WHAT DETERMINES FOREIGN EXCHANGE MARKET INTERVENTION IN AN EMERGING ECONOMY? 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 ofthe 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. Deviationof 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.

Keywords: Central Bank Intervention, Determinants of Intervention, Exchange Rate, Central Bank Reaction Functions, India.

INTRODUCTION

Sterilised foreign exchange intervention is frequently utilized 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 target exchange 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 that a 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 et al., 2005; Gregorio & Tokman, 2004).

In the EMEs, foreign exchange markets are thin with a high degree of uncertainty and

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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 mismatch vulnerabilities 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.

Liquidity in the foreign exchange market is one of the critical challenges in underdeveloped and developing economies. Central banks from developing and underdeveloped economies act as a market maker to minimise demand-supply gap or to prevent an excessive speculative attack. Through intervention, central banks help in *"price discovery"* or give a direction to the directionless market and save the market from a potential currency crisis. Central banks purchase foreign exchange when there is excess liquidity and sell foreign exchange in the illiquid market. RBI uses Non-Deliverable Forward (NDF) exclusively for ensuring liquidity in the spot market. It also uses *"Futures"* for ensuring liquidity during the period of considerable supply-demand mismatch. Similarly, during the periods of market uncertainty, RBI uses open foreign exchange swaps to meet the daily Dollar requirements of public sector oil marketing companies, as the payment for oil import has a considerable impact on Rupee depreciation. Using Special Market Operation, RBI tries to overcome this pressure up to an extent.

Intervention objectives of a central bank could vary with time (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. Thus, examining the motives of RBI intervention is a relevant exercise. This Study seeks to answer the following few questions in this regard:

1. What are the different motives of RBI intervention?
2. Does RBI support Rupee depreciation than appreciation?
3. Is reserve accumulation a by-product or objective of intervention?

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

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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.

Neely & Weller (2001) and Lecourt & Raymond (2006) 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 used determinants of intervention by central banks from emerging economies (Akinci et al., 2005; Herrera & Ozbay, 2005; Ito & Yabu, 2007; 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 also prompt 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 of intervention in case of Australia (Kim & Sheen, 2002), Japan, Germany and the USA (Almekinders & Eijffinger, 1996; Kim & Sheen, 2006) found that these countries intervene with an objective of rectifying exchange rate misalignment. ÖzIü & Prokhorov (2008) discovered that rectification 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 were documented by Tashu in case of Central Reserve Bank of Peru. Central Banks try to minimize market misalignment or to bring it into the perceived equilibrium level.

Researchers like Obstfeld et al. (2010) and Bastourre et al. (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 et al., 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 (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 is a potential constraint of intervention. This fear of loss could be one of the reasons why central banks in the EMEs show 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 in an 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

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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.

Central Bank Reaction Function

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

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

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

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 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 (central bank defends depreciating domestic currency by selling foreign currency). Coefficient α_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.

Methodology and Data

This study used a binary choice dependent variable as in Dhrymes (1986) which signifies the extentof 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 bivariate Probit 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 by (Kim & Sheen, 2002). For this purpose, the binary choice variable was generated

1. 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 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

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through purchase of foreign exchange, rather than selling US Dollar.

Corresponding to outcomes of both purchase and sale of intervention. After considering the explicit and implicit intervention objectives of RBI, the basic model is modified according to the followingform:

$$\text{Prob}\,(INT_{s,t}=1|FX)=f(a_0+a_1(S_t-S^T)+a_2\Delta S_t+a_3VOL_t+\cdots+a_nX_t) \quad (2)$$

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.

$$INT^{Purchase}_t = a_0+a_1(S_t-S^T)+a_2\Delta S_t+a_3Volatility_t+a_4DEREER_t + a_5DTREER_t+a_6Liquidity_t+a_7Reserve_t+a_8Cost_{t-1}+\varepsilon_t \quad (3)$$

$$INT^{sale}_t = b_0+b_1(S_t-S^T)+b_2\Delta S_t+b_3Volatility_t+b_4DEREER_t+b_5DTREER_t+ b_6Liquidity_t+b_7Reserve_t+b_8Cost_{t-1}+\varepsilon_t \quad (4)$$

S_t-S^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 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. DEREER and DTREER represent deviation of the export weighted and trade weighted REER from 100. Liquidity measures the difference in thesupply-demand mismatch in the merchant segment of the foreign exchange market. Reserve is thelevel of foreign exchange reserve of RBI.

$a_1<0$: Deviation of the exchange rate from its existing trend ($S_t-S^T<0$: appreciation) increases the probability of purchase of foreign currency assets.

$b_1>0$: Deviation of the exchange rate from its existing trend ($S_t - S^T > 0$: depreciation)

increases the probability of sale.

$a_2<0$, $b_2>0$ If the currency depreciates, central bank reduces the purchase intervention and/orincreases the sales intervention to reduce the speed of depreciation or

$a_2>0$, $b_2<0$ If the currency appreciates, central bank increases the purchase intervention toreduce the speed of appreciation or/and reduces the sales intervention

$a_3> 0$, $b_3>0$ increases exchange rate volatility which stimulates purchase and sale intervention.

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a_4,>0 : a_5>0 deviation of REER from its equilibrium level (REER >100: overvaluation)increases the probability of purchase of foreign currency assets.

b_4<0: b_5<0: deviation of the exchange rate from its equilibrium level ($REER$ <100: undervaluation) increases the probability of sale of foreign currency assets.

a_6 >0: excess liquidity increases the probability of intervention (supply-demand >0)

b_6 <0 illiquidity in the market enhances the probability of intervention (supply-demand < 0)

a_7<0:b_7<0 indicate that greater the size of reserve, lesser the probability of both purchase and sale intervention.

Following Chen et al. (2012), this study used deviation of the nominal exchange rate from its three-monthly moving averages (central parity) ($S_t - S^T$) for measuring the exchangerate misalignment. A positive (negative) value represents depreciation (appreciation) of nominal Rupee exchange rate. Appreciation of the currency triggers purchase intervention and depreciation stimulates a prompt response from the central bank to manage through sale intervention. It may not be necessary that central banks always target nominal exchange rate deviation. Some researchers argue that EMEs target Real Exchange rate rather than nominal one to maintain the competitiveness and external stability of the domestic currency (Berganza & Broto, 2012). Therefore, this study included two types of real exchange rate misalignments to understand the policy response of RBI. It calculated the deviation of RBI's Trade-Weighted Real Effective Exchange (TREER) Rate and Export weighted Real Effective Exchange Rate (EREER) by consider an index point of 100 as the equilibrium level. TREER and EREER are considered here for being the measure of trade and exporting competitiveness. If RBI targets trade competitiveness or export competitiveness, deviation of these indices from 1002 (central parity) induces intervention.

In a managed floating regime, reversing the existing trend is not an easy task. Hence, central banks support the existing trend but try to reduce the speed of exchange rate movement. This strategy of *'leaning against the wind'* is more practical and sustainable if the exchange rate moves far away from central bank's expectation. Such a policy can be measured by the behaviour of central banks towards exchange rate change (ΔS_t). The coefficient of leaning against the wind is expected to be negative, because the depreciation of domestic currency influences central banks to sell foreign currency (US$) to prevent the pace of depreciation. The coefficient is expected to be positive as the appreciation (depreciation) of Rupee triggers volatility.

Curbing exchange rate volatility is one of the most commonly stated objectives of intervention. Excessive volatility hampers market development and stops the liquidity traders from the market. As a central bank in an EME, RBI has clearly stated that curbing exchange rate volatility is the prime motive of intervention. Volatility can be estimated using market determined option pricing and time series methodology. Due to the non-availability of market-determined option price, three monthly moving average of the standard deviation of the daily exchange rate data is used for measuring volatility.

The objective of maintaining an adequate level of foreign exchange reserve also influences central bank's decision to intervene because it has a direct connection with the currency crisis. Reserve is an insurance against potential crisis and external vulnerabilities. It also helps to defend the excessive speculation in the foreign exchange market as the market participants take their positions depending on the available foreign exchange reserve because it is considered as the

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'potential gun powder' for a currency war. As a developing economy, reserve management is an integral part of exchange rate management. RBI used to intervene in the market with an insurance/precautionary motive, to maintain the desired level of foreign exchange reserve (Reddy, 2002). Thus, including the level of reserve in the model helps to understand whether the recent reserve accumulation by RBI is driven by a policy objective or is a result of asymmetric response driven from *'fear of appreciation'*.

As a lender of last resort, the central banks have to ensure liquidity for the smooth operations in the foreign exchange market. Lack of a depth in the market makes central banks the biggest player in the foreign exchange market of EMEs. Liquidity can be measured through the bid-ask spread or the demand-supply inequality in the market. Since it is challenging to get data on bid-ask spread, this study used demand-supply mismatch as suggested by (Dua & Ranjan, 2011).It is calculated by taking the difference between merchant segment's spot market purchase and sale transactions. Theoretically, it is argued that interventions are induced by excess demand- supply conditions.

Cost of intervention is also an essential part of intervention decision because it has a direct impact on central bank's income statement. Theoretically, it can be argued that central bank purchases foreign currency when it is cheap and sells it in a profitable market. Though profit making is not an objective of intervention, it has a crucial role in the intervention decision. A high cost of intervention may create a threat for the autonomy of the central bank. Thus central banks try to avoid losses from intervention operations. However, the cost of intervention should be examined in the context of the potential benefits it offers to different sectors in the entire economy. Its practical impossibility motivated researchers to estimate the potential opportunity cost (the cost incurred per dollar utilised in the total intervention operation) as a variable to represent the cost of intervention in the central bank reaction function. It covers both interest rate differences and valuation gain (loss). It assumes that higher cost demotivates RBI intervention, hence it expect a negative sign.

RESULT AND DISCUSSION

Determinants of Spot Market Intervention

Estimated result of the bivariate Probit model is reported in Table 1. The estimation is focused onthe 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				

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const	4.00502	1.83829	2.179	0.0294
$S_t - S^T_t$	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 (Melesse, 2014).

The coefficient of exchange rate deviation shows expected sign, and it is statistically significant. Deviation of the Rupee exchange rate from the existing trend ($S_t - S^T < 0$: appreciation) decreased (increased) the probability of the purchase intervention. Whereas the deviation of the Rupee from its short-term trend ($S_t - S^T > 0$: 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. These points out that RBI aggressively used saleintervention 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 of export-weighted REER, mainly owing to the

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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 et al., 2015). This indicates 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 a colossal 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.

High cost discouraged the purchase intervention, but it was not an essential cause of sale intervention. In the presence of multiple determinants, cost of intervention is not much significant though it has a strong influence on central bank's profitability. Moreover, the purchase interventions may be directed by the discretionary power of the decision-making authority whereas the sale intervention might be an unwanted one. Usually, it is executed only because of the pressure from the government. Kim & Sheen (2002) argued that during the periods of extreme turbulences, RBA simply observes the market instead of interfering in the price discovery. But in case of India, governments put pressure on RBI to intervene in the market for short-term benefit. Such type of interventions may not be supported by economic fundamentals and sometimes may contradict existing monetary policy. Thus, it forces RBI to neglect the cost of intervention during the periods of political pressure (Taylor, 1995).

Determinants of Forward Market Intervention

Apart from spot market intervention, RBI also intervenes in the forward market for achieving somespecific objectives. Ensuring liquidity in the market without an immediate impact on the domesticmoney 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-runtrend 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:

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

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$$FINTsale = b0 + b1Volatilityt + b2(St - S3T)\ t + b3\ (St - S6T)t + b4Liquidityt + \varepsilon t \quad (7)$$

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
$\frac{(S_t - S^{3T})}{t}$	0.0234167	0.230982	0.1014	0.9192
$\frac{(S_t - S^{6T})}{t}$	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
$Volatility_t$	0.619375	0.360317	1.719	0.0856
$\frac{(S_t - S^{3T})}{t}$	−0.528386	0.226121	−2.337	0.0195
$\frac{(S_t - S^{6T})}{t}$	0.501270	0.143283	3.498	0.0005
$Liquidity_t$	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.

The core determinants of intervention used in this study reveal that RBI secretly follows a 'fear of appreciation' trend derived from the external competitiveness of Rupee. Adoption of aggressive one-sided intervention and accumulation of foreign exchange reserve beyond the theoretically prescribed level provide clear evidence for the same. In a flexible exchange rate regime, it is difficult to maintain the exchange rate within the specific range. Thus, it is better to target external competitiveness only after ensuring enough support from macroeconomic fundamentals.

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Reserve Accumulation as an Objective or By-product

Like the central banks in other EMEs, RBI also accumulated substantial amount of reserve beyond the required level during the post-subprime crisis period. Similarly, there was also a tremendous increase in the asymmetric intervention operations of RBI during that period. By examining the dynamics between the characteristics of reserve accumulation and the import benchmark, the studyattempts to find out if the reserve accumulation during certain periods was a policy outcome or an intervention by-product. Since the accumulated reserves crossed the conventional yardsticks like average of three months import, this study considered "*Greenspan and Guidotti rule"* (reserve to short-term debt) and coverage for capital flight risk[3] (reserve to M3) for estimating the same.

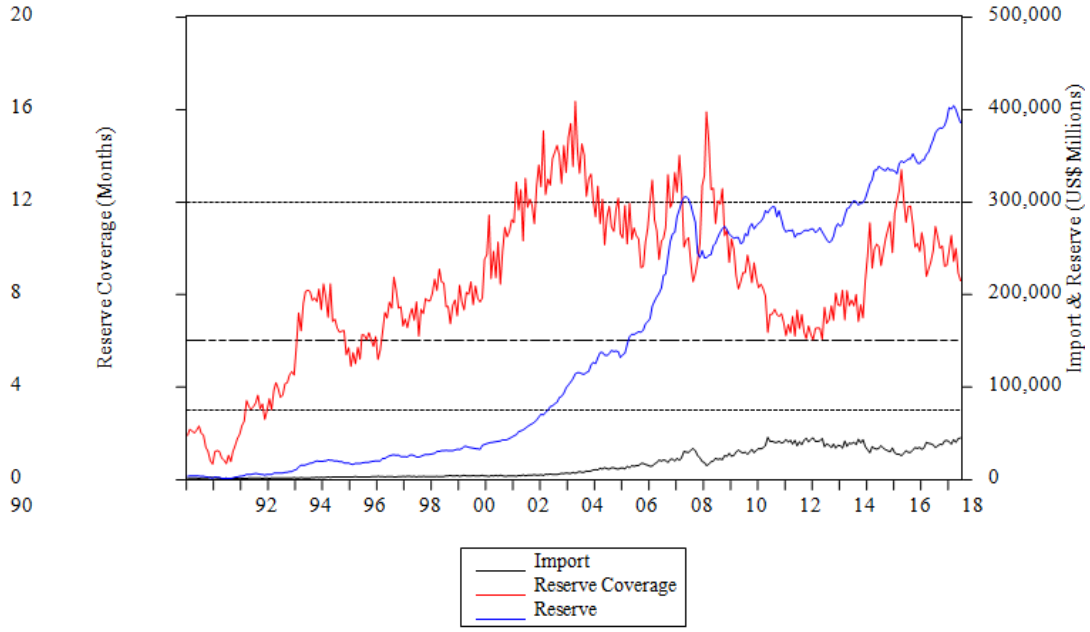

FIGURE 1
RESERVE TO MONTHS OF IMPORT

Data Source: RBI

Import coverage ratio of foreign exchange reserve is the most popular and conventional method of the precautionary motive of reserve requirement in an economy. According to this method, reserve coverage equivalent to expected import level for three months periods should be available (IMF, 2014). As per this rule, the country will be able to pay its next three months import even if the capital inflow or export receipt gets totally cut off. This three-month criterion may not the ratio of reserve to money is used to capture exposure of capital flight. As per IMF (2016), currency crisis was escorted by outflow of residents' deposits in the recent episodes which severely amplified the impact of crisis. So, monetary authorities should give special attention to this phenomenon.

Be adequate in the changing scenario, especially in a country like India which imports its necessarygoods from foreign countries. However, in the initial periods of floating regime, India's foreign exchange reserve was above three months coverage, but it was not in a stable position Figure 1. Post-Asian crisis witnessed a remarkable growth in import coverage ratio. In 2004, it

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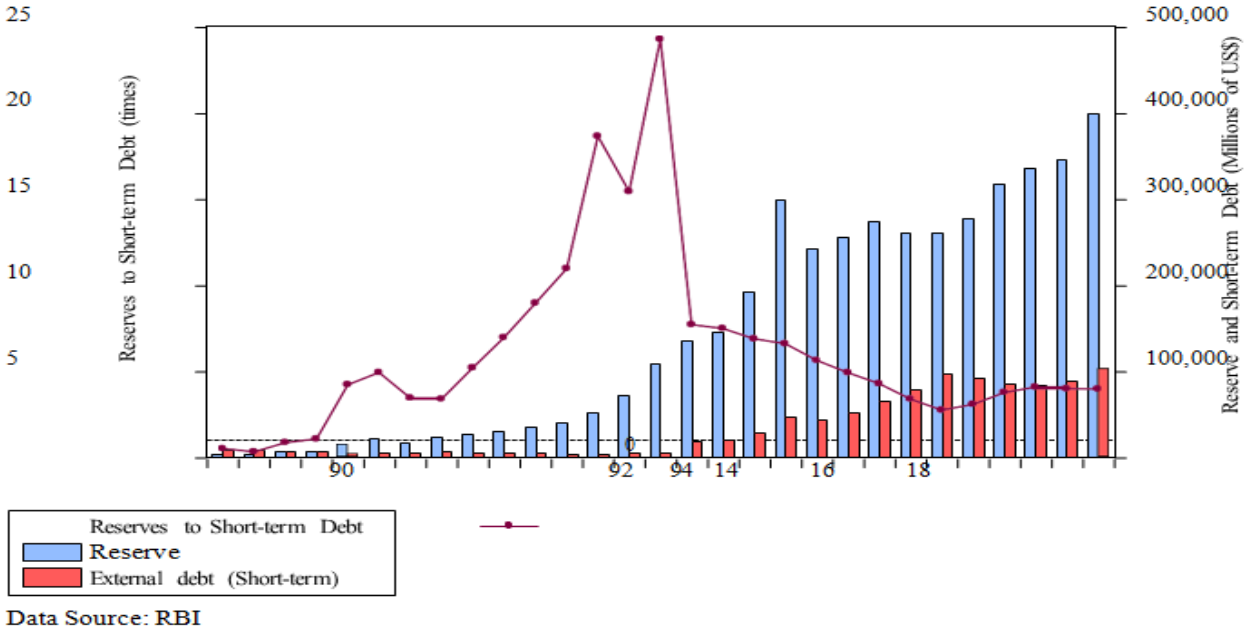
peaked withimport coverage for 16.4 months. But after the sub-prime crisis, this declined to six months coverage in January 2013. It is worth noting that after the implementation of floating regime, import coverage ratio of reserve never came down below the benchmark level. Similarly, it alwaysstayed above six months coverage after 1997. This clearly shows that the exclusive use of intervention to maintain an adequate level of reserve was never a policy objective.

Reserve to external debt ratio is another important criterion to assess the precautionary level of reserve. The sustainability of an economy is assessed based on its ability to withstand for a specific period without any form of borrowings (Jeanne, 2007). As per this criterion, a ratio above one (i.e., 100%) signifies the precautionary level of reserve. If the reserve to debt ratio goes below unity, central bank tries to refill the reserve at any cost. This ratio was always above unity in post- floating regime Figure 2. It reached at its peak in 2003-04 when there was enough reserve to cover 24 times of existing short-term debt due to lumpy capital inflow. In the post-subprime crisis period, irrespective of tremendous growth in reserve, reserve to short-term debt ratio decreased due to an increase in short-term debt. However, as per this criterion for precautionary motive, RBI's foreign exchange reserve was always above the benchmark level. Thus, fending off vulnerability to financial crisis is not a motive to accumulate foreign exchange reserve.



Data Source: RBI

FIGURE 2
RESERVE TO SHORT-TERM DEBT

The third measure of the level of adequate reserve is the level of reserve to the broad money. This measures central bank's ability to support its liability and maintain credibility. A higher ratio indicates a greater confidence of foreign investors (external drain) and the general public (internal drain). There is no benchmark value for the reserve to broad money ratio, but Wijnholds & Kapteyn (2001) suggested an accepted ratio of 5% to 20% per period. Following their argument, RBI's reserve level was always above 5% and it was above 20% between March 2003 to September 2009 Figure 3. Absence of such a security motive also reveals that reserve accumulation was a by-product of intervention.

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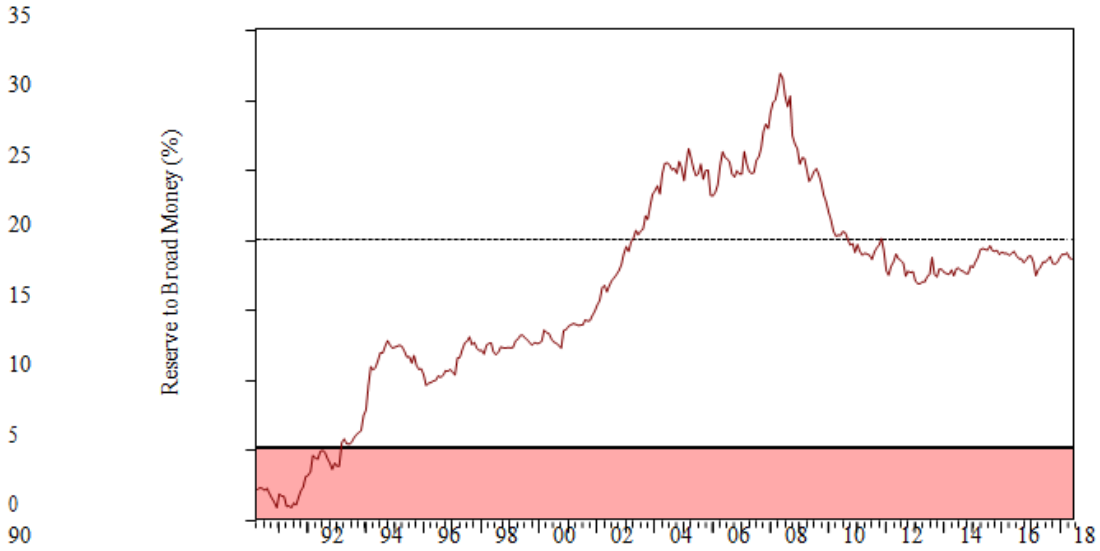

FIGURE 3
RESERVE TO M3

Interestingly, it can be observed that RBI's foreign exchange reserve level crossed the benchmark level such as reserve to short-term external debt, reserve to money (M3) and reserve to months of import during the period of heavy intervention. So, self-insurance (precautionary) motive only partially explains the reserve replenishment behaviour. But the rapid accumulation of reserve without adequate justification confirms that it is a by-product of *"fear of appreciation"* intervention, than an outcome of a policy objective.

These findings can be explained in multiple ways. Calvo et al. (2012)argued that *"fear of appreciation"* could be the reason for rapid reserve accumulation in EMEs even if there is no expected crisis in the economy. As per this argument, accumulation of a huge amount of reserve by RBI could be a by-product of their attempt to prevent the appreciation pressure on Rupee. Aizenman & Lee (2007) argued that developing economies hoard reserve for neo-mercantilist motives. RBI's accumulation of foreign reserve could be a developing strategy with a neo-mercantile motive to prevent potential loss of export and capital inflow. Following the arguments of Dooley et al. (2005), it can be assumed that slower development of financial market stimulates RBI to export their savings in the form of foreign exchange reserve and later bring back them through foreign capital. Here reserve acts as collateralfor promoting FDI.

Based on the descriptive analysis, it can be assumed that reserve accumulation during the post-Asian crisis may be driven by the precautionary motive. This self-insurance motive can be observed immediately after every financial crisis including the subprime crisis. Through reserve accumulation, central banks insure against unexpected capital reversal which may create a situation like Asian Currency crisis.

CONCLUSION

This paper examines the different determinants of RBI spot and forward market interventions witha bivariate Probit model. The result shows that trend deviation, exchange rate volatility, presence of a *'leaning against the wind'* and market liquidity stimulate spot market

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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 related to forward market determinants show that forward purchase was initiated to ensure liquidity in the market. The intention to curb volatility was also one of the key determinants of forward purchase. Similarly, ensuring liquidity, curbing volatility and correcting the long-run trend deviations were the primary motives of forward sale. Based on these findings, it can be concluded that the primary determinants of RBI intervention aim to reduce market uncertainty. However, this study focused more on determinants related to foreign exchange market. But including macroeconomic determinants would have yielded a clearer picture on their time-specific impact. Moreover, the present study did not consider the role of speculators, market microstructure and channels of intervention. These limitations shall be addressed by future studies.

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