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We analyse India's exchange rate regime through the prism of exchange market pressure. We estimate the various regimes that India's exchange rate has been through during the period from 2000 to 2020. We find four specific regimes of the Indian rupee differentiated by the degree of flexibility. We document the manner in which EMP in India has either been resisted through foreign exchange market intervention, or relieved through exchange rate change, across these four exchange rate regimes. We find that in only one of the four regimes the rupee-dollar exchange rate was relatively more flexible and the share of exchange rate in EMP absorption was the highest. This regime corresponded with the aftermath of the 2008 global crisis. In contrast, after 2013 the exchange rate was actively managed using spot as well as forward market intervention. We also find that the RBI has been intervening in the foreign exchange market in an asymmetric fashion to prevent the rupee from appreciating.

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Abstract

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Keywords: Exchange rate regime, Forex intervention, Reserves, Exchange market pressure, Structural change

JEL codes: E58, F31, F41

Introduction

The exchange rate regime of a country depends on the manner in which the currency of the country is managed with respect to other countries' currencies. There are primarily three different types of exchange rate regimes – freely floating, fixed and pegged or managed floating. Most developed countries of the world have freely floating exchange rate regimes wherein the central banks do not intervene in the foreign exchange markets to stabilise currency fluctuations. On the other hand there are countries such as HongKong which has a a fixed parity with the US dollar and the HongKong central bank uses its monetary policy to maintain this peg. Majority of the emerging economies lie somewhere in between these two extremes. They are mostly characterised by 'managed floating' exchange rate regimes or some version of a 'pegged' regime, with their respective central banks intervening in the foreign exchange market on a regular basis.

India falls in this category. In 1993 India officially moved towards a "market determined exchange rate" from a fixed peg to the US dollar. This was part of the liberalisation and deregulation reforms of the early 1990s. There has been a currency market since then, and at the same time the Reserve Bank of India actively trades in this market.[1] In this paper we infer and document the evolution of India's exchange rate regime (henceforth, ERR) over a long period of time, from 2000 to 2020. We introduce a novel angle of analysing the ERR, by using an exchange market pressure index (henceforth, EMP). Specifically we ask how was EMP managed across the different exchange rate regimes. The degree of foreign exchange intervention and the degree of flexibility in the exchange rate are likely to differ across the regimes based on the response of the central bank to the EMP.

The official de-jure classification of ERR of a country often diverges substantially from the de-facto ERR that exists in practice (Reinhart and Rogoff, 2004). Full information about the exchange rate regimes is often not disclosed by the central banks and hence the ERR needs to be uncovered from historical data using statistical methods. Given the active foreign exchange intervention by the RBI, it is difficult to decipher India's ERR by simply looking at the level of the exchange rate or the volatility. The actual rate that is observed is partly an

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1   See Patnaik (2005) and Patnaik (2007) for more details.

outcome of the underlying macro-financial conditions or shocks faced by the economy and partly of the intervention policy or currency policy of the central bank.

The IMF's AREAER report (till 2004) has classified India's *de-facto* ERR as "managed floating with no pre-determined path for the exchange rate". Existing literature classifies India's ERR as a *de-facto* pegged exchange rate to the USD in the post-liberalisation period (Patnaik, 2005, 2007; Zeileis et al, 2010 and Patnaik and Shah, 2009). Using data on market-determined parallel exchange rates, Reinhart and Rogoff (2004) classifies India's *de-facto* ERR (in the post liberalisation period) as a "peg to US dollar" from August 1991 to June 1995 and a "crawling peg to US dollar" from July 1995 to December 2001. Calvo and Reinhart (2002) use a metric of currency flexibility that combines exchange rate volatility, reserves volatility and interest rates volatility. They find that currency flexibility in India has not changed in the 1979-1999 period despite the move to a 'market-determined' ERR in 1993.

The RBI intervenes in the forex market with the stated goal of "containing volatility" (Patnaik, 2005) but there is evidence that the central bank intervenes in an asymmetric manner, buying US dollars and selling rupees in order to prevent a currency appreciation (Sen Gupta and Sengupta, 2013). This shows that India offers an interesting case-study for deciphering the underlying ERR using a data-driven analytical framework.

EMP measures the pressure on the exchange rate, which is either resisted through foreign exchange market intervention or relieved through an exchange rate change. In a floating ERR, when macro-financial shocks hit the economy, this exerts pressure on the exchange rate and the exchange rate freely fluctuates according to market forces. In a pegged or a managed ERR, when shocks materialise, there is EMP and the exchange rate does not change or changes much less. Instead, the central bank intervenes in the foreign exchange market to absorb the EMP.

In the last decade, significant advances have been made in the literature in the context of dating exchange rate regimes and also measuring exchange market pressure. New and

relatively more sophisticated statistical tools are being used in these fields which offer greater conceptual clarity. In this paper we make use of these methodological innovations.

We estimate the exchange rate regimes in India using the methodology outlined in Zeileis et al (2010). Their method is an improvement on a much-used linear regression framework popularised by Frankel and Wei (1994). Once we find the ERR, we study the exchange market pressure that prevailed during each of the regimes. For this, we use a new EMP index proposed by Patnaik et al (2017). They measure EMP by analysing the amount of adjustment needed in the exchange rate to remove any excess demand or excess supply of the currency that may exist in the foreign exchange market in the absence of any currency intervention.

We look at the evolution of this EMP index in India over the last two decades and document the manner in which the RBI may have responded to changes in EMP across the different exchange rate regimes. Specifically we ask whether the RBI attempted to manage the EMP or let the exchange rate absorb the EMP. As mentioned above, an attempt to manage or counter the EMP would lead to stabilisation of the exchange rate which has direct implications for the underlying ERR. We also try to understand the transition from one regime to the next. The Covid-19 pandemic has triggered unforeseen consequences for economies all over the world. While on one hand the US government has announced a massive fiscal stimulus which is already causing overheating of the economy, on the other hand India continues to struggle with economic recovery amidst slow pace of vaccinations. Towards the end of our paper we briefly discuss what this pandemic might imply for India's exchange rate dynamics going forward and what policy options might be available in this context.

If the objective is to stabilise the exchange rate, this can be done using three instruments from the central bank's toolkit: (i) forex intervention, (ii) capital controls and (iii) monetary policy. According to the Impossible Trilemma which is a key insight of modern day open economy macroeconomics, a country cannot simultaneously have an open capital account, a fixed exchange rate and monetary policy independence. This implies that if India has an open capital account, and the RBI prefers to fix the exchange rate, monetary policy is driven solely by the need to maintain the fixed exchange rate.

Alternatively, if the RBI wishes to retain monetary policy autonomy and at the same time fix the exchange rate, it has to impose capital controls. In other words, if the decision is to manage the exchange rate as opposed to letting the exchange rate float, then this objective can be fulfilled in multiple ways. In this paper we primarily analyse how the RBI used forex intervention to manage the exchange rate from time to time. In future research we plan to delve deeper into the use of monetary policy and capital controls to stabilise the exchange rate across ERR.

Our paper is closely related to the sizeable literature that exists by now on analysing exchange rate regimes (see for example, Reinhart and Rogoff 2004; Levy-Yeyati and Sturzenegger 2003; Bubula and Ötker-Robe 2002 among others). This literature mostly developed in the 2000s when it became increasingly clear that a country's de-jure ERR (announced by the central bank) is not always the same as its de-facto ERR. Our study is also related to existing work on dating structural breaks in India's exchange rate (for example, Patnaik and Shah, 2009).

The contribution of our work is to analyse ERR through the prism of the EMP, and also to use the Zeileis et al (2010) methodology to study ERR in India for more than a 20-year period. Most of the existing studies end in 2008. Extending the sample period gives us the opportunity to throw light on the evolution of the de-facto ERR over a long period of time.

We find that during our sample period India witnessed four ERRs, roughly spanning the periods from 2000 to 2004, 2004 to 2008, 2008 to 2013 and 2013 to December 2020. In 3 out of the 4 regimes, the pressure on the rupee was to appreciate. The RBI responded to this appreciation pressure by intervening in the forex market and buying dollars which resulted in a large accumulation of reserves. In only one regime, in the aftermath of the 2008 global financial crisis, there was pressure on the rupee to depreciate. The RBI mostly allowed the rupee to freely fluctuate in this time period. This is consistent with the additional evidence we provide in the paper that confirms that the RBI intervenes in the forex market in an asymmetric fashion, predominantly buying dollars when the rupee faces an appreciation pressure. We find that in the fourth and last ERR ranging from 2013 to 2020, the rupee was being actively managed through currency trading in both the spot and forward markets.

In the rest of the paper, we describe the methodology used to estimate ERR and discuss the results we obtain for India in Section 2. In Section 3 we introduce the EMP measure and analyse the exchange rate regimes using this EMP index. We discuss the transition periods from one regime to the next in Section 4. In Section 5 we discuss the the ERR during the period of the Covid-19 pandemic and touch upon the way forward. Finally, we end with our concluding remarks in Section 6.

2. Exchange rate regimes

We estimate the exchange rate regimes prevalent in India from 2000 onwards using the structural change dating methodology described in Zeileis et al (2010). They devise a data-drive, inferential framework to study the evolution of ERR. Their method is based on the standard, linear exchange rate regression model popularised by Frankel and Wei (1994) which has been used in a number of studies to analyse a country's de-facto ERR.[2] The model uses the returns on cross-currency exchange rates expressed in terms of a suitable numeraire currency.

To apply this method, we use the New Zealand dollar (NZD) as the numeraire currency given its stability over a long period of time.[3] The underlying model that is estimated is as follows:

$$y_t = x^T_t \beta + u_t \ (t = 1......n) \qquad (1)$$

where y_t are the returns of the target currency, in our case Indian rupee (INR) in terms of NZD and the x_t are the vectors of returns of a basket of currencies at time t. For our purpose

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[2]   See for example Kawai and Akiyama (2000), McKinnon (2000), Baig(2001), Ogawa (2002), Ogawa (2004), Bowman (2005), Patnaik et al (2005), B´enassy-Qu´er´e et al (2006), Ogawa and Kudo (2007), Frankel and Wei (2007), Ogawa and Yang (2008), Shirono (2008), Patnaik and Shah (2009), Kawai and Pontines (2016) among others.

[3]   While Zeileis et al (2010) used the Swiss Franc as the numeraire currency, we use the NZD instead because in recent years the SWF has been actively managed with respect to the Euro. However as mentioned in Frankel and Wei (1994, 2007), for managed exchange rates the results of the regression analysis do not critically depend on the choice of the numeraire.

we use the US dollar, Japanese Yen, Euro, and British Pound all expressed in terms of the NZD. These are the most important floating currencies in the world.[4] We use the weekly returns of these exchange rates in order to reduce the noise in the data and also ease the computation burden of the regime-dating algorithm.[5] This regression picks up the extent to which the INR/NZD rate fluctuates in response to fluctuations in any of the currencies on the right-hand side of the equation.

For example, if the INR is pegged to the USD, then the corresponding beta value will be close to 1 and all the other beta values will be close to zero. If on the other hand the INR is not pegged to any of these currencies, then all the beta values will be different from 0 and will reflect the true trade and financial linkages of the economy with the rest of the world. If the INR is instead pegged to a basket of currencies, then the beta values would reflect the corresponding weights of the currencies in that basket. In the case of reduced exchange rate flexibility, the R squared of this regression would also be very high, while lower values would be obtained for floating currencies.

Using this linear regression model one can find out the relationship that exists between the y_t and x_t currencies over a specific period of time. However one cannot infer whether this relationship is stable within a given time period, whether it remains stable with future incoming observations and in case of instabilities in the model parameters, when and how did the estimated regime undergo a change. In other words, this regression model alone cannot help to understand whether and when changes in ERR take place.

Exchange rate regimes can change due to changes in the policy interventions by the central bank. However, the precise timing of these interventions is often not known which makes it difficult to assess the time-window oveer which this model can be fitted. As a result of these interventions, the underlying model parameters would change. In order to estimate the changes in ERR, we need a methodology that takes into account the parameter instabilities and dates the regime-changes based on these instabilities. This is the main premise of the Zeileis et al (2010) method. They use statistical procedures for testing the stability of ERR

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4   Since our sample period starts from 2000 we can safely use the Euro which was introduced as the official currency of the Euro zone from 1999 onwards.

5   We compute log-difference returns (in percentages) of all the currencies i.e. 100 (log p_t– log p_{t-1}), with p_t being the price of a currency at time t expressed in terms of a numeraire currency.

based on past data, monitor the stability of the regimes as new data comes in and estimate the break-points when the ERR changes using the structural change methodology of Bai and Perron (2003).

The conventional method of estimating structural changes in exchange rates was based on the algorithm devised by Bai and Perron (2003). One shortcoming of this method was that it did not take into consideration changes in the error variance as a full model parameter. A change in the underlying ERR necessarily involves a change in the error variance and hence excluding this parameter would result in an incomplete picture. The error variance captures the flexibility of the ERR. If for example the INR is pegged to the basket of five currencies then the error variance will take a low value whereas if the INR is in a floating ERR, then the error variance will be relatively high.

Zeileis et al (2010) extend the dating algorithm of Bai and Perron (2003) to maximum-likelihood and quasi maximum-likelihood (ML and QML) models, include the error-variance in the set of model parameters, over and above the estimated beta coefficients, and assume that the error is normally distributed. In particular, they estimate a quasi-normal model specified by the following density function:

$$f\,(y|x,\,\beta,\,\sigma^2) = \varphi\,((y - x^T\,\beta)/\sigma)/\sigma \qquad (2)$$

where φ (.) is the standard normal density function with combined parameter $\Theta = (\beta^T,\ \sigma^2)^T$ which has a length of $k = c+2$ (i.e. c currency coefficients or betas, intercept and error variance). This way they are able to assess the parameter instability *jointly* for β and σ^2. They then devise a unified framework for testing and monitoring the stability of these parameters and apply the dating algorithm of Bai and Perron (2003) to their maximum-likelihood model.

They assume *n* observations of y_t and x_t such that the conditional distribution $y_t|x_t$ follows the quasi-likelihood function f (y_t |x_t , Θ_t), with Θ_t being a *k*-dimensional parameter, as mentioned above. The hypothesis they test is that the parameter is stable over time i.e.

$$H_0 : \Theta_t = \Theta_0 \ (t = 1, 2, ...n) \qquad (3)$$

The alternative hypothesis is that Θ_t changes over time (which is what we would expect in the case of changes in ERR). If the parameters Θ_t are stable over time, they can be estimated by minimising the corresponding negative log-likelihood function (i.e. - log f (y_t |x_t , Θ_t)).[6]

If the null hypothesis in Equation (3) is rejected i.e. there is evidence that the parameters do change over time then dating algorithm can be applied to find out when these changes take place. If the break-dates are known apriori, then estimation of the model parameters would be relatively straightforward for each of the regimes or segments. Typically however the break-points are not known. In that case, the optimal number of regimes (and hence break-points, *m*) can be computed by using some information criteria (such as the BIC and a modified BIC suggested by Liu et al, 1997).

Zeileis et al (2010) applied their methodology to India to uncover the de-factor ERR. They found that during the period from April 1993 to April 2008, the optimal number of breaks was m=3, implying four exchange rate regimes. Using their methodology we too find four distinct exchange rate regimes in India during our sample period, 2000-2020, with the first two regimes overlapping with the last two segments found by Zeileis et al (2010). We report the dates of these regimes along with the corresponding, estimated coefficients of the basket of currencies, the standard errors as well as the values of the error-variance and the R squared in Table 1.

- The first regime ranges from January, 2000 to March 2004, and can be categorised as one where the rupee was closely pegged to the US dollar. The highly statistically significant coefficient of the US dollar is close to 1 (0.95) while the coefficients of the remaining 4 currencies are close to 0. The σ is the lowest in the sample period and the R-squared value is the highest, further confirming a pegged ERR.

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6   Further details on the tests and the monitoring mechanism can be seen from Zeileis et al (2010).

Table 1: INR exchange rate regimes, 2000-2020.

start/end	USD	JPY	EUR	GBP	Sigma	R-squared
2000-01-14 2004-03-19	0.95*** (0.02)	0.00 (0.02)	-0.01 (0.02)	0.00 (0.02)	0.24	0.97
2004-03-26 2008-02-29	0.75*** (0.05)	0.09** (0.04)	0.03 (0.07)	0.05 (0.06)	0.51	0.86
2008-03-07 2013-11-22	0.63*** (0.06)	-0.05 (0.05)	0.11* (0.06)	0.02 (0.06)	0.95	0.61
2013-11-29 2020-12-31	0.87*** (0.04)	-0.04 (0.04)	-0.02 (0.05)	0.00 (0.03)	0.59	0.73

Note: Standard errors in parentheses. *p<0.1; **<0.05; ***p<0.01. Source: Bank of International Settlements (BIS) database and authors' calculations.

- The second regime spans the period March, 2004 to February, 2008. The R squared value comes down from 0.97 to 0.86 and the σ goes up from 0.24 to 0.51. The weight of the USD, though still the highest, is lower than regime 1.

- The next regime goes from March 2008 to November 2013, and is characterised by the lowest value of the R-squared, and the highest value of σ. This can therefore be classified as the most flexible ERR in our sample period. The estimated coefficient of the USD is also the lowest.

- The fourth and final regime lasts from November 2013 to the end of our sample period. It is the longest period under one single exchange rate regime. The flexibility of the INR gets reduced compared to the previous regime as shown by the increase in R-squared value and decrease in σ. The weight of the USD is also the second highest in the sample period, implying that the INR went back to being relatively more 'pegged' to the dollar, compared to its increased flexibility in the preceding ERR.

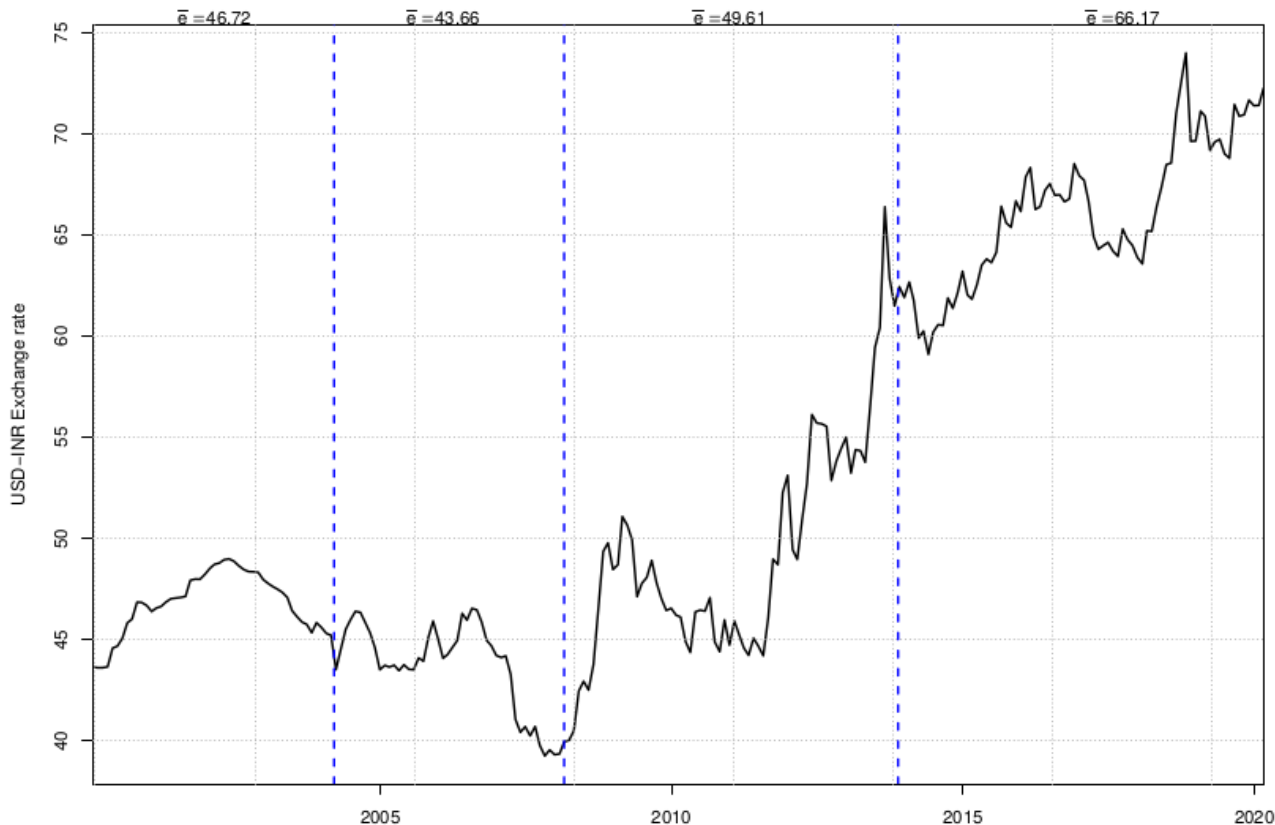**Figure 1: Exchange rate regimes and Volatility of INR/USD exchange rate**
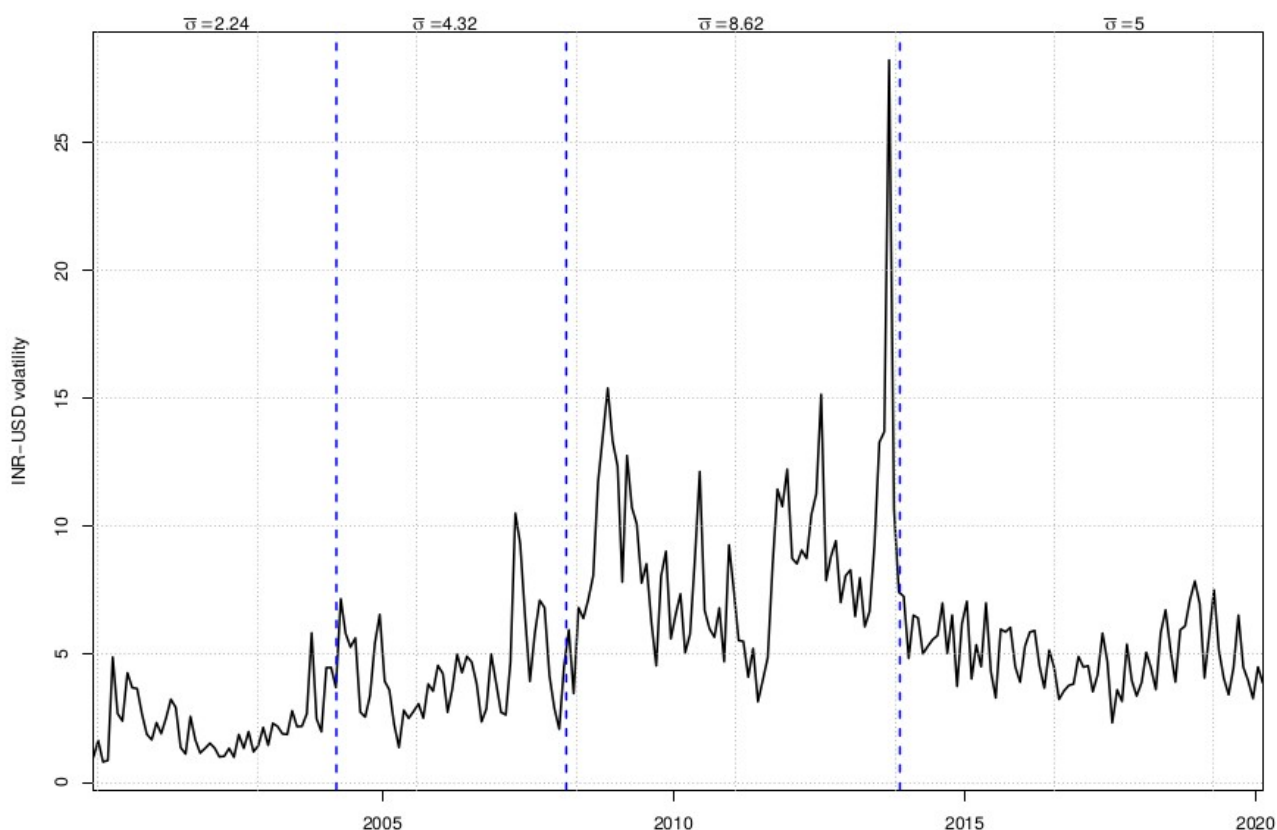
Note: This graph plots the annualised volatility of the INR/USD nominal exchange rate across the different exchange rate regimes. The mean currency volatility in each regime has been mentioned at the top of the graph. Source: BIS database and authors' calculations.

We next plot the annualised volatility of the rupee-dollar exchange rate as well as the level of the exchange rate across the four regimes in Figures 1 and 2, respectively. Consistent with our categorisation of the ERR, we find that the average currency volatility was the highest in regime 3 (8.62%) and lowest in regime 1 (2.24%). Volatility increased in a staggered fashion implying a gradual increase in the flexibility of the exchange rate which peaked in regime 3, and then declined sharply in the last regime (5%), almost down to the same level as regime 2, indicating a more managed ERR.

Figure 2 shows that while there were brief phases of currency appreciation especially towards the beginning of our sample period, overall the rupee has overall been depreciating. This largely reflects the underlying macroeconomic fundamentals of the Indian economy,

specifically the inflation differential between the US and India. The only exception seems to be regime 2 during which the rupee on average seems to have appreciated.

Figure 2: Exchange rate regimes and INR/USD nominal exchange rate

Note: This graph plots the level of the INR/USD nominal exchange rate across the different exchange rate regimes. The average value of the exchange rate in each regime has been mentioned at the top of the graph. Data is from the BIS database.

3. Exchange market pressure

Exchange market pressure measures not only the change in the exchange rate that is observed, but also the foreign exchange intervention that prevented a movement of the exchange rate. ERR analysis focuses on observed changes in the currency. EMP allows us to understand how much of the observed change was policy determined.

3.1. Measuring EMP

EMP is the total pressure on the exchange rate, resisted primarily through forex intervention (thereby causing change in reserves) or relieved through exchange rate change. There exist several measures of EMP in the literature that combine changes in the exchange rate and reserves, but most of them suffer from problems of units. Some other measures tried to resolve this problem by normalizing exchange rate and reserves and weighing them by the inverse of their respective volatilities (or using alternative weights).[7] However as pointed out by Pontines and Siregar (2008) all these EMP indices are characterised by a common problem of arbitrary choice of weights.

This in turn can result in misleading conclusions about EMP especially during ERR changes. For example, having the inverse of the standard deviation of the exchange rate and reserves as the weights imply that in a fixed ERR, the weight assigned to movements in exchange rate by construction would be infinity (Patnaik et al, 2017). This means that if in a country with a fixed ERR, small changes in the exchange rate are allowed, this will show up as very high EMP values because of the large weight assigned to exchange rate movements and small weight to reserve changes.

The EMP measure proposed by Patnaik et al. (2017) avoids these problems and also measures the EMP in consistent units i.e. percentage change in exchange rate. They calculate EMP as the actual change in the exchange rate that took place and the change that would have occurred in the absence of any forex intervention. They estimate the following equation to derive the EMP measure:

$$EMP_t = \Delta e_t + \rho_t I_t \qquad (4)$$

where, Δe_t is the percentage change in nominal exchange rate, I_t is the actual intervention in the forex market measured in billion dollars and ρ_t is the percentage change in exchange rate associated with \$1 billion forex intervention. They estimate the value of ρ_t which they call the conversion factor. $\rho_t I_t$ is therefore the exchange rate change that would have

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7 See for example Eichengreen et al. (1996), Sachs et al. (1996), Kaminsky et al. (1998), Pentecost et al. (2001), Klaassen (2011) among others.

materialised had there been no forex intervention. This added to the actual change in the exchange rate gives a comprehensive measure of the pressure faced by the exchange rate.

A negative EMP value denotes an appreciation pressure vis-a-vis the US dollar, whereas a positive EMP value captures depreciation pressure. The EMP index is expressed in units of percentage change in exchange rate over a one-month period.

Figure 3: Exchange rate regimes and Exchange Market Pressure Index
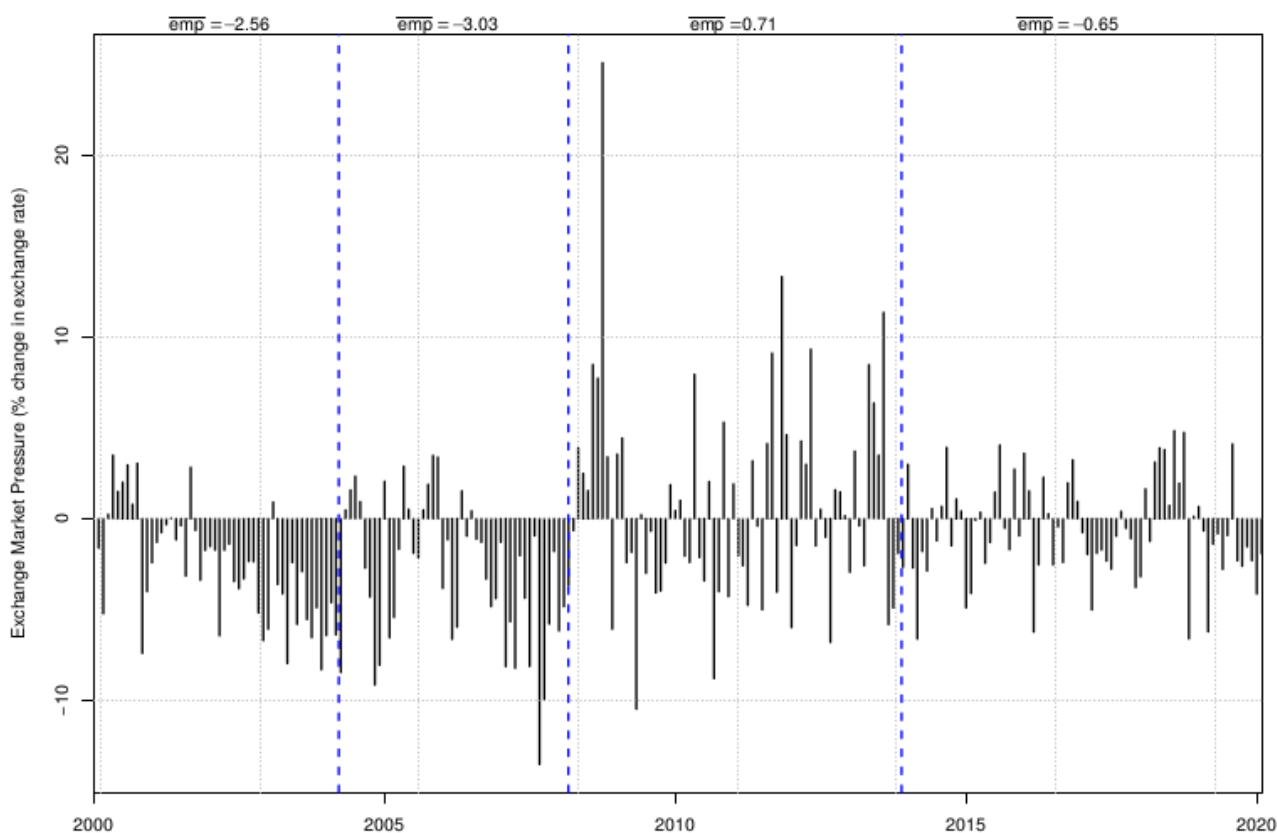
Note: This graph plots the Exchange Market Pressure index across the four exchange rate regimes. The average value of the EMP index in each regime has been mentioned at the top of the graph. This EMP measure is constructed based on equation (4) and using data on forex intervention, percentage change in exchange rate and the same rho values as in Patnaik et al (2017). A negative EMP index denotes pressure on the currency to appreciate whereas a positive EMP implies pressure on the currency to depreciate. Source: Authors' calculations based on Patnaik et al (2017).

We plot the EMP over our sample period in Figure 3 and highlight the four exchange rate regimes using vertical lines.[8] We find that during the first, second and fourth ERR, the EMP

8   EMP for India refers to the pressure on the rupee to appreciate or depreciate vis a vis the US dollar. As shown in Table 1, the dollar consistently comes up as the currency against which the rupee is managed during the period of

was mostly negative. This implies that the rupee experienced a pressure to appreciate for majority of the sample period. The direction of EMP changed around the time of the 2008 global financial crisis. During the third ERR which ranges from 2008 to 2013, the rupee primarily faced a pressure to depreciate.

When we look at Figure 2 and Figure 3 in conjunction, the implications are interesting. During three of the four regimes, the EMP and the actual movement of the exchange rate seem to have been in the same direction. In regimes 1 and 2, the EMP shows a pressure on the rupee to appreciate and the exchange rate seems to have actually appreciated. In regime 3, the EMP shows a pressure on the rupee to depreciate and the currency seems to have actually depreciated. However, this does not seem to be the case for regime 4. In the next section, we explore this in greater detail and for this we look into the response of the RBI to EMP across the four exchange rate regimes.

3.2. Managing EMP across exchange rate regimes

In this section we ask how was the EMP managed across the four exchange rate regimes? Specifically we look into the proportion of EMP that was resisted through forex intervention and the proportion that was relieved through exchange rate change, in each of the regimes.

Equation (5) below shows the share of EMP absorbed by the exchange rate change ($\Delta e_t/EMP_t$) and the share of EMP absorbed by forex intervention ($\rho_t I_t/EMP_t$). If the ERR is a pegged (flexible) or actively (less actively) managed one, the share of forex intervention in EMP absorption would be relatively higher (lower) and the corresponding share of exchange rate would be lower (higher).

$$EMP_t = \Delta e_t + \rho_t I_t$$
$$1 = \Delta e_t/EMP_t + \rho_t I_t/EMP_t \qquad (5)$$

In Table (2) we report the average values of shares of EMP absorbed by exchange rate change and forex intervention for all four exchange rate regimes. Here we look at the currency spot market intervention. We also report the average values of the EMP, the actual change in exchange rate that took place, and the net spot market intervention (dollar purchase less dollar sale) during these regimes.

Table 2: EMP Management across exchange rate regimes

FX regimes	EMP	Change in exchange rate	Net Spot Intervention (USD Bn)	Share of exchange rate	Share of Intervention
2000-01-14 2004-03-19	-1.945 (app)	-0.005 (app)	1.140 (bought)	-0.094	1.094
2004-03-26 2008-02-29	-2.075 (app)	-0.174 (app)	2.792 (bought)	0.653	0.347
2008-03-07 2013-11-22	1.017 (dep)	0.647 (dep)	-0.804 (sold)	1.029	-0.029
2013-11-29 2020-02-29	-0.526 (app)	0.186 (dep)	2.074 (bought)	0.603	0.397

Notes: The columns report averages across the four exchange rate regimes. Net spot is the purchase of dollars minus the sale of dollars. App refers to currency appreciation, dep is currency depreciation. While the last regime continues till the end of our sample period (Dec 2020), here we only show till February 2020 because after that the country got hit by the Covid-19 pandemic and we analyse the exchange rate dynamics of the pandemic period in a subsequent section. Source: RBI and BIS databases and authors' calculations.

We find that during regime 1 (2000-2004), the EMP and the exchange rate moved in the same direction. The average EMP was -1.95%, indicating a pressure on the rupee to appreciate. The actual change in exchange rate was -0.005%, meaning the exchange rate appreciated but by much less than what was implied by the EMP. This was because the RBI during this period intervened in the forex market and bought enough reserves to counter the currency appreciation but not change the direction of movement of the exchange rate.

As Table (2) shows, the average net spot market intervention (dollar purchase net of dollar sale) by the RBI was $1.14 billion. The average share of spot market intervention was also

higher than the share of the exchange rate in EMP absorption; in fact it was the highest in the sample period. This can also been seen in Figure (4) which plots the EMP series against the actual change in the nominal exchange rate. This is consistent with the description of regime 1 as one where the rupee was mostly pegged to the dollar as shown in Table (1) earlier.

By comparison, the rupee was relatively less managed in regime 2 (2004-2008). The actual appreciation in the exchange rate (-0.174%) was significantly lower than the appreciation pressure indicated by the EMP (-2.075%) implying that forex intervention by the RBI continued to have a role to play. The appreciation pressure on the rupee in this regime was the highest in our sample period. This might explain why the RBI's average net purchase of dollars ($2.79 billion) was also the largest in this regime. We throw more light on this in the next section where we dive into the details of each ERR. At the same time the share of the exchange rate (65%) was higher indicating that the rupee was allowed to fluctuate more.

This trend of the RBI intervening and buying dollars to prevent or lower the extent of rupee appreciation was reversed during regime 3 (2008-2013). The average change in the exchange rate was closer in magnitude to the average value of the EMP. This was the only period in our study during which the RBI became a net seller in the currency spot market. In the aftermath of the 2008 crisis, the rupee faced depreciation pressure as shown by the positive, average EMP value of 1.02. RBI sold dollars in the forex market as a result of which the exchange rate depreciated but by less (0.65% on average) than what was implied by the EMP.

Attempts by the RBI to resist the currency depreciation by selling reserves did not contribute significantly to EMP management. The EMP was primarily relieved through exchange rate change as can also be seen from Figure (4). The absolute magnitude of the average change in exchange rate was the highest in this regime and the share of exchange rate change in EMP absorption was also the highest. This shows that during this period the exchange rate was predominantly in a floating regime. This confirms our earlier observations based on the results presented in Table (1) which showed that this was the only regime in our sample period when the rupee came closest to being a flexible currency.

Figure 4: EMP and Change in exchange rate across regimes
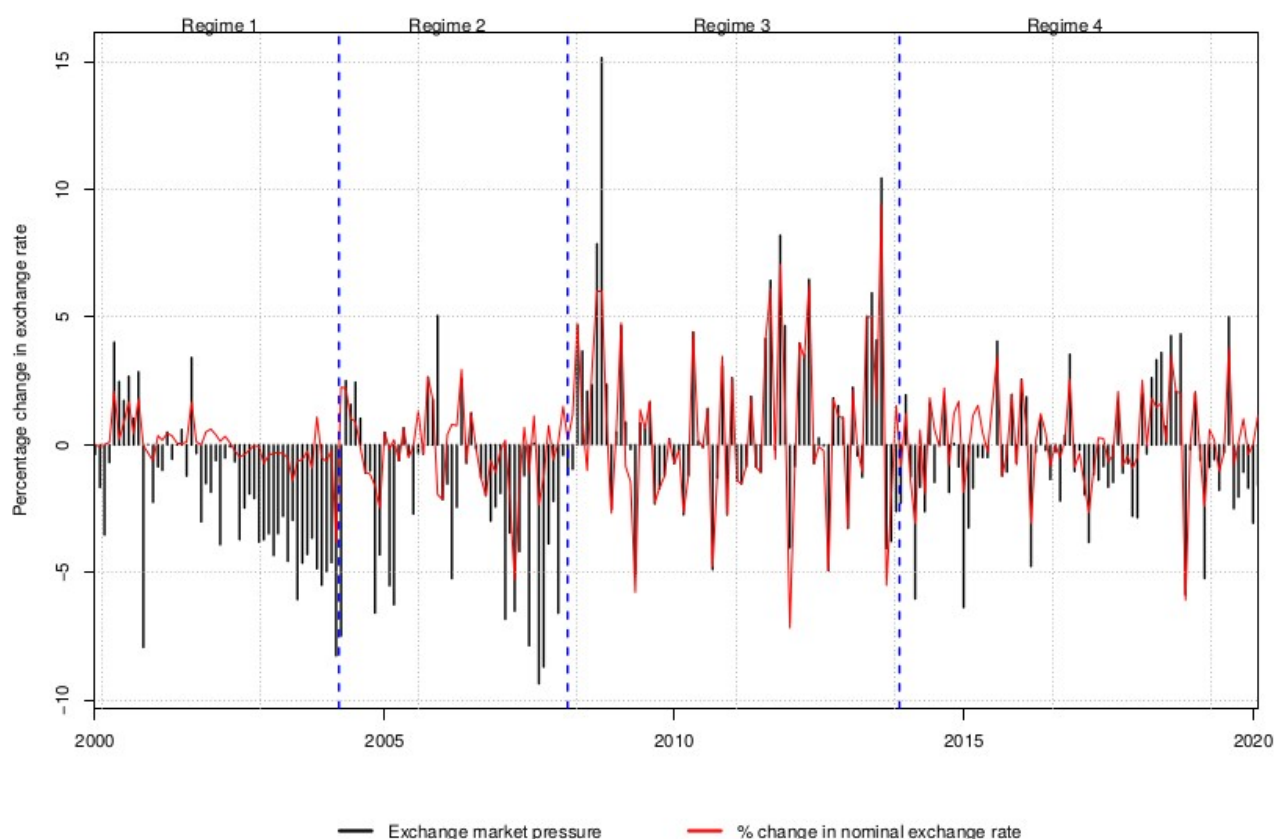
Source: BIS database and authors' calculations.

The contrast of regimes 1 and 2 on one hand and regime 3 on the other hand are further highlighted in Figure (6) which plots the EMP series against the net spot market intervention. The figure clearly shows that spot market intervention was relatively lower during regime 3 and in the direction of dollar sale whereas the higher interventions in regimes 1 and 2 were mostly in the direction of dollar purchases. Figure (5) plots the gross intervention by the RBI in the forex market (dollar sale + dollar purchase) . The figure shows similar magnitudes during regimes 1 and 2. During regime 3 the turnover in the forex market was the lowest. It went up again in regime 4.

Figure 5: Gross turnover in the currency spot market
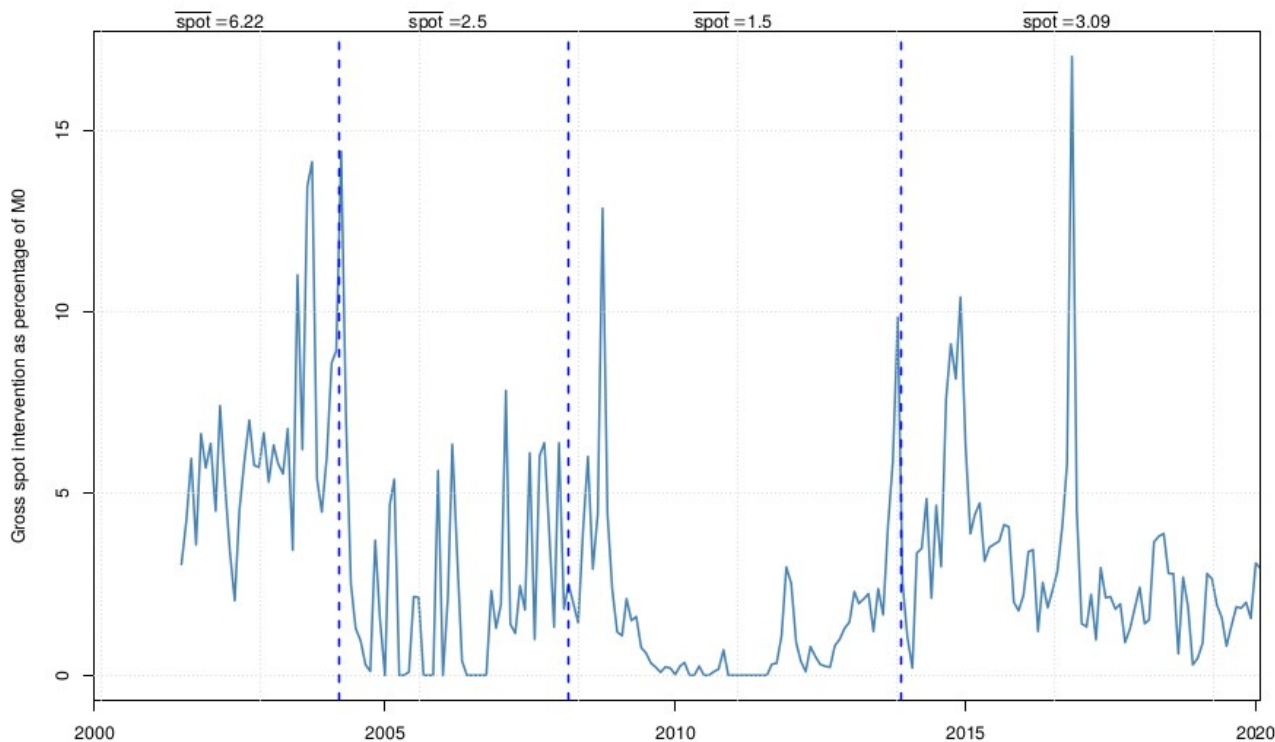
Note: This is a graph of the total dollar sale and purchase by the RBI expressed as a share of M0. The average values are reported at the top of each regime. Data is obtained from RBI database.

During the last and most recent regime (2013-2020), the average EMP was -0.53% and the actual change in exchange rate was 0.19%. This means that on average there was a pressure on the exchange rate to appreciate but the exchange rate depreciated. The only way this could have happened was if the RBI did 'excessive intervention' in the forex market to buy dollars. If the RBI bought enough dollars to counter the currency appreciation or simply to reduce the currency volatility then the exchange rate on average would still have appreciated but the magnitude of appreciation would have been less than what was reflected in the EMP, as was the case in regimes 1 and 2.
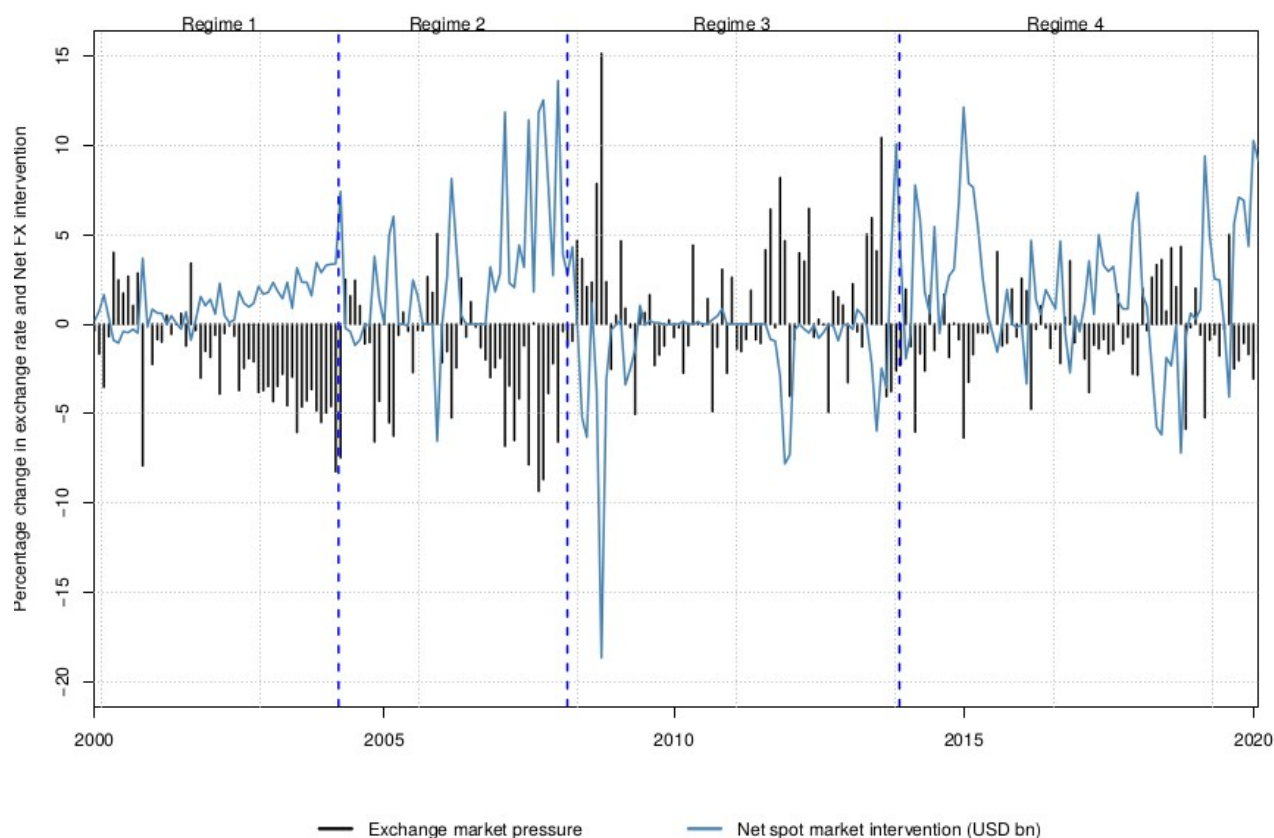
Figure 6: Net intervention in the currency spot market
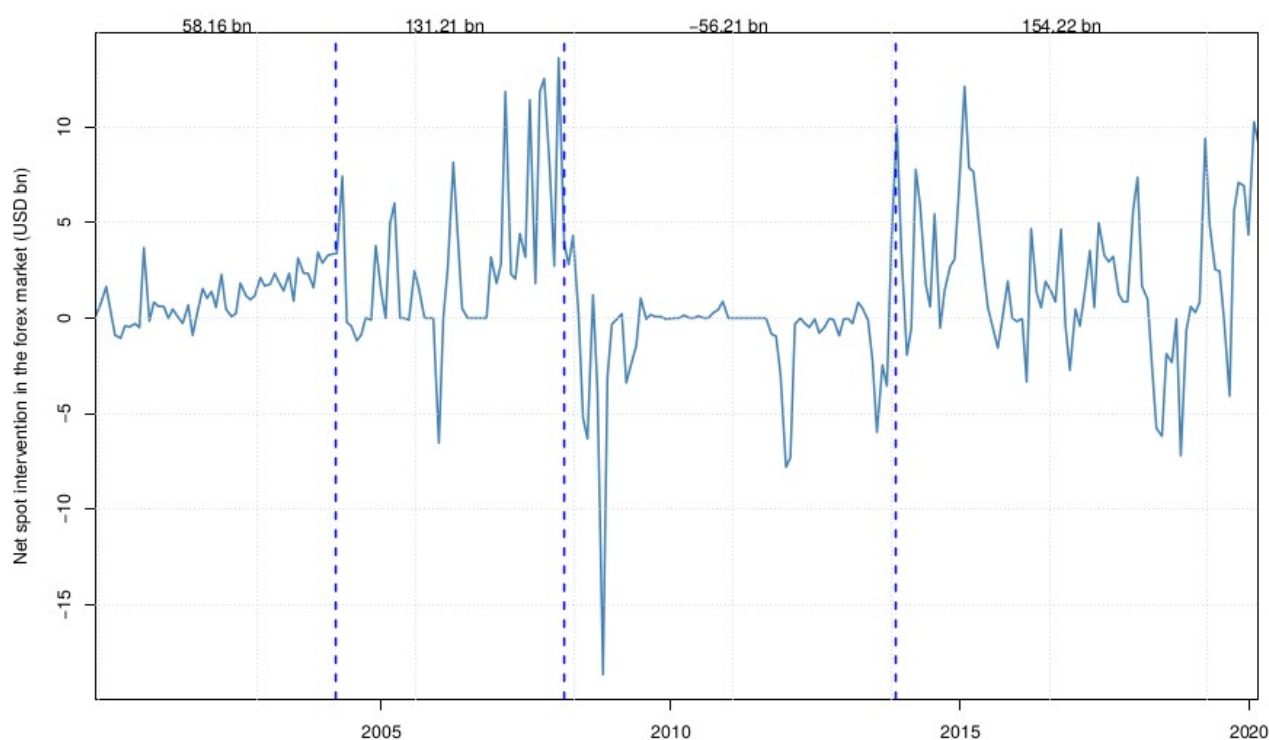
Source: RBI database and authors' calculations.

It is interesting to note a sort of anomaly in this context. In regime 2 when RBI's net dollar purchase was the highest ($2.79 billion), the appreciation pressure on the rupee was also the highest (-2.08%), whereas in regime 4, even though net purchase was the second highest ($1.86 billion) in the sample period, the appreciation pressure on the rupee (-0.53%) was the lowest during our study period. This potentially indicates 'excessive' forex intervention by the RBI. The average share of exchange rate in EMP absorption was higher than that of spot market intervention but regime 4 was clearly one where the exchange rate was more managed compared to the previous ERR and was in fact largely similar to regime 2. This corroborates our findings from Table (1) as well.

**Figure 7: EMP and Net spot market intervention**

Source: RBI database and authors' calculations.

Over and above intervening in the currency spot market, the RBI also intervenes in the forward market. Figure (8) shows the monthly outstanding position of the RBI in the currency forward market as a percentage of the total money supply.[9]

In Figure (9), we plot the EMP measure against RBI's net foreign exchange intervention in a four-quadrant graph. The figure sheds some more light on the RBI's asymmetric intervention in the currency market. For majority of the time, the RBI has been a net buyer of dollars in response to an appreciation pressure on the rupee, as seen from the density of the scatter plot in the lower right hand quadrant of the graph. This further suggests that the RBI does not intervene in the forex market only to contain volatility of the rupee because if that had indeed been the case then we would have seen a more well-rounded distribution of the scatter plot.

9   In the absence of detailed data on the RBI's forward market interventions we are not able to delve deeper into this
      particular aspect of currency management.

Figure 8: Outstanding position in the currency forward market
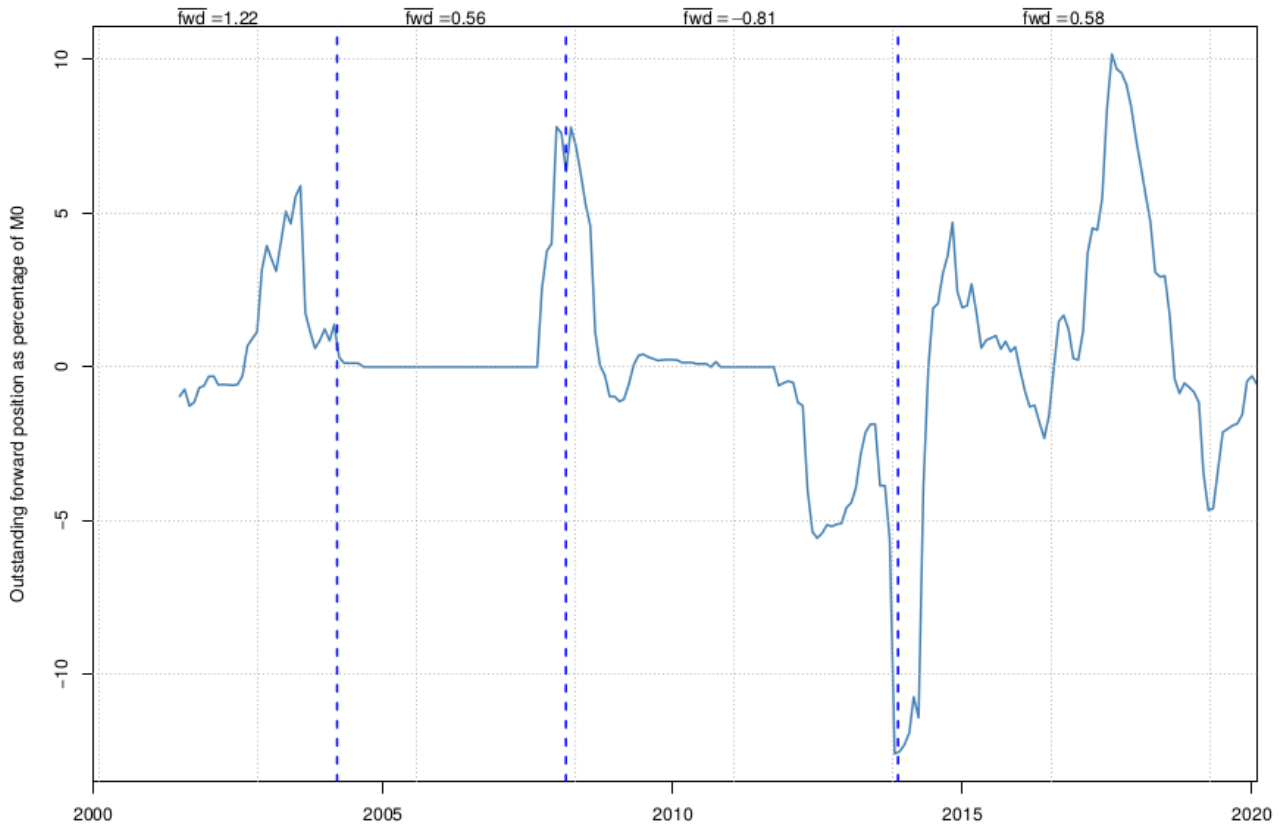
Note: This is a graph of the monthly outstanding forward position as a share of M0. The average values are shown at the top of each regime. Source: RBI database and authors' calculations.

**Figure 9: RBI's Asymmetric intervention in the forex market**
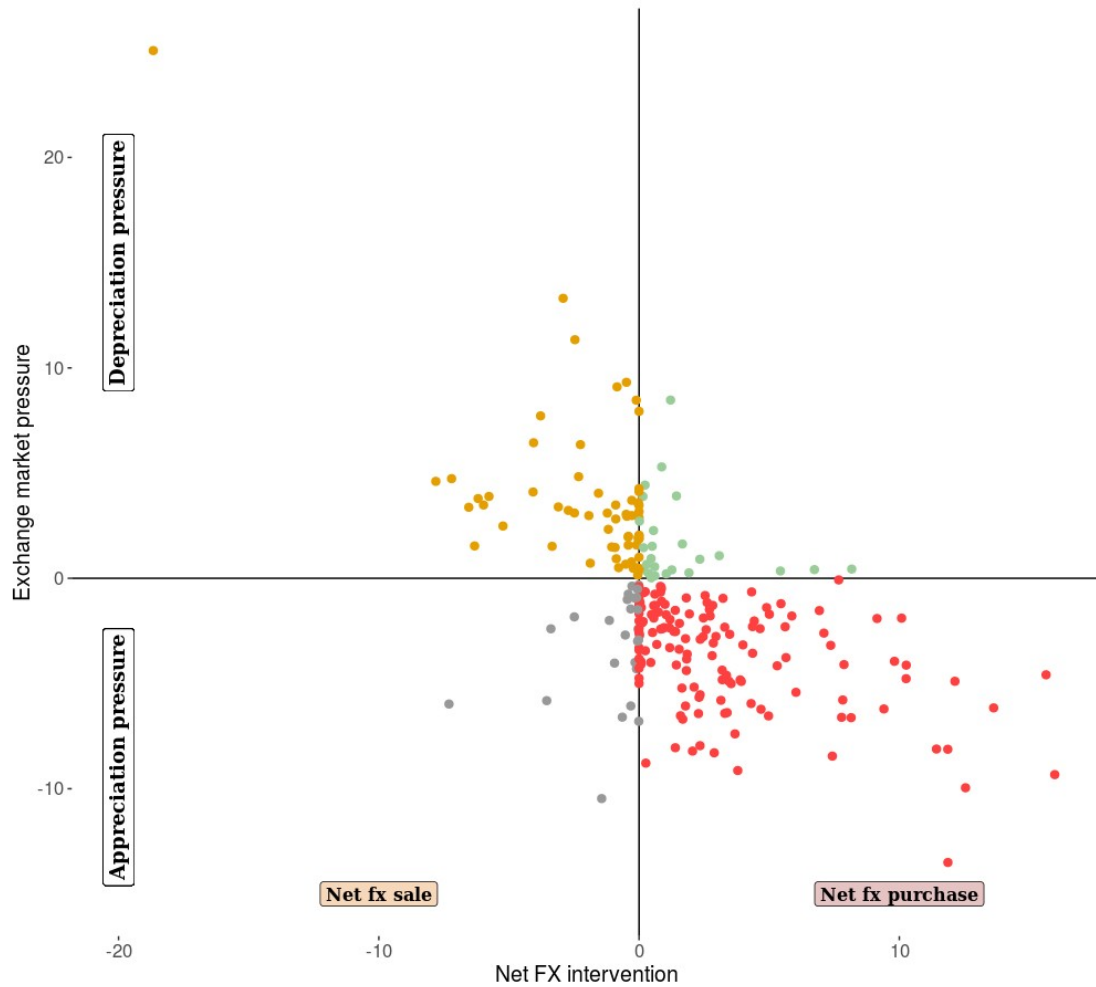
Note: This is a four qudrant graph plotting the monthly net forex intervention by the RBI against the EMP index. Source: RBI database and authors' calculations.

4. Understanding the regime transitions

In this section we delve deeper into the transitions from one ERR to the another to throw some light on the underlying macroeconomic conditions. While it is difficult to exactly pinpoint the factors that cause regime changes, we provide a descriptive analysis of the events leading up to a regime transition. The idea here is that the manner in which EMP was managed in one regime vs. the other, might have been a function of the underlying macroeconomic conditions or shocks faced by the economy during the transition periods.

Figure 10: Exchange rate regimes and Foreign exchange reserves
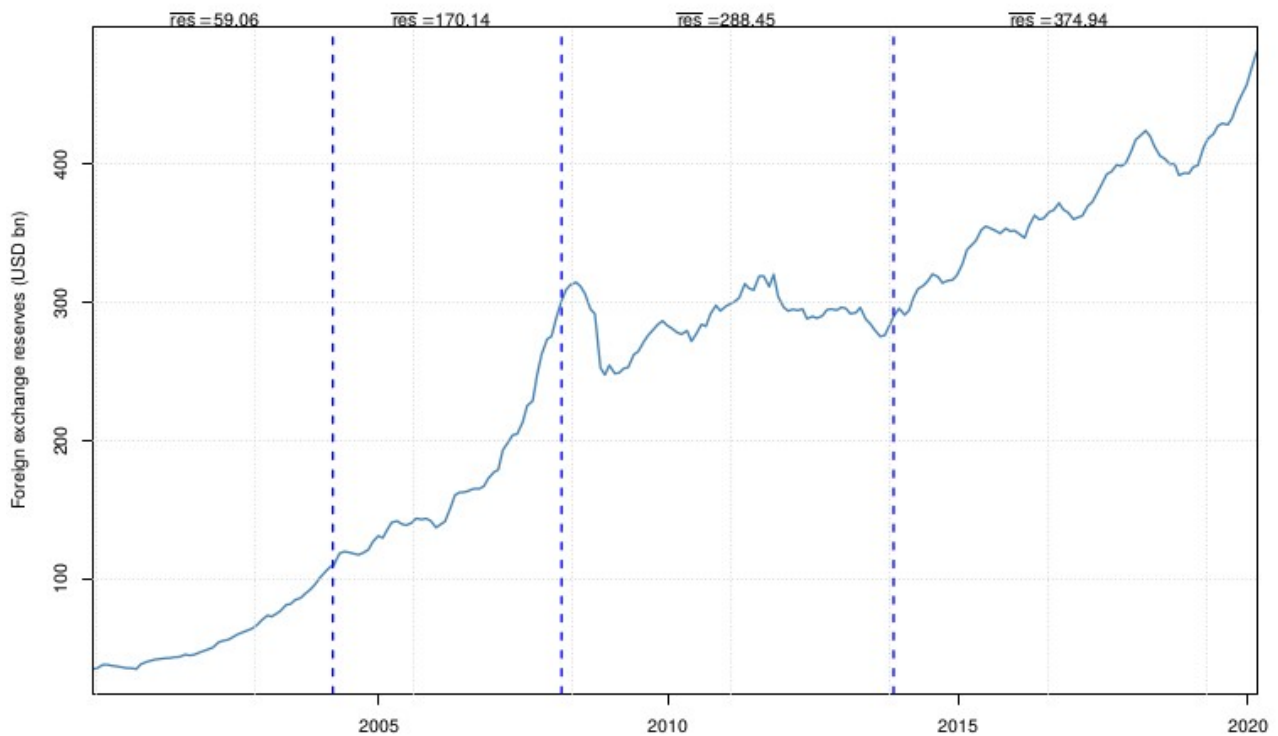
Note: This graph plots the level of the foreign exchange reserves held by the RBI, across the different exchange rate regimes. The average value of the reserves in each regime has been mentioned at the top of the graph. Data is obtained from RBI database.

We primarily analyse the transisitons across the regimes from the perspective of changes in capital flows, resultant changes in EMP and how this was subsequently managed by the central bank. As discussed in Ilzetzki et al (2017), forex intervention and reserves accumulation by countries since early 2000s has much to do with the desire to stabilise

exchange rates in an environment of increased capital market integration.[10] Figure (10) shows the evolution during our sample period of the forex reserves holding of the RBI across the four ERR.

4.1. Transition to regime 2 (March 2004)

The transition from regime 1 to regime 2 was shaped by the depletion of government bonds on the RBI's balance sheet towards the beginning of 2004, thereby hampering the process of sterilisation of the RBI's net dollar purchases in the forex market.

During the first exchange rate regime (Jan 2000 to March 2004), the Indian economy received a total capital inflow of roughly $220 billion and witnessed an outflow of $175 billion. The net capital inflows led to appreciation pressure as reported in Table (2). This in turn caused the RBI to intervene in the forex market and conduct an aggregate net purchase of dollars of $58.2 billion. Reserves went up sharply from $34 billion in 2000 to $110 billion by early 2004 registering an average annual growth rate of around 33%, the highest in our sample period. Most of this forex intervention by the central bank was sterilised as a result of which inflation could be kept insulated from the consequences of RBI's reserve accumulation.

The purchase of dollars and full sterilisation by the RBI had led the market participants to believe that once the stock of government bonds on the RBI's balance sheet was exhausted, RBI would stop buying dollars as it would not want to do unsterilised intervention lest it fuels inflationary pressures. As a consequence, when that happened i.e. when the RBI indeed ran out of government bonds, the rupee would appreciate. This further pushed up the level of capital flows into India as foreign investors believed that the rupee was a one way bet.

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10 While we describe what the various regimes in India were during our period of study, we do not go into the potential rationale behind the central bank's actions, for example we are not trying to explain why the RBI let the rupee depreciate in 2008-2013 or why the RBI attempted to prevent an appreciation in the 2013-2020 period. This maybe taken up in future research.

As a result, the pressure on the currency to appreciate continued unabated and the RBI did not stop buying dollars either. In 2004, a new arrangement for sterilisation of forex intervention was put in place. Under this system, the RBI could continue to peg to the USD, buy dollars and sell Market Stabilisation Scheme (MSS) bonds whose sole purpose was sterilisation. This allowed the RBI to continue its purchase of dollars without worrying about how to sterilise them.

4.2. Transition to regime 3 (March 2008)

In March 2008, Bear Sterns in the US had a liquidity crisis. These were the first signs of trouble in the US financial system that eventually led up to the Global Financial Crisis culminating in the collape of Lehman Brothers in September 2008. For emerging economies like India this was the beginning of pressure on the currency to depreciate. Net capital inflows fell sharply by 93%, from $106 billion in 2007-08 to a mere $7 billion in 2008-09. The average EMP went from an appreciation pressure of -5.8% in 2007 to a depreciation pressure of roughly 2.6% in 2008 in response to the massive capital outflows. The ERR turned from one of a pegged rupee that was not being allowed to appreciate to one that was much more volatile with RBI permitting it to depreciate.

4.3. Transition to regime 4 (November, 2013)

The exchange rate transitioned to the fourth and last regime in November 2013. The events leading up to this date may help throw some light on the transition. In May 2013 the erstwhile Federal Reserve Chair Ben Bernanke announced that the US Fed would soon commence tightening of monetary policy and would taper the quantitative easing program that had been initiated in the aftermath of the 2008 crisis. This episode was widely known as the 'taper tantrum'. In response to this announcement the US 10 year yield went up drastically which in turn triggered massive capital outflows from emerging market economies including India. India's net capital inflows nearly halved from $89.3 billion in 2012-13 to $48.8 billion in 2013-14. This was the second biggest decline in net inflows in

our sample period, the largest being during the 2008 Global Financial Crisis. This resulted in a sharp currency depreciation.

In April 2013, the EMP value for India was -2.58% indicating pressure on the currency to apppreciate. This increased to 8.46% in May 2013, implying a strong pressure on the rupee to depreciate. The average EMP for the period Jan-April 2013 was -0.55% while the average EMP for the next four month period from May to August 2013 increased to 7.41%. In fact, if we ignore the turbulent period of the 2008 Global Financial Crisis, August 2013 witnessed the highest depreciation pressure on the rupee in our sample. Figure 1 shows the sharp increase in currency volatility during this period. Volatility went up from 6.8% in May 2013 to 28.2% by September 2013, once again the highest in our sample period. This goes on to show the kind of pressure and volatility experienced by the rupee-dollar exchange rate towards the end of regime 3.

The RBI and the government responded to the sharp and rising depreciation pressure on the Rupee, in the immediate aftermath of the tapering announcement, in multiple ways. These involved restrictions on the currency derivatives markets, a series of steps by the RBI to squeeze liquidity in the banking system and raise short-term interest rates, tariff hikes, restrictions on gold and silver imports, tightening of capital controls to discourage capital outflows by firms and households, increasing investment limits for foreign institutitonal investors, liberalising external commercial borrowing by Indian firms and so on.

The 91-day Treasury Bill rate which is a reasonable proxy for the overall monetary policy stance went up from roughly 7.5% in May 2013 to 12% in October 2013, a dramatic increase of 440 basis points. At the same time however the RBI did not actively intervene in the forex market to defend the rupee. Between May and October 2013, it sold a net amount of only $10 billion in the spot market. In other words, the Rupee defense was carried out mostly through monetary policy and capital controls.

It seems that after a prolonged period of minimal intervention to stabilise the currency (2008-2013), the measures undertaken in the wake of the taper tantrum episode to reduce liquidity in the system and defend the exchange rate may have triggered a change in the

ERR. As shown in Figure 1 earlier, from 2013 December onwards, the average volatility of the currency came down from 8.6% to 5% indicating a more managed exchange rate.

5. Pandemic and beyond

During the period of the Covid-19 pandemic (March 2020 to March 2021), specifically in the April-June and July-September quarters of 2020, India witnessed a current account surplus after 17 years of deficit. Exports from India are expected to rise going forward as the US economy and world trade recover from the shock imposed by the pandemic. In addition, India remained an attractive investment destination with both foreign direct investment (FDI) and foreign portfolio investment (FPI) flows coming into India.

Between March 2020 and February 2021, the average EMP was -1.95% implying that the rupee faced an appreciation pressure, whereas on average the rupee appreciated only by 0.2%.[11] RBI did an aggregate net purchase of $70 billion during this period, presumably to reduce the extent of rupee appreciation. Foreign exchange reserves went up from roughly $475 billion in March 2020 to close to $580 billion by March 2021. Our estimation of ERR shows that the pandemic period was a part of regime 4 which started in November 2013. In other words, the trend of the RBI intervening in the forex market to buy dollars and to manage the EMP by reducing currency appreciation continued during the pandemic.

With the opening up of the trade and the capital accounts, the currency market has grown very large.[12] Old solutions, like buying a few billion dollars to prevent appreciation, or selling a few billions from the central bank's reserves to prevent a currency depreciation may no longer work. Moreover the Indian economy is struggling to recover from the adverse impact of the Covid-19 pandemic which has dealt a severe blow to economic growth. If in the event of an external shock (such as the US Fed announcing a tightening of

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11   The EMP index constructed in Patnaik et al (2017) extends from January 2000 to April 2021.

12 The gross turnover in the currency spot market in January 2000 was roughly $2.34 billion (total dollar sale and purchase by the RBI). This had gone up to $47.92 billion by February 2021. This only captures trading by the central bank.

monetary policy, similar to the 2013 taper tantrum episode) and the consequent rupee depreciation against the dollar, the RBI attempts to defend the currency either by tightening liquidity in the domestic financial system or raising interest rates to discourage capital outflows, this may hamper the growth recovery process. The RBI would need to weigh the pros and cons of a currency defense strategy especially from a medium term perspective, before embarking on a drive to prevent the rupee from depreciating.

6. Conclusion

The research on *de-facto* exchange rate regimes is an evolving field. In this paper we have tried to understand India's exchange rate regime using the techniques developed in the field in recent years. The *de-facto* exchange rate regime literature is limited in that while it uses observed data on exchange rates, it is unable to integrate this behaviour with the policy intentions of the central bank. We therefore use the techniques developed in the Exchange Market Pressure literature to understand how the pressure on the exchange rate is absorbed, through forex interventions, or relieved through the movements of the exchange rate. This brings into the analysis the exchange rate policy of the central bank.

We find 4 periods in India's *de-facto* ERR. Among these, we find that there was one regime (2008-2013) inwhich the rupee faced a pressure to depreciate and it was a period of relatively high volatility of the rupee. The other 3 periods saw pressure on the rupee to appreciate and relatively low volatility of the rupee. In these periods RBI accumulated reserves. We also provide some evidence that the RBI has been intervening in the forex market in an asymmetric fashion to prevent the rupee from appreciating.

In this paper we have not been able to measure the role of monetary policy (Goldberg and Krogstrup, 2018) or of capital controls (Akram and Byrne, 2015). The techniques for measuring these in absorbing exchange market pressure are still evolving. This is thus an agenda for future research.

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