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Determination of official intervention: Insights from India

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***ABSTRACT**--During the past 25 years, Reserve Bank of India has often intervened in foreign exchange market. The magnitude and frequency of its interventions have varied widely. This study developed a central bank reaction function that renders it feasible to examine the determinants of spot market interventions. The study employed a bivariate Probit model to examine the intervention policy of the Reserve Bank of India in the INR/U.S. Dollar market during the period from April 1995 to March 2019. The result shows that trend deviation, exchange rate volatility, market liquidity and 'leaning against the wind' policy stimulate spot market purchase and sale intervention. Deviation of the trade weighted REER stimulates spot market purchase whereas a divergent of export weighted REER triggers sale intervention to maintain the equilibrium level. The study also found that accumulation of foreign exchange reserve is the by-product of intervention, not a policy outcome.*

***Key Words**-- Central Bank Intervention,Determinants of Intervention, Exchange Rate, Central Bank Reaction Functions, India.JEL Classification: E44, E58,F31.*

I. INTRODUCTION

Sterilised foreign exchange intervention is frequently utilised as an instrument to manage exchange rate movements in Emerging Market Economies (EMEs). Interventions are primarily directed to 'calm a disorderly market' by dampening exchange rate volatility and to targetexchange rate level. Central banks often intervene in the foreign exchange market, even after adopting a market-oriented exchange rate regime. Thus, it is not surprising thata significant number of studies has analysed the reasons that led central banks to intervene in foreign exchange markets.

Most central banks have officially acknowledged in the past that volatility management is one of the prime motives of intervention. However, Bank for International Settlement (BIS) (2005) survey report showed that they have some hidden motives as well. Mihaljek (2005)argued that there is a drastic decline in the intervention operations by central banks over a period of time which reveals that the level of volatility tolerance has increased. This elasticity in the exchange rate mainly owes to macroeconomic and financial market development through proper management of short-term exchange rate pass-through effect on inflation. Similarly, some researchers argued that floating exchange rate has an advantage of preventing overvaluation of domestic currency and helps to safeguard economy from consequential financial vulnerabilities (Akinci, Çulha, Ozlale, & Ahnbeyolu, 2005; Gregorio & Tokman, 2004). Another reason for a decline in intervention is the high cost of

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intervention and sterilisation. Both direct and indirect interventions hinder the process of stabilising speculation and thus it slows down the foreign exchange market growth. Some researchers point out that this is a significant reason why central banks from industrialised economies exercise minimum intervention practices (Morgan, 2009).

In the EMEs, foreign exchange markets are thin with a high degree of uncertainty and information asymmetry. The dominance of the central bank in the market as a market maker gives direction to the directionless market. As a regulatory authority, central bank is responsible for ensuring liquidity and reducing the bid-ask spread which creates market uncertainty. However, most often, central bank interventions in the EMEs are one-sided bets to protect domestic economic interest. In case of economies with high debt, weak financial sector and considerable currency mismatchvulnerabilities in the foreign exchange market are high. Thus, it can be inferred that lack of market intensity is one of the main reasons for intervention in India. Empirical and theoretical studies highlighted various immediate and medium to long-term objectives of interventions.

Intervention objectives of a central bank could vary withtime (changed or interpreted in different ways at different times). They might have objectives meant for short-term, medium-term and long-term depending on the prevailing economic condition and the central bank's policy preferences. Moreover, an independent intervention decision may not be for a short-term or only to correct severe diversion of exchange rate without the support of economic fundamentals (Almekinders & Eijffinger, 1994). For instance, Bank of Japan (BoJ) intervention before June 1995 was following a 'leaning against the wind' policy, but post-1995, interventions followed a 'leaning with the wind' policy. It also changed the strategy from small, frequent interventions to bulky, infrequent interventions during this period. But this conditionally varying nature of intervention motives is not always revealed to the other market participants.

II. LITERATURE REVIEW

Theoretical literature and survey of BIS (2005) highlighted multiple determinants of interventions. They can be classified as determinants derived from the general economic conditions and those specific to the foreign exchange market. These factors generally exist simultaneously. For instance, intervention to maintain external competitiveness of Rupee is derived from the general economic condition, but such an intervention is necessary because of the overvaluation of Rupee. Similarly, some of the factors trigger immediate intervention whereas some factors may need only a less quick reaction in the foreign exchange market. For instance,if exchange rate volatility management is the primary motive, it demands immediate interventions. But intervention with an intention to accumulate reserve will be slow-paced even if it is the primary motive.

surveyed central bank officials and official documents to identify different motives of interventions. In addition to that, BIS conducted an extensive survey on motives and effectiveness of intervention in the EMEs during 2005 and 2013. All these surveys showed that curbing exchange rate volatility is the prime motive of intervention in emerging and industrialised economies. However, correcting exchange rate misalignment is also one of the widely useddeterminants of intervention by central banks from emerging economies(Akinci et al., 2005; Herrera & Ozbay, 2005; Ito & Yabu, 2007; S. Kim & Sheen, 2002; Loiseau-Aslanidi, 2011; McKenzie, 2004). Their findings also supported the findings of BIS survey. Apart from the direct determinants, some

country specific unique determinants alsoprompt an intervention decision. For instance, interventions carried out by Bank of Zambia had a direct connection with copper price because about 90% of total foreign exchange earnings of Zambia was from copper export only(Chipili, 2014).

Researchers have examined intervention practices among industrialised and emerging economies to assess the status of rectification of exchange rate misalignment as the primary motives of intervention. For instance, studies examined the determinants ofintervention in case of Australia(Kim & Sheen, 2002), Japan, Germany and the USA(Almekinders & Eijffinger, 1996; Kim & Sheen, 2006; Sarno, Taylor, & Frankel, 2003) found that these countries intervene with an objective of rectifying exchange rate misalignment. ÖzIü & Prokhorov (2008)discovered thatrectification of exchange rate misalignment was one of the key determinants of Turkish intervention. While examining the Georgian case,Loiseau-Aslanidi (2011) detected a similar trend. Malloy's(2013) investigation on determinants of intervention in the EMEs found that deviation from a predetermined trend (monthly or daily or weekly moving average of exchange rate) triggered intervention. Similar results weredocumented by Tashu (2014)in case of Central Reserve Bank of Peru. Central Banks try to minimise market misalignment or to bring it into the perceived equilibrium level.

Researchers like Obstfeld, Shambaugh, & Taylor (2010) and Bastourre, Carrera, & Ibarlucia (2009) argued that capital account and current account vulnerabilities stimulate central banks to intervene in the foreign exchange market.Exposure to current and capital accounts motivate central banks to accumulate foreign exchange reserve (Ghosh, Ostry, & Tsangarides, 2017). However, these motives are not constant as they exclusively depend on the economic and financial conditions exist in the economy.

profitability is one of the elements to measure the credibility of the central bank as an economic institution and it is necessary for its autonomy. Thus,researchers argued that profitability is also one of the determining factors of intervention, especially in industrialised economies (See Ito, 2003; Kim & Sheen, 2002). Correcting exchange rate misalignment and curbing uncertainty have an inevitable impact on profitability because of the counterproductive behaviour of market participants (Neely, 1998; Szakmary & Mathur, 1997). Kim & Sheen (2002)argued that the possibility of incurring loss isa potential constraint of intervention. This fear of loss could be one of the reasons why central banks in the EMEsshow asymmetrical behaviour in intervention operations. Preventing appreciation provides the dual benefit of maintaining currency competitiveness and accumulating foreign reserves.

The declared objective of RBI intervention is to curb excessive volatility without targeting any specific exchange rate level due to higher levels of market uncertainty. Being the monetary authority inan emerging economy with a flexible exchange rate regime, RBI is only concentrated in calming the market by reducing uncertainty. However,BIS (2005, 2013) survey noted that most of the central banks have multiple objectives of intervention which exist simultaneously. Those objectives are less transparent. Thus, this study is an attempt to address the gap in the existing literature about different determinants of central bank intervention in India.

III. DATA AND METHODOLOGY

Determinants of interventions are estimatedbased on the theoretical framework of central bank reaction function. Ito (2003) developed an empirical model of linear reaction function to estimate the central bank reaction function. It is described as:

$$INT_t = \alpha_0 + \alpha_1 \Delta InS_t + \alpha_2 (InS_t - S_t^T) + \beta X_t + \varepsilon_t \qquad (1)$$

$$\varepsilon_t \sim i.i.d$$

Where INT_t is the intervention at the time t. A positive value $INT_t>0$ is a purchase intervention and $INT_t<0$ represents sale intervention. S_t is the spot exchange rate at a time t and S_t^T is the targeted exchange rate (equilibrium exchange rate extracted from Purchasing Power Parity or calculated by moving average of foreign exchange rate in the past), exchange rate is represented by home currency price per foreign currency. Δ is the first difference operator and X_t is the vector of other factors triggering intervention (like reserve accumulation, lagged intervention, interest rate differential) and ε is an error term.

In equation (1) the coefficient α_1 is expected to be negative as long as central bank follows the leaning against the wind policy. It tries to capture reaction of central bank towards a depreciating currency (centralbank defends depreciating domestic currency by selling foreign currency[4]). Coefficient $\alpha_2$reveals central bank's reaction towards the deviation of the exchange rate from its targeted level. It is expected to be negative because deviation from central parity or targeted level leads central bank to sell foreign currency to bring back exchange rate to the targeted level.

This study used a binary choice dependent variable as in Dhrymes (1986) which signifies the extent of the probability of purchase and sale intervention. There are two reasons for choosing a bivariate Probit model. Firstly, many scholars argue that using Ordinary Least Square (OLS) framework in the presence of non-linearity and clustering of intervention data may lead to inconsistent results and may violate the normality assumptions of errors of OLS estimators. Using a bivariateProbit model helps to overcome the limitations of OLS estimators because the study constructed a binary dependent variable (1, 0) which is similar to the dummy variable. Bivariate Probit model can be used for simultaneous estimation of motives of purchase and sale intervention.

To estimate the different motives of RBI intervention, this study adapted the empirical model developed byKim & Sheen (2002).For this purpose, the binary choice variable was generated corresponding to outcomes ofboth purchase and sale of intervention. After considering the explicit and implicit intervention objectives of RBI, the basic model is modified according to the following form:

$$Prob\,(INT_{s,t} = 1|FX) = f(a_0 + a_1(S_t - S_t^T) + a_2 \Delta S_t + a_3 VOL_t + \cdots + a_n X_t) \qquad (2)$$

[4]A positive coefficient of α_1 indicates that the central bank follows a strategy of leaning with the wind, which aims to accelerate the speed of exchange rate movement. Edison (1993) argued that such reactions are exceptional, rather than rule based. But Japanese intervention reaction function shows that post-Sakakibara episode of leaning with the wind was rule-based. Whenever Yen depreciated, Bank of Japan intervened through purchase of foreign exchange, rather than selling US Dollar.

INT is a dummy variable that sets the value 1 in the presence of either purchase or sale intervention and 0 otherwise. FX indicates the variable which includes the volatility, long term trend deviation, leaning against the wind and other possible determinants.

For estimating the determinants of RBI intervention, this study modified the equation (2) into the following form.

$$INT_t^{Purchase} = a_0 + a_1(S_t - S_t^T) + a_2\Delta S_t + a_3 Volatility_t + a_4 DEREER_t + a_5 DTREER_t + a_6 Liquidity_t + a_7 Reserve_t + a_8 Cost_{t-1} + \varepsilon_t \quad (3)$$

$$INT_t^{sale} = b_0 + b_1(S_t - S_t^T) + b_2\Delta S_t + b_3 Volatility_t + b_4 DEREER_t + b_5 DTREER_t + b_6 Liquidity_t + b_7 Reserve_t + b_8 Cost_{t-1} + \varepsilon_t \quad (4)$$

$S_t - S_t^T$ indicates the deviation of exchange rate from its target level. Since RBI does not explicitly target any specific exchange rate level, study considers three monthly moving average as the target level.

$$S_t - S_t^T = \frac{S_t - \sum_{i=1}^{3} S_{t-i}}{3} \quad (5)$$

S_t is the exchange rate (i.e Rupee per unit of US$) and S_{t-1} measures the instances of using leaning against the wind policy. $Volatility$ is measured as the three-monthly moving average of the standard deviation of the daily exchange rate. DEREERand DTREER representdeviation of the export weighted and tradeweighted REER from 100.Liquidity measures the difference in the supply-demand mismatch in the merchant segment of the foreign exchange market.Reserve is the level of foreign exchange reserve of RBI.

Determinants of Spot Market Intervention

Estimated result of the bivariate Probit model is reported in table (1). The estimation is focused on the primary determinants of purchase and sale interventions in the spot market.

Table 1. Determinants of Spot Intervention

Variable	Coefficient	Std. Error	z	p-value
Spot Purchase				
const	8.44129	2.00569	4.209	0.0001
$S_t - S_t^T$	−0.252744	0.187509	−1.348	0.0777
ΔS_t	−0.0528327	0.0755849	−0.6990	0.0846
$Volatility_t$	1.04491	0.477554	2.188	0.0287
$DEREER_t$	−16.3887	9.12096	−1.797	0.0724
$DTREER_t$	23.6358	10.6373	2.222	0.0263
$Liquidity_t$	3.33245	1.21730	2.738	0.0062
$Reserve_t$	−0.793759	0.173648	−4.571	0.0001
Spot Sales				
const	4.00502	1.83829	2.179	0.0294

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$S_t - S_t^T$	0.353448	0.191056	1.850	0.0643
ΔS_t	0.0660444	0.0690450	0.9565	0.0388
Volatility_t	1.60161	0.478263	3.349	0.0008
DEREER_t	7.78531	7.56245	1.029	0.3033
DTREER_t	−3.74884	8.06371	−0.4649	0.6420
Liquidity_t	−2.63618	1.37219	−1.921	0.0547
Reserve_t	−0.438406	0.161714	−2.711	0.0067
Log-likelihood	−149.7277			
rho	0.855953			
Chi-square	25.9941	3.42464e-007		

Source: Author's calculation

Estimated results of the central bank reaction function with bivariate Probit model offer a Chi-square value 66.9523 (p-value 0.0000) which emphasise that the specified model is statistically significant. The estimated value of rho is 0.855953. Since it is positive and statistically significant, the model is validated.

The coefficient of exchange rate deviation shows expected sign, and it is statistically significant. Deviation of the Rupee exchange rate from the existing trend ($S_t - S_t^T < 0$: appreciation) decreased (increased) the probability of the purchase intervention. Whereas the deviation of the Rupee from its short-term trend ($S_t - S_t^T > 0$: depreciation) enhanced the probability of the sale intervention. It indicates that deviation of Rupee from its target level induced the probability of RBI's purchase (sale) intervention. The coefficient of the leaning against the wind (ΔS_t) shows that rapid depreciation of the Rupee triggered a sale intervention to reduce the speed. Thus, it can be argued that RBI intervention tried to prevent the appreciation pressure through spot purchase and the depreciation of Rupee encouraged a correction in the magnitude without correcting the existing trend.

The coefficient of volatility is positive in both sale and purchase intervention which indicates that RBI aggressively intervened in the foreign exchange market to curb volatility. It is a key objective of intervention as it potentially impacts the currency crisis. The coefficient of sale intervention is much higher than that of purchase. This points out that RBI aggressively used sale intervention over purchase intervention to curb market volatility. Uncertainty driven from the excess demand for US$ generates much noise in the market, and it keeps liquidity traders away. Moreover, supply demand volatility may not be persistent. So, RBI prefered to prevent demand driven volatility over the supply driven one. It can be assumed that a higher degree of exchange rate volatility enhanced the probability to increase the supply of foreign exchange in the market through intervention. The lower magnitude of the purchase indicates that withdrawing the liquidity from the market would intensify exchange rate volatility. However, large interventions (by size) are needed to manage the demand-driven volatility in an EME like India which has a massive trade deficit.

Over-valuation and under-valuation of Rupee based on REER also stimulated RBI interventions. Deviation of trade-weighted REER from 100 (over-valuation) induced purchase intervention to bring down the real exchange rate to equilibrium level. Similarly, under-valuation of the export-weighted REER stimulated RBI sale intervention to bring back the real exchange rate to equilibrium level. It can be assumed that RBI tried to keep the REER close to 100 for maintaining the external competitiveness of Rupee. Deviation of Trade-weighted

REER stimulated purchase intervention but not that ofexport-weighted REER, mainly owing to the methodological framework of developing these indices (weights given to the basket of currencies). Export weighted REER allocates more weight to US$ and Euro in contrast to the trade-weighted REER (Bhagwati, Barua, & Khan, 2015). Thisindicates that RBI would not be eager to depreciate over-valued Rupee against US$ and Euro.

Ensuring liquidity also triggers interventions in India, due to the deficiency of market depth. The coefficients of liquidity are significant in purchase and sale interventions. The positive coefficient of liquidity in the purchase equation indicates that RBI increased the intervention to absorb the excess liquidity in the market. This is in consonance with the argument of Rajan, (2016) that RBI never allows Rupee to appreciate only because of the capital inflow. Most often, excess market liquidity is a result of excess capital flow into the economy. During the period of liquidity shortage (supply-demand), RBI goes for sale intervention to ensure market liquidity.

The coefficient of foreign exchange reserve shows statistically significant negative coefficient for both purchase and sale interventions. It indicates that greater the size of foreign exchange reserve, lesser the probability of intervention. Central banks intervene in the market for accumulating reserves during the periods of shortage of reserves. Accelerated capital inflow after the subprime crisis and consequential purchase intervention to prevent the appreciation of the Rupee resulted in accumulating acolossal amount of foreign exchange reserves, which crossed the conventional required level of reserve in India. A higher level of foreign exchange reserve improves the macro-prudent position of the economy and ensures the exchange rate stability.

Determinants of Forward Market Intervention

Apart from spot market intervention, RBI also intervenes in the forward market for achieving some specific objectives. Ensuring liquidity in the market without an immediate impact on the domestic money supply is the key objective of forward intervention. Apart from volatility reduction, RBI also tries to minimise market misalignment or brings it into the perceived equilibrium exchange rate. For this, central bank needs to assess the existing market trend (long-term, medium-term and short-term trends). This study considered deviation from 3 monthly moving averages as short-run trend and deviation from 6 monthly averages as the medium-term trend. Since RBI never announced any intention to correct long-run exchange rate misalignments through intervention, this study selected only medium and short period misalignment.

The modified equation for the forward market intervention is described as:

$$FINT_t^{Purchase} = a_0 + a_1 Volatility_t + a_2(S_t - S_t^{3T}) + a_3(S_t - S_t^{6T}) + a_4 Liquidity_t + \varepsilon_t \quad (6)$$

$$FINT_t^{sale} = b_0 + b_1 Volatility_t + b_2(S_t - S_t^{3T})_t + b_3(S_t - S_t^{6T})_t + b_4 Liquidity_t + \varepsilon_t \quad (7)$$

Results of the bivariate Probit model for estimating central bank reaction function in the forward market shows a Chi-square value 70.1999 (p-value 0.0000) which validates that the specified model is statistically significant. The estimated value of rho is 0.891416. It is positive and statistically significant which validates the model.

The result of the equation (6 & 7) shows the determinants of forward market intervention in table (2). It can be observed that exchange rate volatility and market liquidity are the key influencing factors for purchase

intervention in the forward market. The potential benefit of forward market interventions is that it does not add immediate liquidity in the spot market but helps to ensure liquidity in the foreign exchange market.

Table 2 Determinants of Forward Market Intervention

Variable	Coefficient	Std. Error	z	p-value
Forward Purchase				
const	0.542335	0.165158	3.284	0.0010
$Volatility_t$	0.313963	0.406998	0.7714	0.0405
$(S_t - S_t^{3T})$	0.0234167	0.230982	0.1014	0.9192
$(S_t - S_t^{6T})$	0.106363	0.142457	0.7466	0.4553
$Liquidity_t$	0.767251	0.355224	2.160	0.0308
Forward Sales				
const	−0.0887204	0.154909	−0.5727	0.5668
$\mathrm{Volatility}_t$	0.619375	0.360317	1.719	0.0856
$(\mathrm{S}_t - \mathrm{S}_t^{3T})$	−0.528386	0.226121	−2.337	0.0195
$(\mathrm{S}_t - \mathrm{S}_t^{6T})$	0.501270	0.143283	3.498	0.0005
$\mathrm{Liquidity}_t$	0.0583978	0.303723	0.1923	0.0475
Log-likelihood	−205.3499			
rho =	0.891416			
Chi-square	70.1999	5.35885e-017		

Source: Author's calculation

In case of sale intervention, all the variables are significant including volatility, liquidity, short-run and long-run deviations of exchange rate. Deviation of the spot exchange rate from its three-monthly moving average (short-run deviation) and six-monthly moving average (medium-term deviation) also trigger forward market intervention. The sign of the coefficient of medium-term deviation is positive and significant. So, it can be assumed that RBI uses forward market intervention to correct long-term trend deviation rather than the short-run one.

IV. CONCLUSION

This paper examines the different determinants of RBI spot and forward market interventions with a bivariateProbit model. The result shows that trend deviation, exchange rate volatility, presence of a 'leaning against the wind' and market liquidity stimulate spot market purchase and sale intervention. Deviation of the trade-weighted REER stimulates spot market purchase, and sale interventions try to reduce the deviation of export weighted REER. Export weighted REER allocates more weight to US$ and Euro in contrast to trade-

weighted REER which makes RBI to target the former. The result shows that RBI is not interested in depreciating overvalued Rupee against US$ and Euro.

Reserve accumulation is not a primary objective of intervention. Hence it can be assumed that huge accumulation of foreign exchange reserve is a by-product of intervention, not a policy outcome. The results of forward market determinants show that forward purchase was triggered to ensure liquidity in the market. Curbing volatility was also one of the key determinants of forward purchase. Similarly, ensuring liquidity, curbing volatility and correcting the long-run trend deviations are the primary motives of forward sale. Based on the findings, we can conclude that RBI intervention aims to reduce market uncertainty.

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