Asymmetries in central bank intervention

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Abstract

When the exchange rate is either fixed or floating, the currency trading of the central bank is relatively well understood. In intermediate regimes, or 'dirty floats', three different alternative behaviours of the central bank can be conjectured: symmetrically preventing changes of the exchange rate vs. preventing appreciation vs. preventing depreciation. In this paper, we describe a testing strategy for identifying the behaviour prevalent in a given period. In the empirical example, we find that it yields useful insights when applied in the subperiods identified by the methodology of Zeileis, Shah, and Patnaik (2007) for identifying dates of structural change in the exchange rate regime.
Keywords: Exchange rate regime, foreign exchange intervention, India, regime switching, asymmetric intervention.

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Contents

1 Introduction

The *de jure* exchange rate regime in operation in many countries that is announced by the central bank differs from the *de facto* regime in operation. The 'fear of floating' (Calvo and Reinhart, 2002) which many central banks exhibit has motivated research into the *de facto* exchange rate regime. This has motivated a small literature on data-driven methods for the classification of exchange rate regimes (see e.g., Reinhart and Rogoff, 2004; Levy-Yeyati and Sturzenegger, 2003; Calvo and Reinhart, 2002; Zeileis, Shah, and Patnaik, 2007). This literature has attempted to create datasets identifying the exchange rate regime in operation for all countries in recent decades, using a variety of alternative algorithms.

Two corners in the exchange rate regime – float and fixed – are relatively well understood. The middle region, which is termed 'the intermediate regime' or 'a dirty float', is harder to characterise. In this region, the central bank is actively engaged in trading on the currency market. There are many different kinds of behaviour that the central bank can engage in. The fine structure of the exchange rate regime can change from time to time. If the central bank is relatively non-transparent, little is disclosed to the economy or to policy analysts about the rules of engagement that govern currency trading, or the *de facto* exchange rate regime.

A better understanding what central banks do in intermediate regimes is hence an important goal of research. In this paper, we seek to identify whether there are asymmetries in the behaviour of the central bank: whether it is more benign towards appreciation or depreciation or neither. All three cases are plausible depending on the period of examination:

Symmetric reponse to movements in both directions Sometimes, a central bank might trade on both sides of the market, aiming to remove large movements of the exchange rate, either because it frowns on currency volatility, or if there is strong exchange rate pass-through and stability of the exchange rate is a route to price stabilisation and *de facto* inflation targeting.

Asymmetric response to depreciation Sometimes, a central bank might fight to prevent depreciation, either because exchange-rate pass-through is strong and depreciations induce inflation, or because there are fears of capital flight if there is a sudden collapse of the currency, or because the firms in the country have built up unhedged currency exposure.

Asymmetric response to apprecation Sometimes, a central bank might fight to prevent appreciation, owing to a desire to subsidise the domestic tradeables sector and to engage in export promotion (Rodrik, 2007).

In this paper, we have no normative judgment about whether or not these kinds of behaviours are appropriate. This paper is focused on the question of measurement. Using data available in the public domain, is it possible to classify the behaviour of the central bank in a given time-period into these three possibilities?

The stance of the central bank need not be constant through time. In certain periods it may allow larger appreciation of the currency, while preventing large depreciation. In others, it may do the opposite. These issues are likely to be closely interlinked with the evolution of the exchange rate regime. Hence, what is required is an exploration into these questions which is consistent with structural change of the exchange rate regime.

In recent years, a literature has emerged which analyses the reserves and currency movements of a few countries (Ramachandran and Srinivasan, 2007; Srinivasan, Mahambare, and Ramachandran, 2008; Pontines and Rajan, 2008; McKenzie, 2002; Suardi, 2007). Most of this literature uses daily intervention data, or uses the change in reserves as a proxy for intervention. The former information is unavailable for most countries in most time periods and the latter information is imprecise given revaluation effects and interest payments.

In this paper, we develop a methodology for testing for asymmetries in the exchange rate time time series in the context of structural change of the exchange rate regime. This strategy requires only daily data for exchange rate movements and is hence implementable in all countries. As an example, we show results of applying this for India.

This research can help in looking beyond the statements of a central bank, to better understand the *de facto* rules of engagement of the trading by the central bank on the currency market. It can help in better understanding the interaction between monetary policy and the exchange rate regime.

2 Methodology

A recent literature has looked at the question of testing for asymmetry in the behaviour of the central bank. Ramachandran and Srinivasan (2007) use a simple positive/negative dummy variable to split appreciations and depreciations, while Srinivasan, Mahambare, and Ramachandran (2008) and Pontines and Rajan (2008) use a cubic term, which can be shown to imply asymmetries. Studies for India use reserve changes as a proxy for intervention. These papers find that India's RBI has intervened during phases of appreciations, but not during depreciations.

McKenzie (2002) uses a threshold GARCH model to examine whether the volatility of returns respond asymmetrically to the central bank intervention. In this model, central bank intervention influences the volatility equation of the GARCH model but not the mean equation. The impact of the central bank varies depending on periods of appreciation and depreciations. Using daily intervention data in Australia, it is found that large sales of reserves have a bigger impact than large purchases.

A key limitation of these papers lies in their reliance on intervention data. High frequency intervention data is seldom released by central banks. Changes in reserves are a poor proxy for intervention. As an example, Figure 1 shows one example of a period where the scatterplot of central bank intervention versus the change in reserves (at monthly frequency) deviates significantly from the 45 degree line.

There may be problems with simultaneity, given the influence of innovations in the exchange rate process on intervention, and the influence of intervention on the exchange rate. Finally, the use of reserves data limits the analysis to monthly or weekly data. The use of daily data would yield better insights into the dynamics of trading by the central bank.

Our approach to deal with those problems is to study only the nominal exchange rate against the US dollar. This has three advantages: this data is available for all time-periods and all countries; it avoids problems of endogeneity; and it allows the use of daily data.

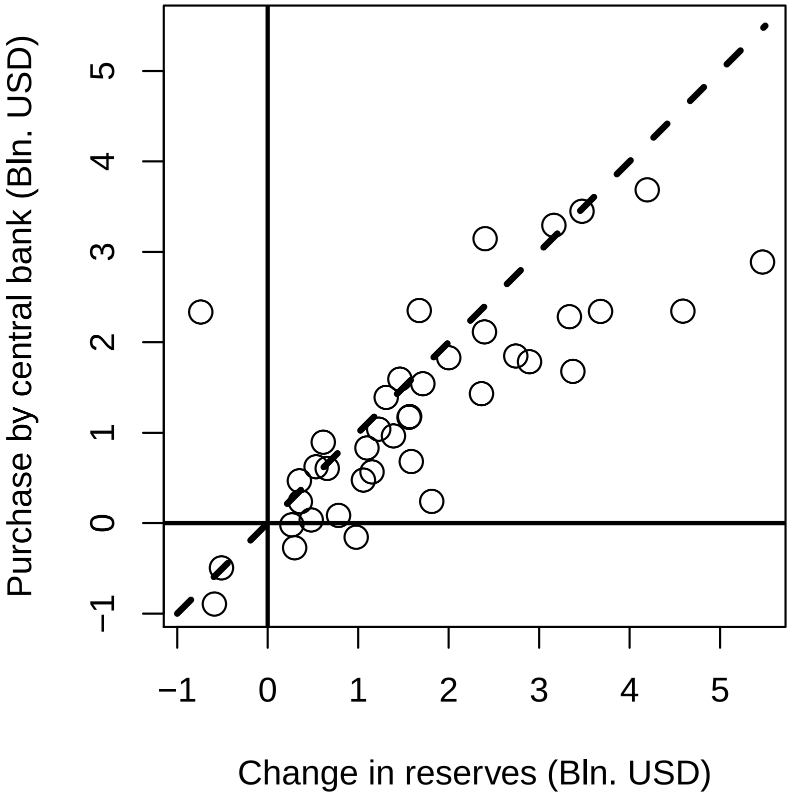
We investigate the question of asymmetries using regime switching models, which allow the model to encompass different behaviours under different conditions. A convenient model for our framework is the self-exciting threshold autoregressive (SETAR) process (Tong, 1990), which splits the data according to whether the observations are below or above a certain threshold θ:

$$y_t = \begin{cases} \mu_L + \zeta_{L1} y_{t-1} + \zeta_{L2} y_{t-2} + \ldots + \zeta_{Lp} y_t + \varepsilon_t & \text{if } y_{t-1} \leq \theta \\ \\ \mu_H + \zeta_{H1} y_{t-1} + \zeta_{H2} y_{t-2} + \ldots + \zeta_{Hp} y_t + \varepsilon_t & \text{if } y_{t-1} > \theta \end{cases} \quad (1)$$

This model allows the exchange rate process to differ based on whether the exchange *rate* high (above θ) or low (below θ). Models allowing for threshold effects have been popular in the real exchange rate literature, where the emphasis has been on testing for nonlinear mean reversion (Obstfeld and Taylor, 1997; Taylor, Peel, and Sarno, 2001). To ease interpretation, we reparametrise this as in the ADF test specification, differencing the left-side variable:

Figure 1 The imprecision of change in reserves as a measure of central bank intervention: An example

As an example of the difficulties of differenced reserves as a proxy for intervention, we use data for a period in India where monthly intervention data has been released, where substantial divergence was visible. This runs from January 2001 till January 2004. The scatterplot of change in reserves (on the x axis) versus true intervention (on the y axis) is shown. These points diverge considerably from the 45 degree line.



$$\Delta y_t = \begin{cases} \mu_L + \rho_L y_{t-1} + \sum_i^{p-1} \phi_{Li} \Delta y_{t-1} + \varepsilon_t & \text{if} \quad y_{t-1} \leq \theta \\ \mu_H + \rho_H y_{t-1} + \sum_i^{p-1} \phi_{Hi} \Delta y_{t-1} + \varepsilon_t & \text{if} \quad \theta \leq y_{t-1} \end{cases} \tag{2}$$

where: ρ $(= \zeta_1 + \zeta_1 + \ldots + \zeta_p)$

This has the advantage that the long run dynamics of the models are concentrated in the ρ coefficient. A value of zero indicates a random-walk process with infinite memory, while a value close to -1 suggests a process with short time memory. Hence, we can interpret the coefficient as the mean reversion parameter, where a decreasing value indicates a stronger mean reversion.

Figure 2 illustrates a SETAR model on the nominal INR/USD exchange rate, in a period when it was a *de facto* fixed rate. One can see the two regimes and on the y axis the horizontal line representing the threshold value ($\theta = 31.39$) splitting the regimes.

This model is useful in expressing the dynamics of a pegged exchange rate with a well defined target rate. It is not useful in defining *de facto* pegged exchange rates where the central bank trades on a large scale but without a fixed target rate. Left panel of figure 3 shows that using a SETAR on a moving exchange rate would does not yield interesting informations concerning regime dynamics[1].

We hence use a modified version, a Momentum Threshold Autoregressive model (MTAR), where the transition variable is the difference of the exchange rate.

$$\Delta y_t = \begin{cases} \mu_L + \rho_L y_{t-1} + \sum_i^{p} \phi_{Li} \Delta y_{t-1} + \varepsilon_t & \text{if} \quad \Delta y_{t-1} \leq 0 \\ \mu_H + \rho_H y_{t-1} + \sum_i^{p} \phi_{Hi} \Delta y_{t-1} + \varepsilon_t & \text{if} \quad 0 \leq \Delta y_{t-1} \end{cases} \tag{3}$$

Introduced by Enders and Granger (1998) in the context of the term structure of interest rates, the MTAR models asymmetric adjustment, where 'increases tend to persist but decreases tend to revert quickly toward the equilibrium'. The model has been used in different contexts (Enders and Siklos, 2001; Abdulai, 2002)). However, few of these papers have a strong economic motivation for using an MTAR model instead of a TAR.

Our motivation for the use of an MTAR model comes from two points of view. First, as was discussed above, while a SETAR may well describe a regime with a fixed rate, it has the drawback to be less interesting in intermediate regimes, as shown in the example of Figure 3.

Second, there is a clear interpretation of the MTAR as splitting the data into periods where the exchange rate rose (i.e. depreciation) vs. decreased (appreciation). If $\theta = 0$, then the first regime occurs when $\Delta y_{t-1} \leq 0$, that

[1] In this case, the SETAR may rather indicate ofr structural breaks, see (Carrasco, 2002)

Figure 2 SETAR model of a fixed rate: An example

This graph illustrates the dynamics of a SETAR model of a *de facto* fixed exchange rate. Red values show the high state and black values show the low state, with an estimate cutoff of Rs.31.39 a dollar. In each of these states, the SETAR model allows a different AR model to hold.

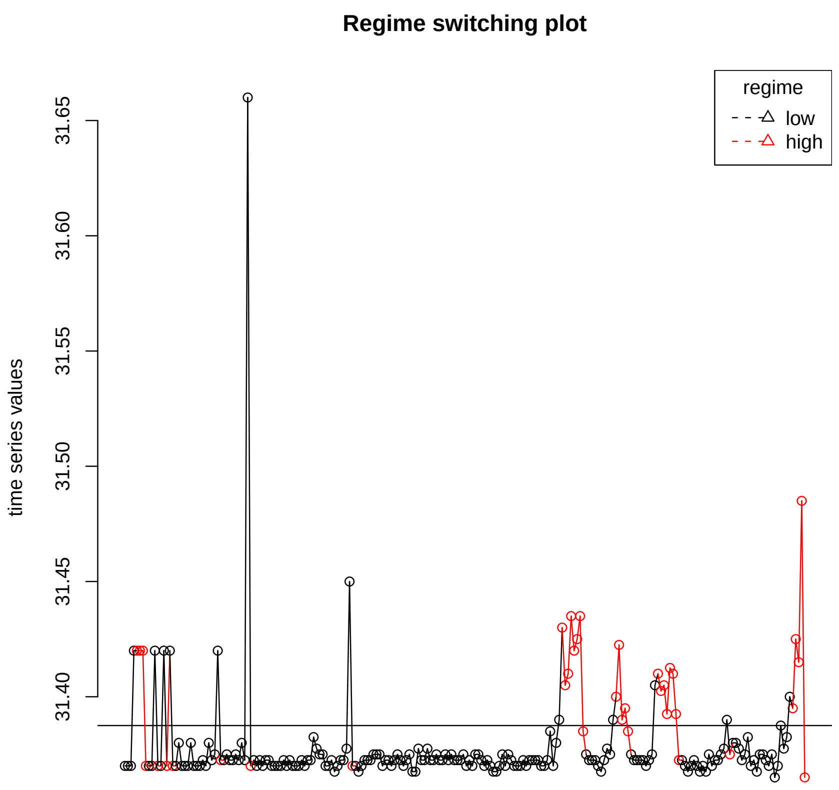
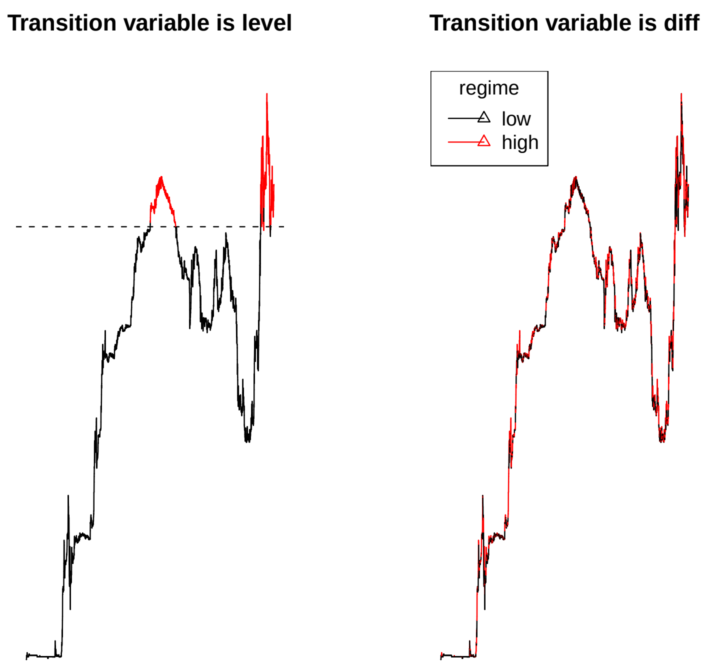


Figure 3 SETAR and MTAR models compared

The left pane shows the splitting between regimes of a TAR model where there the transition variable is the level of the exchange rate. Values above it become the high regime and values below it are the low regime. While it would make sense if the central bank has a clear and fix target, it is hard to argue that the central bank might behave differently in the high regime vs. the low regime when demarcated in this fashion.

The right pane shows the model where the transition variable splitting between regimes is based on the *change* in the exchange rate. The asymmetry hypothesis here is that the central bank behaves differently in the red periods (depreciation periods) versus the black periods (appreciation periods).



is, when we have an appreciation, whereas the second occur when $\Delta y_{t-1} > 0$, i.e., a depreciation. This permits us to test whether the central bank is agnostic between appreciations and depreciations.

The dynamics of these processes are complex. The most useful interpretations are based on ρ_L, ρ_H, often called the long-run coefficients. In a simple AR process, this value lies between -2 and 0, the case of $\rho_L = 0$ being a random-walk with no mean reversion, while a smaller value, close to -1, indicates strong mean reversion.

In a situation when a central bank prevents appreciation, we would get $\rho_L < \rho_H$, that is, appreciations periods have a stronger mean reversion (a smaller ρ_L value) due to intervention as compared with periods with depreciation.

Testing such hypothesis is complicated as the case of a unit root in one regime (i.e., $\rho_i = 0$ cannot be ruled out, and hence unit root tests accounting for threshold effects need to be used. Hence, we are actually jointly testing two hypotheses: the presence of a threshold effect ($\rho_L \neq \rho_H$ or $\phi_{Li} \neq \phi_{Hi}$) as well as the stationarity of the regimes ($\rho_i < 0 \ i = L, H$). Only if we find evidence of threshold effect and evidence of stationarity can we test formally for the inequality $\rho_L < \rho_H$.

Caner and Hansen (2001) study an interesting intermediate case where there is a threshold effect but only one of the regimes is stationary[2], which they term a "partial unit root model". This model is potentially important for exchange rate analysis, given that appreciations would follow a stationary mean reverting process, while depreciations would follow a random-walk process, i.e. a process which does not "mean revert" and flucutuates randomly. Note that it is not yet well understood whether such partial unit root model is a stationary process[3].

In order to disentangle threshold and stationarity effects, Caner and Hansen (2001) suggest a two-step analysis. The first step checks whether there is a threshold effect by testing if there is a change in the coefficients depending on the regime. The second step check for the stationarity of the processes. The second step involves two different test statistics, the first testing for stationarity of the whole process ($\rho_H < 0 and \rho_L = 0$), the second for stationarity of at least one of the regimes ($\rho_H < 0 or \rho_L = 0$). Critical values for both steps are obtained through residual-based bootstrap replications,

[2]Thats is, either $\rho_H = 0, \rho_L < 0$ or $\rho_H < 0, \rho_L = 0$

[3]For the MTAR model, only sufficient conditions have been obtained. Whereas the trivial condition of stationarity of all regimes is sufficient to ensure the stationarity of the whole process, weaker conditions have not been established in opposite to the SETAR model, where the process can have unit roots in the regime but still be stationary, see for example Chan, Petruccelli, Woolford, and Tong (1985).

where the null of the test for threshold tests is either based on a stationary or non-stationary process, whereas the null of the test for stationarity is either based on the assumption of a threshold effect or not.

In the MTAR model presented above, we made the assumption that the threshold value is zero. While this makes sense in our context as it clearly differentiates between appreciations ($\Delta y < 0$) and depreciations ($\Delta y > 0$), it may be the case that actually this value is different to zero. Indeed the threshold effect (the fact that coefficients differ according to regime) may be stronger based on other values, differentiating for example a "normal" regime from a "high" appreciation regime, meaning that intervention would occur only after a large appreciation taken place. In such case, small positive deviations are not corrected whereas bigger positive ones are. This could describe exchange rate systems such as the ERM, where exchange rates were pegged and intervention occured when the deviation reached a band. While the ERM was symmetric between appreciations and depreciations, in our context we are also keen on identifying asymmetries in central bank intervention.

Estimation of the threshold value is done using concentrated least squares (Chan, 1993; Hansen, 1996). Inference on the threshold value is rather messy, as the distribution of the threshold estimator is highly non-standard and full of nuisance parameters (Chan, 1993). Some methods for the SETAR have been proposed in the literature (Hansen, 2000; Seo and Linton, 2007; Gonzalo and Wolf, 2005), but it is not clear that these can be used in our context as they rely on the assumption of stationarity of all regimes. As the threshold parameter is super-convergent[4], it can be taken as given in the estimation and hence the slope parameters have usual asymptotic normal distribution (in the stationary case).

Problems using threshold models arise from the sensitivity of the models to the parametrisation. In several monte carlo studies Hansen (2000); Gonzalo and Wolf (2005); Seo and Linton (2007) found that the variability of the threshold parameter and the slope parameters is relatively high. Indeed, the threshold value can vary strongly depending on the number of lags in each sub-regimes or on the model specification.

To summarize, our methodology is following:

- Use the structural break methodology of Zeileis, Shah, and Patnaik (2008) to identify a set of breakdates
- Test for the presence of threshold effects in the sub-periods
- Test for stationarity of the process using threshold unit root tests. We have then:

[4] Converging at rate T instead of the usual $\sqrt{T}$

- If both regime are non-stationary, there is no conclusion
- If only one regime is stationary (partial unit root case), we interpret it as evidence for intervention in the stationary regime, while the non-stationary regime fluctuates randomly without intervention.
- If both regimes are stationary, test whether their long-run coefficients are equal. If not, we interpret it as a stronger intervention in one of the regimes

Note that this methodology allows to detect mean reverting processes, but that their interpretation as intervention from the central bank is only conjectured, as there is no data on intervention.

3 Example: The Indian rupee

3.1 Data

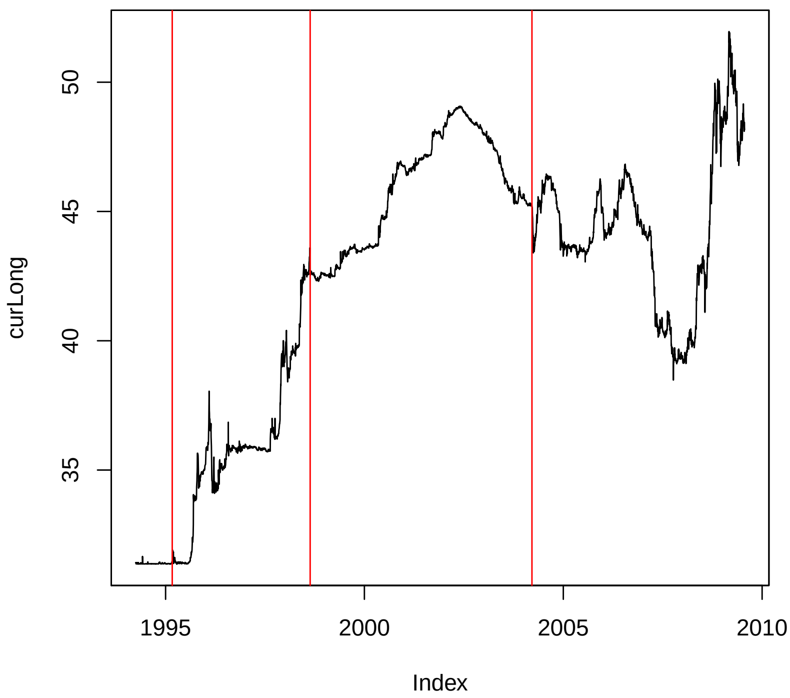
We use daily data for the INR/USD exchange rate from April 1994 to July 2009. While the rather big sample size of the data is advantageous for the estimation and testing as unit root tests are known to have low power in moderated sample size, it has the disadvantage that structural change in the exchange rate regime may be present. Zeileis, Shah, and Patnaik (2008) found evidence of structural breaks in March 1995, August 1998, March 2004 and April 2008. Table 4 shows the series as well as dates for the structural breaks.

3.2 Analysis

As a first step, we conduct the analysis on the whole sample, from 1993 to 2009. We first examine the the stationarity of the series using standard unit roots tests. The conventional ADF test, the test of Elliott, Rothenberg, and Stock (1996) which is more adapted when the series may have a trend component, as well as the stationarity test of Kwiatkowski, Phillips, Schmidt, and Shin (1992), all indicate that the series is non-stationary, for various values of the lag length. The same tests applied on the differenced series reject the null of a unit root, and we hence conclude that the nominal exchange rate is integrated of order one.

As discussed before, it could be possible that the series is indeed stationary in phases of appreciation whereas it may be non-stationary in other phases. We use then a MTAR model, and find the selected threshold value

Figure 4 Time-series of the INR/USD exchange rate



to be 0.2, with 95% observations in the first regimes (all appreciations and deprecations smaller than 0.02) and 5% in the second "high depreciations" regime (i.e. depreciations higher than 0.2).

Table 1 MTAR model with a trend

	Estimate	Std. Error	t value	Pr(>|t|)
const L	0.046	0.02	2.19	0.03
phiL.1	-0.001	0.00	-2.01	0.04
DphiL.1	-0.056	0.02	-2.54	0.01
DphiL.2	0.024	0.02	1.38	0.17
DphiL.3	0.050	0.02	2.83	0.00
const H	-0.033	0.10	-0.33	0.74
phiH.1	0.003	0.00	1.31	0.19
DphiH.1	-0.269	0.05	-5.50	0.00
DphiH.2	-0.042	0.04	-1.04	0.30
DphiH.3	-0.027	0.04	-0.67	0.50

The long-run coefficient in the high depreciation regime has an unexpected positive value, indicating explosive behavior of depreciations. The threshold effects test (based on the null of a linear random-walk model) shows evidence of regime differentation, but the threshold unit root test (based then of the null of a threshold model) is not rejected. Non rejection of the test can be due to the model specification, as is the linear case where unit root tests have a low power against trend stationary alternatives. We hence include a trend in the model specification and find the surprising result that the threshold value is now negative, about -0.18 (with 5% of the observations below and 95% above). While this sudden change is not intuitive, the results now get a clearer interpretation, as there is no more any explosive behaviour, and the long-run coefficient in the high appreciations regime is now highly significant:

Running the non-linear unit root tests, we see that the first regime is indeed stationary, while the second has a unit root. We hence find the case of partial unit root, which confirms our hypothesis of appreciation prevention. This result should nevertheless be taken with caution as they seem to be highly sensitive to small changes in the model specification.

This can be due to the fact that the management of the exchange rate has differed over sub-periods. We now turn to an analysis of those sub-periods.

3.3 Analysis of sub-regimes

Zeileis, Shah, and Patnaik (2008) found evidence of structural breaks in the

Table 2 MTAR model

	Estimate	Std. Error	t value	Pr(>|t|)
const L	0.455	0.13	3.56	0.00
trend L	0.000	0.00	7.18	0.00
phiL.1	-0.017	0.00	-4.81	0.00
DphiL.1	-0.087	0.05	-1.74	0.08
DphiL.2	-0.014	0.03	-0.43	0.67
DphiL.3	0.094	0.03	2.83	0.00
const H	0.029	0.02	1.17	0.24
trend H	-0.000	0.00	-1.17	0.24
phiH.1	-0.000	0.00	-0.57	0.57
DphiH.1	-0.084	0.02	-3.97	0.00
DphiH.2	0.023	0.02	1.25	0.21
DphiH.3	0.022	0.02	1.20	0.23

Indian exchange rate regime. They identify four periods:

- 1993-04-09 to 1995-03-03: Clear and tight peg to USD, low flexibility
- 1995-03-10 to 1998-08-21: Peg to the USD, higher flexibility
- 1998-08-28 to 2004-03-19: Peg to the USD and to Euro, low flexibility
- 2004-03-26 to end: Peg to basket of currencies: USD, Euro, JPY and GBP, higher flexibility.

Given these substantial changes in the exchange rate regime, it is reasonable to think that the nature of trading by the central bank would also vary substantially in each of these periods. Hence, we apply our analysis for each of these sub-periods separately.

First period (April 1993 to March 1995) The first period is characterized by a fixed rate to the USD around a first a value of 31.42 (28% of the time) and then of 31.37 (55% of the time). In this period, there is little complexity in understanding the nature of engagement of the central bank on the currency market. The central bank trades to ensure that its target rate is achieved. Nevertheless, we apply our analytical tools to this period in order to deepen our understanding of the tools.

Depreciations and appreciations have been fast and strongly corrected, so that on a total of 452 days, there have been only 16 different values of the exchange rate. This small number of different observations makes it difficult to compute the value of the potential threshold, and results in a high uncertainty of the estimates. Indeed, the selected threshold value is 0 (with 97% below or equal and 3% above).

The results of the model are shown in table 3. The autoregressive coefficients are -0.1046 and -0.196. One sees hence that the mean reversion is slower in the regime with changes below 0 than in the regime with changes higher than 0, which seems to indicate that depreciations have been prevented. The difference between the coefficients is nonetheless not statistically significant.[5]

Second period (March 1995 to August 1998) The selected threshold value is 0.15, with 90% of observations below and 10% above, thus rather indicating an extreme depreciation regime. One can see from table 4 that there seems to be a difference between the normal regime and the high depreciation regime, where the long-tun coefficient of high depreciations is small (faster mean reversion).

The threshold test indicates the presence of threshold effects at high levels ($< 1\%$). The threshold unit root test rejects the unit root at 5%[6] only for the regime with depreciations above 0.15. The rejection is nevertheless only in the case of a model without trend.

This is thus a period of prevention of depreciation. After the trade liberalisation of the early 1990s India had built up a large current account deficit, and there was pressure on the rupee to depreciate. This period also includes the period of the Asian crisis. It was a time when there was a sharp depreciation of the exchange rates of many Asian economies. While India was relatively isolated in comparison to Asian economies, it was also part of the turmoil that hit Asia, and there was pressure on the exchange rate to depreciate. Apart from direct intervention in the foreign exchange market, the RBI also raised interest rates to prevent rupee depreciation. On January 16, 1998, as part of this policy RBI raised interest rates by 200 basis points on one single day. In summary, our testing strategy suggests that in this period, the nature of central bank trading was one of preventing depreciations.

Third period (August 1998 to March 2004) The period from August 1998 to March 2004 had reduced flexibility. This is once again not an intermediate regime. There is relatively little complexity in understanding what a central bank does in such a period.

[5] Using a normal Wald test or a specifical test with alternative for the second coefficient smaller than the first one

[6] Based on 1000 bootstrap replications.

There was a long period of depreciation and then of appreciation. While the threshold test shows evidence of regime specific dynamics (with a threshold value of 0.09 splitting into 5% and 95%), the null of a unit root is rejected in neither regime. So the hypothesis of an active appreciation prevention is not confirmed during this sub-period.

The result that there was no active appreciation or depreciation prevention, is consistent with the intuition that our methodology is more useful in the case of intermediate regimes when the exchange rate is relatively more flexible. This means that in a situation of a tight peg, the behaviour of the central bank is not asymmetric.

Fourth period (March 2004 to July 2009) The fourth period is characterized in Zeileis et al. (2008) by a higher volatility as well as a change in the peg, the RBI including the Yen, the Pound and the Euro. One may argue that our univariate analysis which takes into account only the the dollar may be in that case less relevant, as the role of the dollar has disminished.

But we find actually that there is a threshold effect around -0.23 (splitting 5% and 95%), and the hypotheis of a partial unit root is rejected[7], i.e., the there was mean reversion in the high appreciation regime, while the normal regime was fluctuating randomly. This corresponds to what we interpret as the intervention of the RBi towards preventing high appreciations.

4 Conclusion

With *de facto* fixed rates and *de facto* floating rates, the behaviour of the central bank in trading on the currency market is well understood. In a fixed rate, the central bank trades as much as required to ensure that a target price comes about. And in a floating rate, the central bank does not trade on the currency market.

This paper contributes to the understanding of intermediate regimes in the context of structural change in the exchange rate regime. We aim to offer greater insight into the rules of engagement of the central bank on the currency market.

In the Indian example, when our testing strategy is applied to data with a long span, it is relatively uninformative, because many different kinds of behaviour are mixed up. When we break down the overall period with dates of structural change, useful results are found. In two of the periods, there was little exchange rate flexibility, and the behaviour of the central bank is

[7] The partial unit root test is rejected at 1% level for various specifications of the model

well understood. The interesting questions concern the other two sub-periods which are intermediate regimes or ‘dirty floats’. In the first period, at the time of the Asian Crisis, we find a focus in the central bank of preventing depreciations. In the second period, we find a focus in the central bank of preventing appreciation.

The strength of this strategy is that it can be applied to any country where daily exchange rate data is available, and where dates of structural change of the exchange rate regime have been obtained. This can hence yield valuable insights into what central banks do in intermediate regimes in many situations.

5 Appendix

Table 3 MTAR model on the first sub-period 1993-1995

	Estimate	Std. Error	t value	Pr(>|t|)
const L	3.283	0.98	3.35	0.00
phiL.1	-0.105	0.03	-3.35	0.00
DphiL.1	0.134	0.11	1.18	0.24
const H	6.162	3.32	1.85	0.06
phiH.1	-0.196	0.11	-1.85	0.06
DphiH.1	-0.214	0.15	-1.47	0.14

Table 4 MTAR model on the second sub-period 1995-1998

	Estimate	Std. Error	t value	Pr(>|t|)
const L	-0.055	0.07	-0.74	0.46
phiL.1	0.002	0.00	0.96	0.34
DphiL.1	0.170	0.05	3.44	0.00
DphiL.2	0.001	0.03	0.03	0.98
DphiL.3	-0.031	0.03	-0.90	0.37
const H	0.857	0.23	3.67	0.00
phiH.1	-0.017	0.01	-2.84	0.00
DphiH.1	-0.619	0.08	-7.87	0.00
DphiH.2	0.542	0.11	5.03	0.00
DphiH.3	0.249	0.10	2.40	0.02

Table 5 MTAR model on the fourth sub-period 2004-2009

	Estimate	Std. Error	t value	Pr(>|t|)
const L	1.245	0.30	4.13	0.00
phiL.1	-0.029	0.01	-4.44	0.00
DphiL.1	-0.301	0.09	-3.31	0.00
DphiL.2	0.007	0.07	0.10	0.92
DphiL.3	0.023	0.06	0.38	0.71
const H	-0.020	0.10	-0.20	0.84
phiH.1	0.000	0.00	0.21	0.83
DphiH.1	-0.061	0.04	-1.68	0.09
DphiH.2	0.010	0.03	0.33	0.74
DphiH.3	0.055	0.03	1.81	0.07

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