves? In the literature on 'reserves as insurance', there are four kinds of measures which have been proposed for judging reserves adequacy :

Trade based measures Trade based measures focus on the current account. Reserves are generally thought to be adequate when they cover six months of merchandise imports.[2]

Debt based measures Trade-based measures of reserves adequacy have been criticised, since they pay no heed to obligations owing to the capital account.

Debt based measures focus on the capital account only, and measure the ability of reserves to support debt servicing. If access to capital markets is limited, or if the country depends heavily on short term debt, then such measures indicate the level of risk in the event of sudden movements in capital, or changes in the availability of capital.

Liquidity based measures Liquidity based measures focus on the extent to which reserves can fund all capital account liabilities. In April 1999, Pablo Guidotti, then the Deputy Finance Minister of Argentina, suggested that emerging market economies should maintain usable foreign exchange reserves that cover debt requirements for atleast a year. Projecting a current account deficit and short term debt provides a measure of new borrowing that may be required by a country. Guidotti proposed that reserves should be adequate to require no new borrowing for a year.

Alan Greenspan extended this 'Guidotti rule', suggesting a 'liquidity at risk' measure that also takes into account a range of possible scenarios for exchange rates, commodity prices, credit spreads etc, and takes cognisance of derivatives such as foreign currency bonds with embedded options.[3]

This has been dubbed the 'Greenspan rule', and it suggests that a country should hold the level of reserves required to ensure no borrowing requirements over a horizon of one year with a 95% probability.

Money-based measures Money based measures focus on the extent to which a country has a domestic currency which is backed by foreign exchange. These measures include ratios such as reserves to broad money, or reserves to base money, which provide a measure of potential for resident based capital flight

[2] Amongst the east Asian countries which experienced a crisis in 1997, reserves went up from 3 months of imports in 1997 to 8 months of imports cover in 1999 (Hawkins & Turner 2000).

[3] This is derived from a speech *Currency reserves and debt*, by Alan Greenspan, at the 'World Bank Conference on Recent Trends in Reserves Management', Washington, D.C., 1999, `http://www.federalreserve.gov/boarddocs/speeches/1999/19990429.htm`

from the currency. To defend a currency peg, the monetary authorities only need enough resources to buy back the high powered monetary base, equal to deposits at the central bank plus currency. In practice a central bank would not need to buy up the *entire* base to repel any speculative attack (Obstfeld & Rogoff 1995).

East Asian countries such as China, Taiwan, Korea, Singapore and Hong Kong are prominent in holding large reserves today. It can be argued that in the period after the Asian crisis, they felt that the insurance motivation demanded a higher level of reserves. However, **?** find that a model explaining 'demand for reserves', based on data for 125 countries from 1980 onwards, under-predicts the reserves holdings of these nations in the period after the 1997 crisis. An alternative explanation is that of Calvo & Reinhart (2002), who suggest that a large number of countries are holding a high level of reserves because they continue to have extremely limited exchange rate flexibility, even though their exchange rate is ostensibly floating.

3.2 Indian experience

In 1991 India had gone down to reserves covering two weeks of imports. Hence, until 1993-94, there was a strong focus upon reserves adequacy measured by months of import cover.

The *High Level Committee on Balance of Payments, 1993*, chaired by Dr. C. Rangarajan, recommended that the RBI should target a level of reseves that took into account liabilities that may arise for debt servicing, in addition to imports of three months.

Later the *Report of the Committee on Capital Account Convertibility* chaired by S. S. Tarapore (1997), suggested that in order to be able to open up to capital account convertibility, India should achieve the following targets of reserves policy :

1. Reserves which give an import cover of atleast six months,
2. Reserves are atleast an import cover of three months, plus 50 per cent of annual debt service payments, plus 50 per cent of annual debt service payments, plus one month's imports and exports to take into account leads and lags,
3. A ratio of short term debt and stock of portfolio investment related non-debt liabilities to reserves at not more than 60 per cent, and
4. A net foreign exchange assets to currency ratio (NFA/currency) ratio at around 70 per cent.

Table 1 shows India's status on various metrics of reserves adequacy over the recent three years.

	31/3/2001	31/3/2002	31/3/2003
Months of import cover	8.0	11.3	14.0
Short term debt/Reserves (%)	8.6	5.1	4.4*
NFA / Currency in circulation (%)	90.4	105.2	125.6
NFA / Reserve Money (%)	65.0	78.0	98.0
Non-debt liabilities + Short term debt / Reserves (%)	100.8	88.4	78.5#

* Pertains to December 2002.
# Pertains to September 2002.

Table 1: Reserves adequacy in India

In terms of months of import cover, reserves had reached 11.3 months by end March 2002. At nearly a year's imports, these would be considered sufficient. The ratio of short-term debt to reserves fell sharply from 146.5% in 1991 and 23.2% at end March 1996 to 5.1% at end March 2002. Reserves were clearly adequate to cover short term debt. The ratio of volatile capital flows, measured as cumulative portfolio flows and short term debt, which was 71.1% of reserves at end March 1996 fell to 48.1% of reserves by March 2002. Measuring reserves as cover for non-debt liabilities and short term debt, by end March 2002, non-debt liabilities and short term debt as a ratio of reserves fell from 105.2% in 2001 to 88.4% in March 2002, indicating that reserves were now adequate. In mid-2002, the RBI Governor Jalan indicated that even if we tested reserves adequacy by the 'liquidity at risk' measure, India had a comfortable level of reserves.[4]

In summary, most indicators of reserve adequacy showed that by 31 March 2002, India had 'adequate' foreign exchange reserves, when focusing upon the 'insurance' motivation for holding reserves. This raises the question of how we can explain the last $20 billion accreted into reserves, which took place in the latest year, i.e. from 1 April 2002 to 31 March 2003. As Figure 2 shows, the net purchase of dollars by RBI in the foreign exchange market did not slow down over 2000-02.

The extent of debt inflows over the 1990s gives us some insight about the extent to which India was following an active reserves policy. If reserves of $75 billion had been *targeted*, then we might have expected a greater addition to debt to reach that target. However, growth in reserves after 2000-01 were not debt creating (see Table 2).

In a recent article, **?** argue that India's reserves accretion, which cannot be explained in terms of the metrics of reserves adequacy as shown above, can be attributed to domestic fiscal problems. They argue that India's accumulation of reserves is an expression of concern on the part of policy

[4]This is derived from the speech by Bimal Jalan at a symposium of Central Bank Governers, hosted by the Bank of England, London, 5 July 2002.

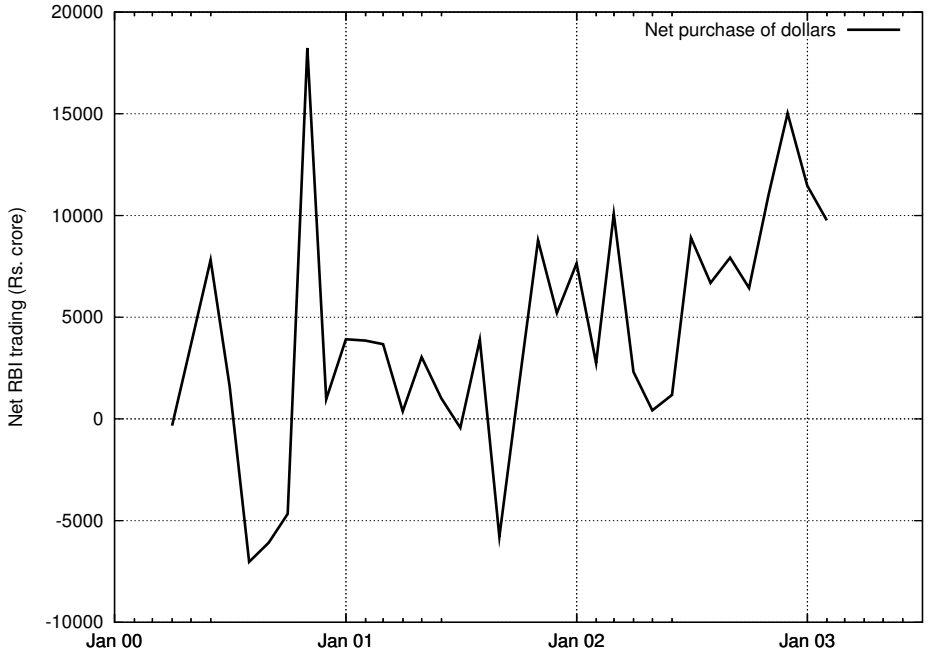

Figure 2: Net purchase of dollars by RBI

	(per cent)
1990-91	83.3
1996-97	61.7
1997-98	52.4
1998-99	54.4
1999-00	23.1
2000-01	69.3
2001-02	14.8
2002-03(Apr-Nov)	23.0

Table 2: Fraction of debt creating capital inflows in total capital inflows

makers owing to the fiscal difficulties that India faces.

4.1 Real versus nominal

We now turn from reserves policy to exchange rate policy. An examination of long term trends suggests that output markets determine the equilibrium exchange rate of the rupee in real terms (Patnaik & Pauly 2001). Thus, the long term trend followed by the rupee in the second half of the 1990s involved a depreciation of the rupee (in nominal terms) vis-a-vis the US dollar, in line with the inflation differential between the two countries. This prevented persistent and sustained deviations, of the bilateral real exchange rate between the two countries, from purchasing power parity.

It is argued that while in the long run it is the real exchange rate that must be watched, in the short run, central banks focus on the nominal rate. In the literature, currency regimes are classified into fixed, floating etc. purely on the basis of the behaviour of the *nominal* rate. A central bank could be keeping the long run real effective exchange rate in mind, while on a day to day basis its currency is a pegged to another currency.

4.2 Understanding a currency regime

There can be three levels of understanding of the regime. The simplest and most transparent case is one in which the central bank operates on rules rather than discretion, and publicly releases documents which define the currency regime. In this case, the currency regime is transparent and can be understood by reading these documents.

The ERM, and New Zealand, are prominent examples of publicly disclosed rules-based interventions by central banks. Going beyond industrialised countries, Colombia is an interesting example of a developing country which has developed a completely transparent framework, where central bank intervention on the currency market is purely driven by publicly disclosed rules. Colombia's intervention algorithm is based on a sophisticated understanding of modern finance, and involves selling options through an algorithm that serves to "reduce volatility", and involves an explicitly stated reserves policy.

RBI has chosen to not have a transparently disclosed reaction function of the central bank such as the above. In this case, the next best alternative is to have high quality disclosure of interventions. The first problem with this path is that of frequency of disclosure. Wickham (2002) notes that central banks of developing countries are often unwilling to release data on official intervention at a daily frequency, even when it is dated enough

to only be used for research purposes. RBI has chosen similar levels of non-transparency, so that interventions data in India is only released at a monthly frequency.

The other problem lies in access for the central bank to other instruments for trading on the currency market. For example, Ghosh (2002) has constructed a dataset about RBI interventions in the currency market, in which it is believed that on occasion, SBI engages in currency trading at the behest of RBI. A governance framework which permits the use of such one-removed methods for introducing orders into the market limits the usefulness of central bank intervention data, even when it is disclosed at high frequency.

The third approach is to focus upon the statistical implications that intervention would have for observables, i.e. the statistical characteristics of exchange rates themselves. Inferences can be made about the currency regime by observing the statistical consequences of the regime upon observables. This is the approach that this paper exploits.

In the literature, one of the most interesting results of this approach is that the resulting classification of the regime often differs from the official position of the central bank. For example, Reinhart & Rogoff (2002) find that in the post Bretton Woods period, of central banks claimed that a currency was a "managed float", 53% were actually *de facto* pegs or crawling pegs. This surprising inconsistency reiterates the value of this statistical approach, even in the presence of assertions by a central bank.

4.3 Official position

According to most official pronouncements, India sharply moved away from a fixed exchange rate regime to a "market determined" exchange rate regime in March 1993. RBI's official position after 1993 is that its exchange rate policy focuses on "managing volatility" with no fixed exchange rate target, while allowing underlying demand and supply conditions to determine exchange rate movements in an "orderly" way (**?**). For example, one statement of the RBI Governor Jalan (1999) is as follows:

> The objective of the exchange rate management has been to ensure that the external value of the Rupee is realistic and credible as evidenced by a sustainable current account deficit and manageable foreign exchange situation. Subject to this predominant objective, the exchange rate policy is guided by the need to reduce speculative activities, help maintain an adequate level of reserves, and develop an orderly foreign exchange market.

These statements are broad enough to permit a wide variety of behaviours on the part of RBI.

The policy of monitoring of the nominal rate, as opposed to the REER, has also been official RBI policy. As the RBI governor says (**?**):

> From a competitive point of view and also in the medium term perspective, it is the REER, which should be monitored as it reflects changes in the external value of a currency in relation to its trading partners in real terms. However, it is no good for monitoring short term and day-to-day movements as 'nominal' rates are the ones which are most sensitive of capital flows. Thus, in the short run, there is no option but to monitor the nominal rate.

5 Methodology for characterising currency regime

In this section, we apply empirical strategies which utilise public domain data, and shed light on the nature of the currency regime that is prevalent.

A currency regime is classified as a *de facto* peg to a given currency when the volatility of the exchange rate against this currency is very low, owing to policy efforts by the central bank. The phrase 'market determined exchange rate', which is used by RBI and several other central banks, indicates that that the exchange rate is not administered as in a *fixed exchange rate* regime. The rate is determined in the foreign exchange market in which the central bank is a major participant. It does not imply that the exchange rate is one that is determined freely by market forces.

Reinhart & Rogoff (2002) test for a *de facto* peg, which may be in operation when the authorities have not announced that their currency is pegged. They approach this in two ways:

1. They examine the monthly absolute percent changes. If the absolute monthly percent change in the exchange rate is equal to zero for four consecutive months or more, that episode is classified (for however long its lasts) as a *de facto* peg if there are no dual or multiple exchange rates in place. This allows them to identify relatively short-lived *de facto* pegs as well as those with a longer duration.

2. They compute the probability that the monthly exchange rate change remains within a one percent band over a rolling 5-year period. If this probability is 80 percent or higher, then the regime is classified as a *de facto* peg or crawling peg over the entire 5-year period. If the exchange rate has no drift, it is classified as a fixed parity; if a positive drift is present, it is labeled a crawling peg; and, if the exchange rate also goes through periods of both appreciation and depreciation it is a moving peg.

The concept of an exchange rate 'peg' employed in this paper is derived from the above definition of a *de facto* peg. In other words, when a currency is classified as a peg to, say, the USD, it is not that its exchange rate to the USD is fixed, but that the central bank trades on the market to a significant extent to influence the price.

5.1 Exchange rate flexibility

At the simplest, it is useful to compare Indian currency volatility against that seen in other countries, in order to obtain a cross-country sense of the extent of exchange rate flexibility in India.

While a large number of countries have currencies that are officially "floating", Calvo & Reinhart (2002) find that in reality a significant number of

them seem to suffer from a "Fear of Floating". They argue that even though the official classification of the regime, as reported to the IMF by many a country, may *say* that the exchange rate is floating, countries seem to use a wide variety of methods to ensure that the exchange rate is not allowed to float. Calvo & Reinhart (2002) propose a metric of exchange rate flexibility λ, which is based on observed volatilities of exchange rate, reserves and interest rates:

$$\lambda = \frac{\sigma_\epsilon^2}{\sigma_i^2 + \sigma_{R/p}^2}$$

where σ_ϵ is the exchange rate volatility, σ_i is the interest rate volatility, and $\sigma_{R/p}$ is the volatility of reserves expressed in local currency at constant prices.[5]

The interpretation of λ is as follows:

- In countries where exchange rates are targeted, exchange rate volatility will be low, and the numerator will be small. In order to achieve this, the central bank will have to incur high volatility in interest rates and reserves (i.e. the denominator). The extreme value is that of a fixed exchange rate regime, where $\lambda = \sigma_\epsilon = 0$, where low exchange rate volatility is achieved at a price of high volatility in reserves and interest rates.
- At the other extreme, with a floating exchange rate regime, σ_ϵ will be large, and the central bank will have stable interest rates and reserves (i.e. a small denominator), giving high values of λ.

Calvo & Reinhart (2002) compute a single λ for a given time period. In order to obtain a better understanding of the changes in the currency regime, we propose to compute λ_t using rolling windows, with a width of one year. At each timepoint t, λ_t is computed using daily or weekly data for the latest one year. This will allow us to see time-variation in λ.

5.2 Volatility

In order to understand the existing regime, we can explore the falsifiable predictions that flow from a null hypothesis H_0 : *the INR/USD exchange rate is the major goal of exchange rate management.* If this null were maintained, we would observe two symptoms:

[5] Alternative metrics of currency flexibility also exist in the literature. For example, Baig (2001) uses a formula $\sigma_\epsilon^2/(\sigma_\epsilon^2+\sigma_{R/M_0}^2)$, which is (in turn) based on Glick & Wihlborg (1997) and Bayoumi & Eichengreen (1998). This variant does not incorporate the role of monetary policy and interest rates in achieving currency targets.

S_1 *INR/USD volatility would be much lower than that of INR against other currencies.*

If the INR/USD exchange rate were the focus of exchange rate management, then the INR/USD volatility would be sharply lower than that seen for other exchange rates, such as the INR/JPY. These other exchange rates of the INR would show volatilities that are 'normal' with cross-currency pairs seen internationally under floating exchange rates.[6]

It is important to contrast this with the consequences of a reserves policy. If reserves were the focus of policy, and India started out with highly inadequate reserves, then the 'normal' volatility of the INR/USD in a floating exchange rate regime could first be amplified by having a large trader (RBI) on the market steadily buying USD. An active reserves policy would give a *more* volatile INR/USD exchange rate. Once a reserves target was attained, trading by RBI would cease; the INR/USD would go back to being a market determined exchange rate, and would then exhibit a normal cross-currency volatility.

S_2 *The volatility of INR against other currencies would assume values of the kind seen with other cross-currency volatilities in the world.*

If the INR/USD exchange rate were the focus of exchange rate management, then other exchange rates which are unmanaged, such as the INR/JPY, would exhibit volatility that is of the same order of magnitude as that is typical with cross-currency volatilities in the world. In the extreme, if the INR/USD were a fixed exchange rate, then the INR/JPY volatility would be exactly equal to USD/JPY volatility.

5.3 Multi currency model

Frankel & Wei (1994) developed a regression based approach for testing for pegging. In this approach, an independent currency, such as the Swiss Franc (CHF), is chosen as an arbitrary 'numeraire'.[7] The model estimated is:

[6]While industrialised countries substantially achieved capital account convertibility by the late 1950s, attempts to influence exchange rates continued till the early 1990s. However, central banks in industrialised countries came to increasingly eschew currency interventions owing to (a) the desire for an independent monetary policy and (b) the increasing ineffectiveness of intervention given the improvements in liquidity of financial markets. For example, in April 1999, Japan expended $20 billion of reserves and obtained only a minute impact upon the JPY-USD exchange rate. The last time the US has engaged in currency intervention was in 1995.

Hence, in the recent period, data for industrial country currency pairs can be assumed to be purely the outcome of speculative market processes.

[7]There can be other choices for the numeraire also, such as the GBP. India has smaller trade and capital account interactions with Switzerland. Hence, we favour CHF as our numeraire.

$$d\log\left(\frac{\text{INR}}{\text{CHF}}\right) = \beta_1 + \beta_2 d\log\left(\frac{\text{USD}}{\text{CHF}}\right) + \beta_3 d\log\left(\frac{\text{JPY}}{\text{CHF}}\right) + \beta_4 d\log\left(\frac{\text{DEM}}{\text{CHF}}\right) + \epsilon$$

This regression picks up the extent to which the INR/CHF rate fluctuates in response to fluctuations in the USD/CHF rate. If there is pegging to the USD, then fluctuations in the JPY and DEM will be irrelevant, and we will observe $\beta_3 = \beta_4 = 0$ while $\beta_2 = 1$. If there is no pegging, then all the three betas will be different from 0. The R^2 of this regression is also of interest; values near 1 would suggest reduced exchange rate flexibility.

In order to obtain a better *time-series* sense of changes in the currency regime, we propose to estimate this regression using rolling windows. This would give us a time-series of β_{2t} and R_t^2, which would give us special insights into the changes in the underlying currency regime through time.

5.4 Measures of market efficiency

The random walk plays a central role in financial economics. In an efficient market, it should not be possible to make speculative profits; that is, it should not be possible to make forecasts about future returns. For this, the price process has to be martingale.

If the INR/USD exchange rate were managed, it would exhibit various symptoms of market inefficiency, such as violations of the random walk. In contrast, other exchange rates, such as the INR/JPY, would not display comparable violations of the random walk in a regime where the INR/USD exchange rate was the focus of currency policy.

Wickham (2002) uses daily currency data to compare the empirical features of floating exchange rates of industrialised countries against the "flexible" exchange rates claimed by developing countries. This is based on an intuitive argument, that the deviations from the random walk for currency pairs like the USD/JPY or the USD/EUR serve as normative benchmarks for the extent to which a true floating exchange rate deviates from the idealised random walk.

We propose to use the variance ratio (VR) statistic (Cochrane 1988, Kim et al. 1991) in order to test for deviations from the random walk. The idea of the variance ratio test is as follows. If a price series p_t follows a random walk, then the returns series r_t exhibits $T-$scaling in variance. Two-day variance is twice of one-day variance, and so on. Suppose the data reveals σ_k^2 and σ_1^2 as the variances of $k-$day returns and one day returns, respectively. Then we define the variance ratio $\text{VR}(k) = \sigma_k^2/(k\sigma_1^2)$. Under the null of market

efficiency, we expect VR(k) to be 1. When the observed VR is significantly away from 1, we reject the null.

We favour the variance ratio test since it is known to have better power than any of the other unit-root and random-walk tests, such as the Box-Pierce Q-statistic, and the ADF, for many different alternatives.

Our testing strategy for variance ratio statistics follows Lo & MacKinlay (1988), who derived general forms of the VR statistic, for both homoscedastic and heteroscedastic nulls, to get statistics that are heteroscedasticity-consistent.[8]

Under the null that the INR/USD exchange rate were managed, while other exchange rates such as INR/JPY were left to the market, we would observe the following symptoms: (a) the INR/USD would exhibit violations of market efficiency while (b) other exchange rates, such as the INR/JPY, would not.

5.5 Did policy target the REER or NEER?

One possible policy regime, which policy makers over the 1990s may have adopted, involves an exchange rate policy which targets the NEER or the REER, instead of targeting the nominal INR/USD exchange rate. In order to target the real exchange rate, the central bank may intervene when the real exchange rate is particularly high or low. Keeping the real exchange rate within a band around a mean would reduce the volatility of the real rate.

Volatility is, once again, a key tool for discriminating between competing hypothesis. If the REER were the subject of targeting, then it would have a lower volatility than the nominal rate. Hence, we propose to compare the volatility of the nominal exchange rate against that of the REER and the NEER, in order to understand the nature of the regime.

[8] We are grateful to Tirthankar Patnaik and Susan Thomas for the use of the software developed by them for Patnaik & Thomas (2003).

Rank	Country	Volatility
1	Malaysia	0.01
2	India	0.17
3	Singapore	0.23
4	Canada	0.33
5	Chile	0.37
6	Turkey	0.37
7	Israel	0.41
8	Korea	0.42
9	Thailand	0.45
10	Mexico	0.47
11	Brazil	0.48
12	U.K.	0.57
13	Philippines	0.58
14	South Africa	0.60
15	Japan	0.63
16	Poland	0.68
17	Switzerland	0.73
18	Czech Republic	0.74
19	Hungary	0.75
20	Australia	0.76
21	Sweden	0.76
22	Germany	0.77
23	New Zealand	0.86
24	Indonesia	1.05

Table 3: Cross-country evidence on currency volatility, from Baig (2001)

6 Indian evidence

We now set about exploiting the methodologies described above, in order to characterise the currency regime in India.

6.1 Currency flexibility

At the level of simple empirical regularities, Baig (2001) has a table of daily currency volatility in 24 countries in 2000 (Table 3). In this, India was the lowest currency volatility other than Malaysia, which had essentially a fixed exchange rate regime.

Analysing the behaviour of nominal exchange rates, reserves and interest rates, Calvo & Reinhart (2002) document two striking facts about India's regime change:

1. They find that the probability of a near non-change in the currency over a one-month horizon went *up*, from 84.5% over the period 2/1979 – 11/1993 to a level of 93.4% over the period 3/1993 – 11/1999. This suggests that the

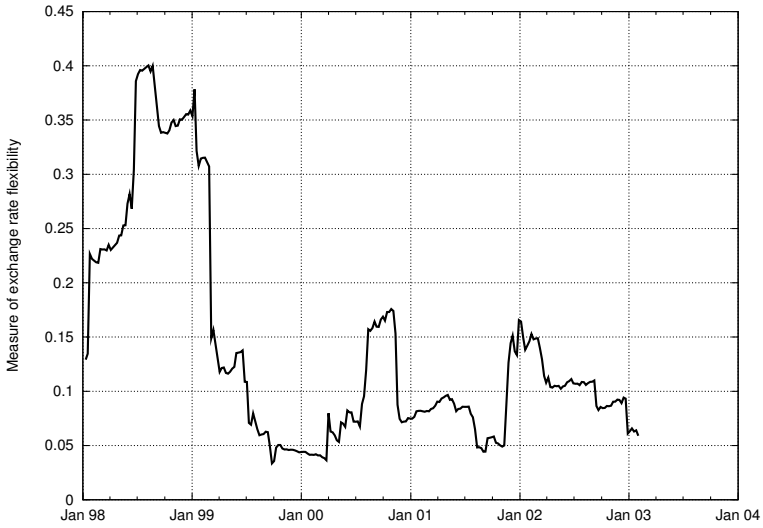

Figure 3: Measure of exchange rate flexibility λ_t using rolling windows

currency was actually *less* flexible in the "post-reforms" period after 3/1993.

2. Using monthly data, they find that the λ_t metric takes the same low value of 0.03 for India in both the "pre-reforms period" (1979-1993) and the "post-reforms" period (1993-1999). This is a striking fact which is inconsistent with the conventional view that India distinctly made a break with fixed exchange rates in 1992.

One partial explanation of this finding might be the episode from 15 November 1993 to 3 March 1995, where the exchange rate was fixed at Rs.31.37 per USD. The computation of λ as one scalar over an entire time-period can mask changes in policies over this period. In addition, the results in Calvo & Reinhart (2002) stop at 1999, which does not include the important period of recent reserves accumulation.

Our approach, using estimation within rolling windows, is an opportunity to observe time-series variation in λ, and to obtain the most recent evidence, going beyond 1999. These results are shown in Figure 3. They are not directly comparable to those obtained by Calvo & Reinhart, owing to our use of weekly data as opposed to their monthly data. However, we find that in the period after 1999 also, λ_t has remained at very low levels, which suggests a continued regime of little exchange rate flexibility. We may also note that Figure 3 shows an interesting period in 1998 where India appears to have experimented with greater currency flexibility.

Dates	Classification	Comments
8/1914 - 22/3/1927	Peg to pound sterling	Convertibility into sterling was suspended.
22/3/1927 - 24/9/1931	Peg	Gold standard.
24/9/1931 - 3/9/1939	Peg to pound sterling	Suspension of gold standard adherence to sterling area.
3/9/1939 - 10/1941	Peg to pound sterling	Introduction of capital controls.
11/1941 - 10/1943	Peg to pound sterling ; "freely falling"	
11/1943 - 1/10/1965	Peg to pound sterling	
1/10/1965 - 6/6/1966	*De facto* band around pound sterling ; parallel market	There were multiple exchange rates. Band width was ±5%.
6/6/1966 - 23/8/1971	Peg to pound sterling	
23/8/1971 - 20/12/1971	Peg to US Dollar	
20/12/1971 - 25/9/1975	Peg to pound sterling	
25/9/1975 - 2/1979	*De facto* crawling band around pound sterling	Band width was ±2%. Officially pegged to a basket of currencies.
3/1979 - 7/1979	Managed float.	
8/1979 - 7/1989	*De facto* crawling band around US dollar	Band width was ±2%. Officially pegged to a basket of currencies.
8/1989 - 7/1991	*De facto* crawling peg to US dollar	
8/1991 - 6/1995	*De facto* peg to US dollar	One devaluation in March 1993 – black market premia rose to 27% in February.
7/1995 - 12/2001	*De facto* crawling peg to US dollar	During this period the black market premium has been consistently in single digits.

Table 4: India's currency regimes, according to Reinhart & Rogoff (2002)

6.2 Evidence from Reinhart & Rogoff, 2002

Reinhart & Rogoff (2002) examine a database of the *de facto* currency regimes in 156 countries from 1946 onwards. Using such a classification algorithm, they classify India's exchange rate regime from July 1995 to December 2001 as a "*de facto* crawling peg to the US dollar" (see Table 4).

6.3 Volatility

We now take up our testable propositions about the volatility of the INR vs the USD and other currencies. We focus on the period after 1/1/1999, where we observe data for the Euro. Over this period, we deal with three

	USD	EUR	JPY
INR	0.13	0.72	0.73
USD		0.71	0.73
EUR			0.92

Table 5: Daily volatility of cross-currency returns

major currencies: the US dollar, the Euro and the Yen.[9]

Table 5 summarises the evidence for cross-currency volatilities. It shows the volatility of daily returns on various currency pairs. Between the USD, EUR and JPY, there are three currency-pairs (USD-EUR, USD-JPY and EUR-JPY), and the daily σ seen takes values of 0.71, 0.73 and 0.92 respectively. This gives us an order of magnitude of the currency volatility that is expected under a floating exchange rate.

Under our H_0, the predicted symptom S_1 involves lower volatility for the INR/USD as compared with that seen between the INR and other currencies. This does show up in Table 5. The INR/USD has a daily σ of 0.13, while the INR/EUR has a daily sigma of 0.72 and the INR/JPY has a daily sigma of 0.73.

The predicted symptom S_2 is also borne out by the data. The values seen for the daily σ of the INR/EUR and the INR/JPY (0.72 and 0.73) are of the same order of magnitude as those seen with the three cross currency pairs between the USD, EUR and JPY.

In the extreme, if the INR/USD were a fixed exchange rate, the INR/EUR volatility would be exactly the USD/EUR volatility, and the INR/JPY volatility would be exactly the USD/JPY volatility. We see something close to this in Table 5, where the INR/EUR volatility of 0.72 is close to the USD/EUR volatility of 0.71, and the INR/JPY volatility of 0.73 is close to the USD/JPY volatility of 0.73.

6.4 Regression based approach

Table 6 shows estimation results for the Frankel & Wei (1994) model, using data from 13/9/1995 till 5/5/2003. They show that the coefficient of the USD/CHF rate was 0.966. The null of a pure peg can be rejected, since the JPY/CHF has a coefficient which is statistically significant. However, its value is only 0.0359. The overall R^2 was around 87%. These results indicate that the rupee was substantially pegged to the USD.

[9]We use 980 days of daily data from 1/1/1999 to 13/3/2003, drawn from the CMIE *Business Beacon* database.

This table shows results for the Frankel-Wei regression, using daily data from 13/9/1995 till 5/5/2003.

Parameter	Coefficent
$d\log\left(\frac{\text{USD}}{\text{CHF}}\right)$	0.96668
	(0.0114)
$d\log\left(\frac{\text{JPY}}{\text{CHF}}\right)$	0.03589
	(0.0074)
$d\log\left(\frac{\text{DEM}}{\text{CHF}}\right)$	-0.00546
	(0.1937)
Intercept	0.00021
	(0.0001)
T	1758
R^2	0.8686
σ_ϵ^2	0.0029

Table 6: Frankel-Wei regression

The difficulty with these results is that they show the 'average' behaviour over the period 1995-2003, and may mask substantial heterogeneity in the operation of the currency regime. Hence, we go on to do 'rolling window' estimates, where at each time point, data over the latest one year is used for estimating the regression.

Figure 4 shows the time-series of coefficients thus obtained, and Figure 5 shows the time-series of the regression R^2. We see that the coefficient of the USD/CHF was near 1 through the entire period, barring a few periods where this coefficient slipped slightly (and other coefficients were higher). From 1999 onwards, there appears to be a stable regime where the relationship is primarily that with the USD. The time-series of the R^2 vividly highlights the brief period with greater currency flexibility, which is also seen in the time-series of λ_t, in 1998. After that, the R^2 has been mostly near 1, suggesting that pegging to the USD was the dominant factor in currency policy.

6.5 Market efficiency

We now turn to measurement of the extent to which the currency pairs under estimation exhibit deviations from the random walk.

Table 7 shows prob values for the Box-Ljung portmanteu Q statistic, computed on the first 40 lags of the returns time-series. This is a simple measure

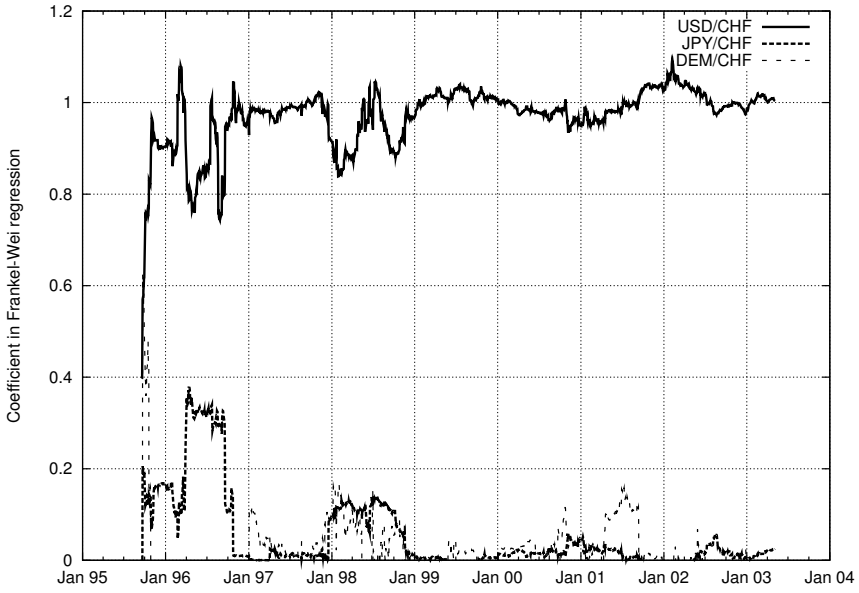

Figure 4: Rolling window Frankel-Wei regressions (coefficients)

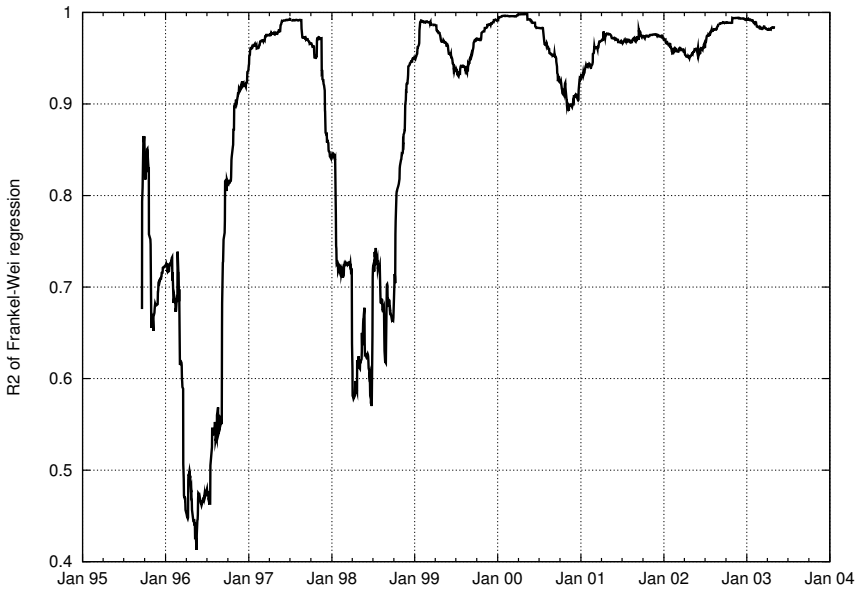

Figure 5: Rolling window Frankel-Wei regressions (R^2)

	USD	EUR	JPY
INR	0.0519	0.3050	0.3358
USD		0.3265	0.1349
EUR			0.2047

Table 7: Prob values of the Box-Ljung Q statistic

of the extent to which the currency series violates the random walk. For the three cross-currency pairs between the USD, EUR and JPY, we see prob values of 0.32, 0.13 and 0.20, which suggest that for all the three cross-currency pairs, we cannot reject the null of a random walk at a 90% level of significance.

Under the null of a managed INR/USD rate, we expected to find violations of the random walk for the INR/USD. We find a prob value of 0.0519; the null of a random walk would be rejected at a 94.2% level.

We argued that if the INR/USD is the subject of exchange rate policy, then the INR/USD series should suffer from rejections of the random walk, but other exchange rates of the INR should be unblemished. This is borne out in Table 7, where the Q statistic for the INR/EUR works out to 0.31 and the Q statistic for the INR/JPY works out to 0.33. The violations of market efficiency are limited to the INR/USD.

Figure 7 shows variance ratios for various lag lengths for three INR exchange rates, and Figure 6 shows variance ratios for the three currency pairs between the USD, EUR and JPY. All six graphs here are superposed with critical values for rejection at a 95% and 99% level of significance.

Figure 6 is useful in illustrating how in a floating exchange rate regime, the price is a random walk, and all the variance ratio statistics come out to be roughly 1 at all lag lengths. This figure is a striking example of the effectiveness of speculative markets at producing market efficiency.

Figure 7 shows the three currency pairs involving the INR. While the variance ratios for the INR/USD do not generate rejection at the 95% level of significance, they come close to that, and are strikingly different from the random walk character that is found in all the other variance ratios. This is consistent with the idea that the INR/USD rate does not enjoy the informational efficiency of a price produced on a speculative market.

Such symptoms are not unique to India. Wickham (2002) finds that in a set of 16 developing countries which claim to have flexible exchange rates, 7 exhibit discontinuities / regime shifts. Of the remaining 9, he finds three countries where the daily returns process is not white noise, leaving only six out of sixteen developing countries where the claim of flexible exchange

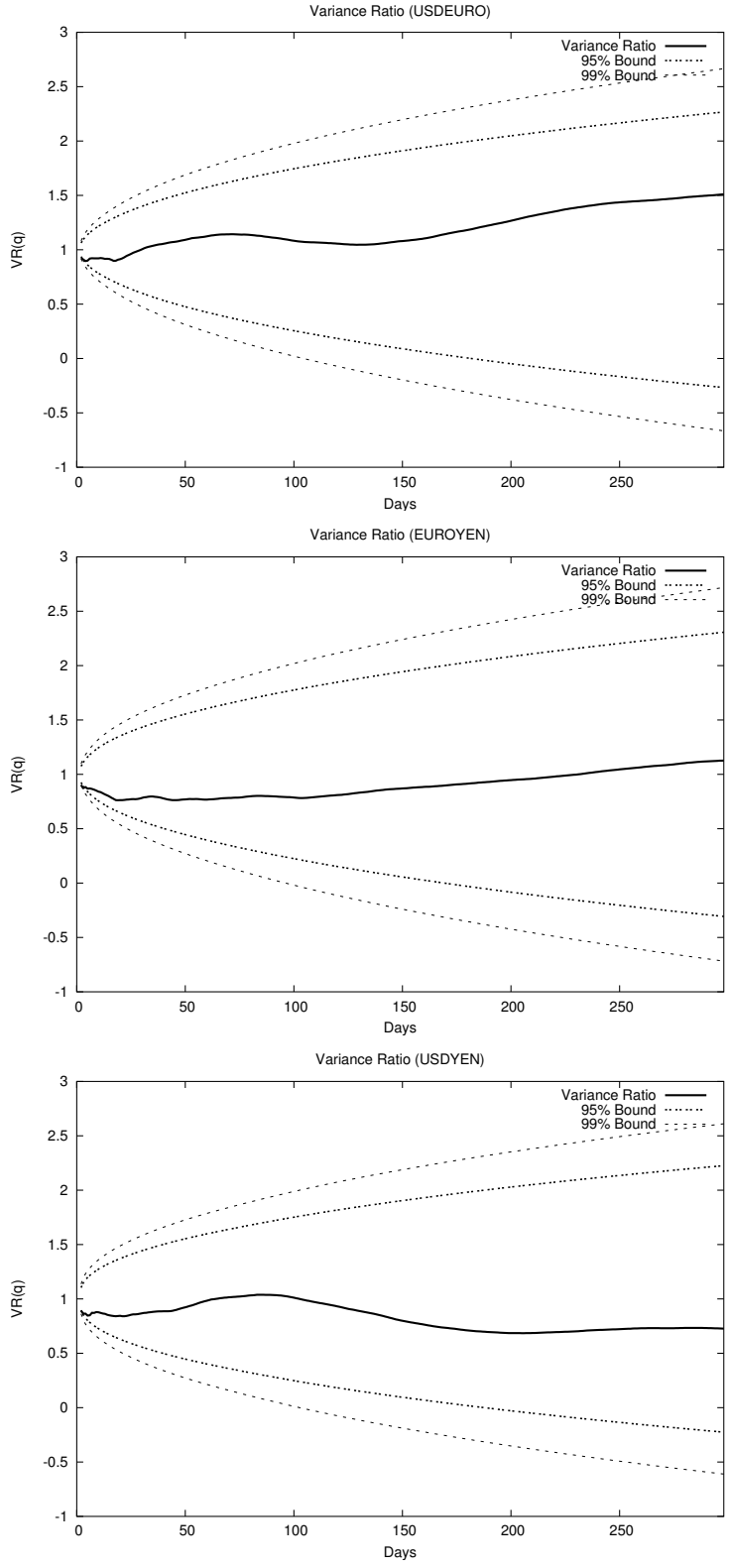

Figure 6: Variance ratio statistics for non-INR exchange rates

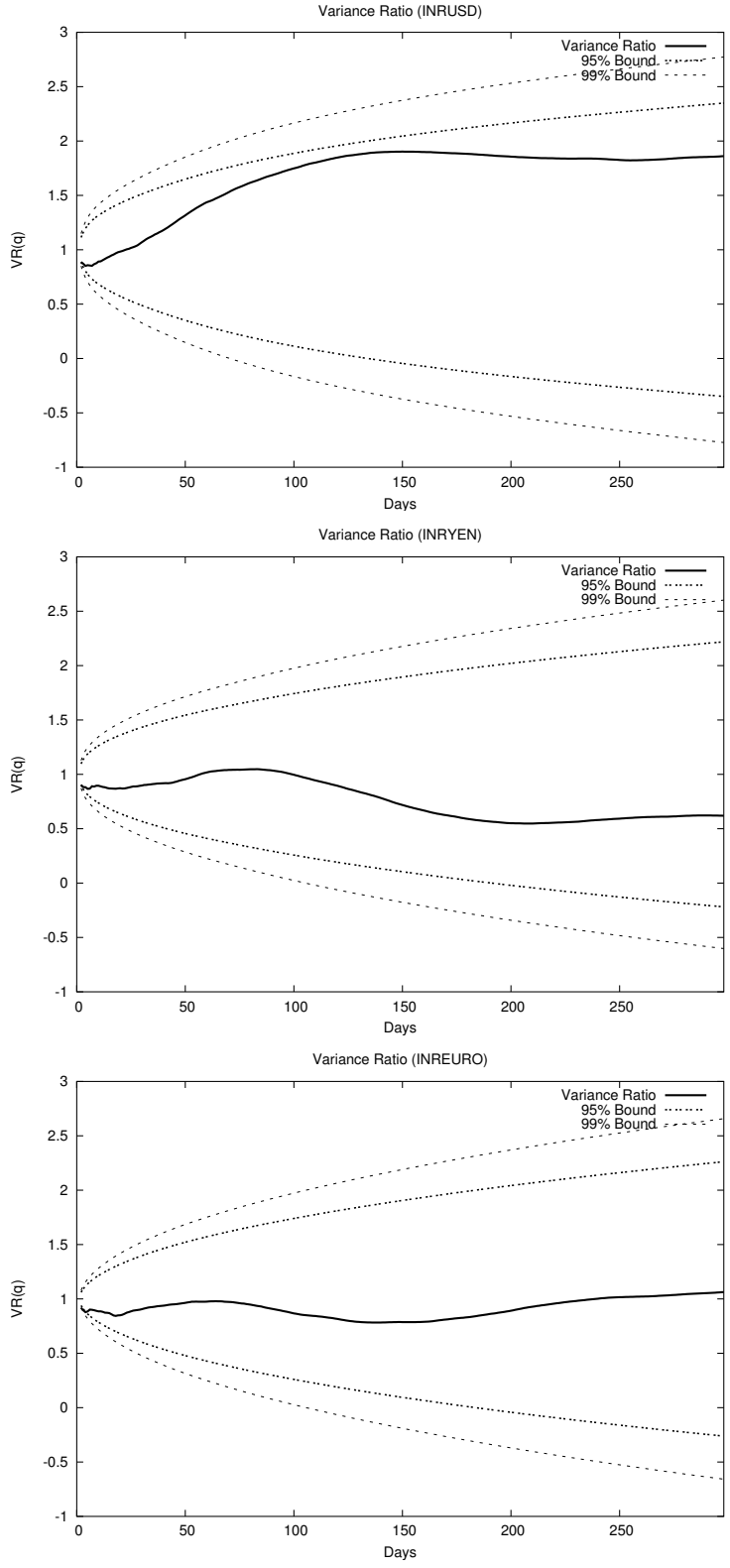

Figure 7: Variance ratio statistics for INR exchange rates

	Anderson-Darling Statistic	Cramer - von Mises Statistic	Kolmogorov-Smirnov Statistic	Kuiper Statistic	Sample Size
3-1-96 – 8-10-96	7.0321*	1.3910*	1.9836*	2.0607*	200
9-10-96 – 3-11-97	13.6069*	209944*	2..6933*	2.8667*	279
4-11-97 – 24-8-98	0.2750	0.0463	0.5140	0.7992	210
25-8-98 – 29-12-00	9.0547*	1.8884*	2.4596*	2.5558*	614

Note: Values marked with a superscript '*' are rejections at a 95% level.

Table 8: Spectral tests of white noise for the INR/USD, from Wickham (2002)

Measure	Standard deviation
36-country REER (1985-86 base)	1.7489
36-country NEER (1985-86 base)	1.7376
5-country REER (2000-01 base)	1.6722
5-country NEER (2000-01 base)	1.5104
INR/USD exchange rate	1.2000

Table 9: Volatilities of monthly percentage changes: 4/1993 to 12/2002

rates is not denied by empirical tests of white noise.

His evidence on India is consistent with our arguments above, and offers additional insights. As shown in Table 8, he finds that for a brief period from 4 November 1997 to 24 August 1998, the null of white noise cannot be rejected, but over other periods, it can. These dates are tantalisingly related to the brief episode with a large value for λ_t that we find in Figure 3. This may suggest that in late 1997 and early 1998, India briefly experimented with greater exchange rate flexibility.

6.6 Is the REER or the NEER being targeted?

As argued above, if RBI were targeting the REER, then the REER should be stable. The evidence seems to deny this. Table 9 compares the volatilities of five monthly time-series: two NEER series, two REER series, and the nominal INR/USD exchange rate over the period April 1993 to December 2002. The nominal INR/USD exchange rate has the lowest volatility of these alternatives. This suggests that over this period, REER or NEER was not targeted.

This table shows an overall average summary statistic, which could mask substantial intertemporal variation. For example, while there may have been strong INR/USD targeting in the period when the exchange rate was fixed

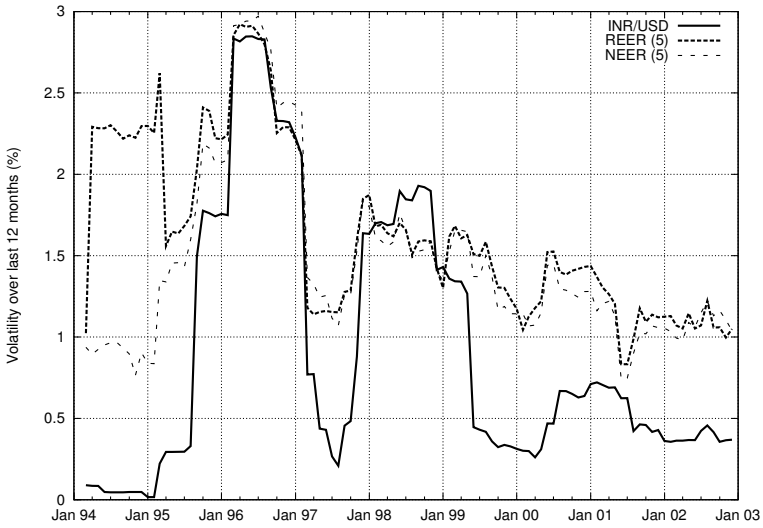

Figure 8: Rolling window volatilities of nominal and real exchange rates

at Rs.31.37/USD (giving a low volatility of the overall INR/USD series), it may be the case that REER targeting may have played a more important role in the later period.

Figure 8 addresses this question by calculating the time-series of volatility in rolling windows, each of which has a width of one year. Hence, the value for June 1998 (say) pertains to the volatility of the twelve months from July 1997 to June 1998.

This figure suggests that while the volatility of the nominal exchange rate has, on occasion, been as high as the volatility of the five-country REER or NEER, the broad regularity is that the INR/USD was the lowest volatility series especially after January 1999. This evidence goes all the way to December 2002, and hence reflects the contemporary currency regime. This appears to be more consistent with the hypothesis that the currency regime was focused on the nominal exchange rate. However, these estimates use rolling window volatilities for one year. They could fail to pick up REER targetting for over longer time horizons.

7 Conclusion

In this paper, we had set out to obtain some insights into India's experience with the currency regime, and the accumulation of reserves in recent years. Did the reserves growth in India, and particularly that observed in the last one to two years, take place as a consequence of a policy that targeted a certain minimum level of 'reserves as insurance', or did the reserves growth take place as a passive side effect of maintaining the currency regime?

These questions are inextricably intertwined with the question of characterising India's currency regime. This is related to the puzzle of interpreting the phrase 'market determined exchange rate' that is used by RBI. The existing currency regime is not based on a transparent set of publicly disclosed rules. The official stance of the RBI about the nature of the currency regime should be approached with caution, given the extensive international evidence that central banks do not do what they say. Hence an analysis of the data is required in understanding the underlying currency regime.

In this paper, we repeatedly resolve questions about the goals of policy by focusing upon volatility. In a system where x and y are related variables, and if x is targeted, then x will experience low volatility and y will experience enhanced volatility if it is either the instrument used by the policy maker, or a side effect of policy measures focused on x. This approach allows us to disentangle the true goals of policy from the 'side effects' and instrumentalities of attaining these goals.

We compare India's reserves holdings against a variety of metrics that have been proposed in the literature. It appears that by March 2002, India had adequate reserves going by all these metrics. In this case, the addition of \$20 billion after this point does not support the proposition that the RBI was motivated by reserves as insurance.

The currency market betrays strong symptoms of a highly managed INR/USD exchange rate, as has been pointed out by two prominent papers in 2002 (Reinhart & Rogoff 2002, Calvo & Reinhart 2002). We argue that if a null hypothesis "the INR/USD is the central focus of exchange rate management" is maintained, this leads to predictions which are substantiated by the evidence. The regression framework of Frankel & Wei (1994) is also consistent with the hypothesis of a nominal peg to the USD. This suggests that India has primarily had a nominal exchange rate policy in recent years, and that reserves accretion has been the side effect of this policy. We ae also able to reject the hypothesis that in the over a one year horizon the RBI targets the REER.

It appears that the phrase 'market determined exchange rate' should be usefully interpreted as saying that the exchange rate is shaped on a market,

and not administratively determined, as was the case in preceding decades. However, it should not be interpreted as meaning that the exchange rate is determined out of the equilibrium obtained from a large mass of economic agents on the currency market. RBI appears to be an active trader on the market, using the large size of its transactions to manipulate the market price.

As the literature suggests, India has been in a homogeneous regime of low exchange rate flexibility from 1979 onwards. In the older period, the highly repressed external sector may have made it easier to achieve goals of currency policy without repercussions for the domestic economy. However, the steady liberalisation of the external sector implies that other elements of policy, particularly reserves and monetary policy, now have to undergo greater stress in order to achieve traditional goals of exchange rate policy.

The arguments of this paper are useful in understanding Indian macroeconomics and macro policy today. The loss of monetary policy independence that accompanies an open capital account and a flexible exchange rate create new policy dilemmas. When exchange rate adjustment is muted, other variables in the economy have to adjust in response to shocks. Moreover, currency regimes with exchange rate targeting are vulnerable to speculative attacks. The failures of market efficiency that this paper documents suggests that there are opportunities for profitable speculative trading strategies. The monetary impact of the current exchange rate regime and questions about speculative activity are topics for further research.

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