*Forex Market Operations and Liquidity Management**

This article explains how forex market operations of the Reserve Bank of India alter domestic liquidity conditions, which are then modulated consistent with the stance of monetary policy. The Reserve Bank's intervention in the forex market is aimed at containing volatility. The attendant impact on liquidity conditions may necessitate durable liquidity absorption/injection operations by the Reserve Bank depending on the state of durable liquidity requirements of a growing economy at any point in time. The effectiveness of sterilised interventions, however, may occasionally become an issue for the independent conduct of monetary policy.

I. Introduction

The Reserve Bank of India's policy on the exchange rate of the rupee has been to allow it to be determined by market forces. It intervenes only to maintain orderly market conditions by containing excessive volatility in the exchange rate, without reference to any pre-determined level or band. In the absence of any intervention by the Reserve Bank in the foreign exchange market, surges and sudden stops in capital flows and the associated disorderly movements in the exchange rate can often have a deleterious impact on trade and investment, besides endangering overall macroeconomic and financial stability. Intervention in the foreign exchange market through purchase or sale of US dollars, however, could pose other challenges by altering domestic liquidity conditions; while purchases lead to injection, sales result in withdrawal of primary rupee liquidity from the system.[1] This requires pro-active management of liquidity consistent with the stance of monetary policy.

If liquidity injected due to forex operations is more than the requirement of a growing economy, excess liquidity may have to be neutralised or sterilised, *i.e.*, specific liquidity management measures may have to be undertaken to withdraw the excess surplus liquidity from the system, in consonance with the objectives of monetary policy. The need for pro-active liquidity management that takes into account the liquidity impact of interventions is best corroborated by the well-known "impossible trinity", according to which an independent conduct of monetary policy, a fixed exchange rate (or a managed exchange rate through interventions) and free cross border capital flows are simultaneously incompatible. This challenge for monetary policy becomes unavoidable irrespective of whether the central bank sterilises the liquidity impact of forex interventions. For example, if the excess liquidity injected through forex purchases is not sterilised (*i.e.*, non-sterilised interventions), then excess liquidity could drag down the operating target of monetary policy and other money market interest rates below the policy interest rate. Non-sterilised interventions, thus, could lead to a loss of control over interest rate, thereby undermining the effectiveness of monetary policy. By contrast, if surplus liquidity is sterilised, depending on the choice of instrument for absorption of liquidity, market interest rates may vary significantly from the desired levels that could be consistent with the stance of monetary policy. This results in greater capital flows, thus defeating the very objective of sterilisation. For example, when a central bank undertakes open market sale of government securities to absorb the surplus liquidity as a part of the sterilised intervention strategy, it could harden sovereign yields, which, in turn, could attract further debt inflows driven by higher interest rate differentials. Thus, sterilisation could amplify the original problem,

* This article is prepared by Janak Raj, Sitikantha Pattanaik, Indranil Bhattacharya and Abhilasha. The views expressed in the article are those of the authors and do not represent the views of the Reserve Bank of India. The authors are grateful to Dr. Amartya Lahiri for his useful comments that helped in refining the paper.

[1] More specifically, while spot market operations immediately alter domestic liquidity conditions, forward market interventions impact liquidity with a lag, *i.e.*, when the forward transactions mature or fall due for execution and are not rolled over.

thereby rendering sterilised interventions ineffective. Moreover, this risk intensifies as the magnitude of sterilisation increases. In this context, capital flows management measures (CFMs) could enhance the effectiveness of sterilised interventions to some extent. For instance, if portfolio investments in both government securities and corporate bonds are capped (as in India), additional portfolio inflows would not materialise even when sterilised intervention widens the yield differential.

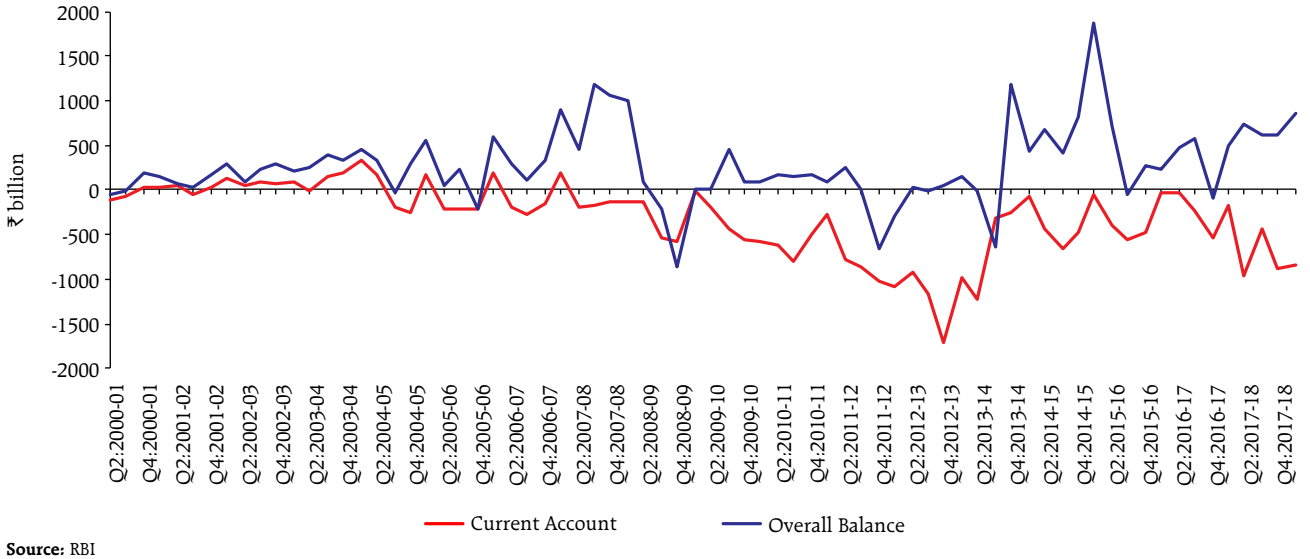
This paper presents in detail as to how the RBI's forex market interventions have impacted domestic liquidity conditions, and how they have been managed. The study is organised into five sections. Section II sets out the mechanics of forex market intervention, its consequences, and cross-country practices in managing the liquidity impact of such intervention through alternative instruments. Recent episodes of capital flows and their attendant challenges in the Indian context are discussed in Section III, while the effectiveness of sterilised intervention is empirically assessed in Section IV. Concluding observations are presented in Section V.

II. Capital Flows and Forex Market Interventions in India

Since the onset of external sector reforms in the early 1990s and with the progressive deregulation of the capital account, India has experienced episodes of surges in capital inflows and sporadic sudden stops/reversals. Theoretically, while capital inflows are required to finance a sustainable current account deficit in an *ex ante* sense, capital inflows, however, have often exceeded the financing requirement, driven by favourable interest rate differentials and/or more promising growth outlook, leading to an overall surplus position in the balance of payments in most years (Chart 1). Given the objective of avoiding disruptive excess volatility in the exchange rate of the rupee, RBI's intervention through purchases led to an accretion in foreign exchange reserves.

In an integrated global financial system, capital inflows pose multiple challenges for overall macroeconomic management. While there are several available tools – ranging from (i) forex market intervention; (ii) fiscal/monetary policy measures; (iii) macro-prudential regulations; and (iv) imposition

Chart 1: External Sector Balance



Source: RBI

of capital controls – to moderate the impact of such inflows, the moot issue is about managing the trade-offs while deploying these instruments either individually or in some optimal mix. This paper, however, solely focusses on forex market intervention and its impact on domestic liquidity conditions.

When a central bank purchases foreign currency, its net foreign assets (NFA) increase, resulting in expansion of primary liquidity or reserve money (RM) (Table 1). In this context, it is important to assess whether the increase in RM resulting from an increase in NFA is: (a) consistent with the required increase in RM during the year, in which case no sterilisation may be necessary; (b) higher than the required increase in RM, thereby necessitating sterilisation; and (c) less than the required increase in RM in which case the central bank may have to inject liquidity over and above what is already injected through intervention.

Unsterilised intervention on a continuous basis can lead to a surfeit of liquidity with attendant implications for inflation, which, in turn, could result in hikes in the policy interest rate. Such hikes may, however, widen the interest rate differential, thereby triggering further inflows. Thus, unsterilised interventions often defeat the very objective of intervention; hence, central banks generally conduct sterilisation operations to neutralise the monetary impact of its operations in the foreign exchange market. Sterilised intervention through open market purchase of securities, however, also keeps interest rates elevated in the economy, as alluded to earlier. There are also limits to intervention operations as central banks may be constrained by the availability of government securities for sterilisation. As a result, several other instruments have been used by most central banks with varying degree of effectiveness (Table 2).

Table 1: Drivers of Primary Money Creation in the Economy

Assets	Liabilities
Net foreign assets (NFA)	Currency (C)
Net domestic assets (NDA)	Required and excess reserves as deposits (D)
Reserve money = (C+D) = (NFA+NDA)	

Note: Non-monetary liabilities are assumed as zero here for the purpose of keeping the analysis simple.

Table 2: Sterilisation Instruments

(Response of 21 central banks, 1-highest score; 3- lowest score)

Instrument	Number of central banks using the instrument	Assessment								
		Highly Effective			Low Cost			Beneficial to overall market development		
		1	2	3	1	2	3	1	2	3
Market -based										
Central bank securities	15	14	1	0	4	7	3	11	4	0
FX swaps	7	2	4	0	4	2	0	3	3	0
Government bonds	6	1	3	1	2	1	2	5	0	0
(Reverse) repos/ uncollateralised borrowing and others	6	2	4	0	0	5	0	2	4	0
Non Market -based										
Reserve requirements	8	3	1	3	4	2	1	0	1	6
Government deposits	7	4	1	1	3	3	0	3	0	3
Special deposit facilities	2	0	0	1	1	0	0	0	0	1
Other (mostly bank deposits)	4	3	1	0	3	1	0	1	2	1
No sterilisation using monetary instruments	3									

Source: Reproduced from BIS (2013).

III. Forex Operations and Liquidity Management in India – Recent Episodes

As emphasised by the Report of the Expert Committee to Revise and Strengthen the Monetary Policy Framework (Chairman: Dr. Urjit R. Patel), the desirable evolution of the base money path (without rigid adherence to any base money rule) is a key component of the liquidity management strategy [Pillar II as distinct from Pillar I, which is about day to day liquidity management under the liquidity adjustment facility (LAF)]. For instance, increase in NFA in 2014-15 was higher than the actual increase in RM (consistent with the annual increase in nominal GDP), necessitating open market operations (OMO) (sales) to absorb excess durable surplus liquidity (Table 3). In contrast, in 2013-14 and 2015-16, the actual increase in RM was significantly higher than the increase in NFA, which necessitated OMO (purchases) by the Reserve Bank for injecting durable liquidity. The year 2016-17 was an exceptional year as the problem of large surplus liquidity post-demonetisation was exacerbated by the increase in NFA. In 2017-18, while the liquidity overhang from demonetisation moderated gradually with increasing remonetisation thus taking the system level liquidity closer to neutrality, primary durable liquidity increased due to forex inflows which was partly offset through OMO (sales), consistent with the Pillar II approach mentioned above.

It is pertinent to note that forward purchases of foreign exchange that are due to mature over the next few months can lead to injection of durable liquidity, unless rolled over. Thus, while forward forex market interventions/rollovers could relax the liquidity management challenges, such an approach carries the risk of distorting forward rates (with forward rates being also influenced by demand-supply conditions at the margin, besides interest rate differentials).

Forex interventions change significantly the composition of the RBI's balance sheet (in terms of the sources of expansion in reserve money), which also poses challenges. A high share of NFA at any point in time and the resultant decline in net domestic assets (NDA) can pose collateral constraints to the Reserve Bank's market-based liquidity absorption operations, particularly open market sales and reverse repo auctions to absorb surplus liquidity. Under conditions of persistently large surplus liquidity, this constraint could become binding. For instance, the sharp rise in the share of foreign assets in total assets in the RBI's balance sheet between 2001 and 2003 (Chart 2) necessitated the introduction of Market Stabilisation Scheme (MSS) in April 2004.[2] Thereafter, the share of foreign assets kept increasing, reaching almost 89 per cent in 2006 and 2008; however, the Reserve Bank was able to effectively sterilise surplus liquidity by issuing securities under the MSS along with the cash reserve

Table 3: Variation in Reserve Money and Main Durable Liquidity Drivers

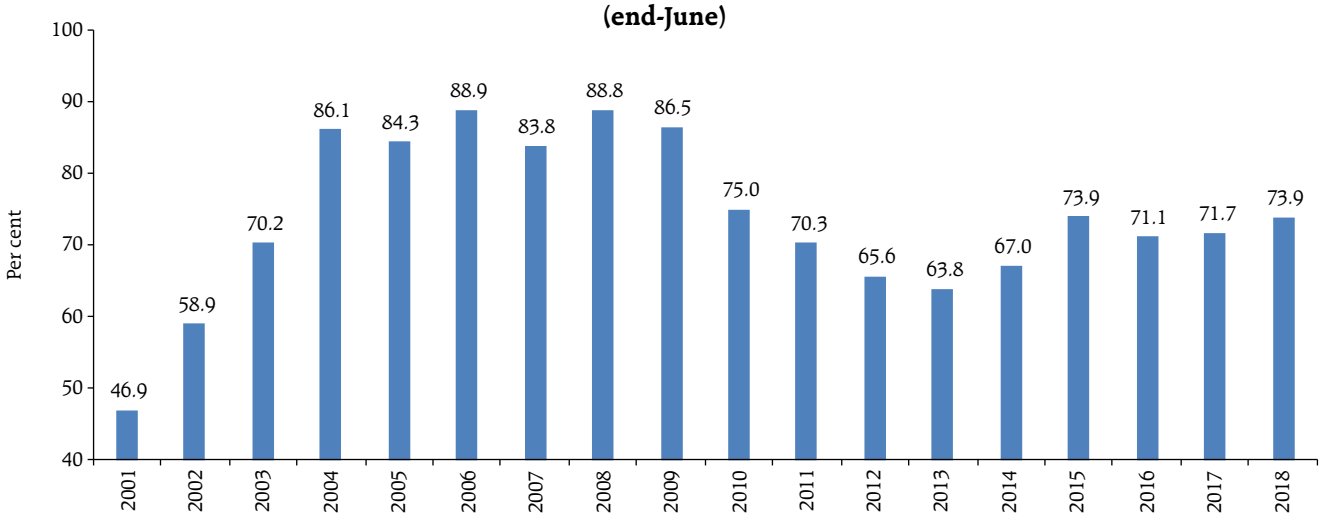
(Amount in Rs. billion)

Year	Partial Income (Nominal GDP) Elasticity of Adjusted RM	Change in Reserve Money	Net Forex Purchases by RBI	Net OMO Purchases(+)/ Sales (-)
1	2	3	4	5
2013-14	1.0	2179	586	523
2014-15	1.0	1957	3431	-640
2015-16	1.2	2523	631	533
2016-17	-	-2803	785	1116
2017-18	2.2	5,182	2,228	-878

Notes: 1. (-)/(+) in column 4 and column 5 indicates absorption/injection of liquidity, *i.e.*, (-) indicates sales of government securities/forex and (+) indicates purchase of government securities/forex.
2. Absorption/injection through LAF under Pillar I are not taken into account here.

[2] The MSS was designed to absorb surplus liquidity of an enduring nature through issuance of Treasury Bills and dated Government securities. The proceeds were parked in a separate identifiable cash account maintained and operated by the Reserve Bank, which could be appropriated only for the purpose of redemption and/or buyback of papers issued under the MSS.

Chart 2: Share of Foreign Currency Assets in Total Assets (end-June)



Source: RBI Annual Report (various issues), RBI Weekly Statistical Supplement of July 6 2018.
Note: Data pertain to balance sheet date (June 30) for all years up to 2017, and June 29 for 2018.

ratio (CRR) and OMO sales. This ensured that the burden of sterilisation was shared by all stakeholders, *i.e.*, (i) the Government (interest cost on MSS); (ii) the Reserve Bank (interest cost on reverse repos); and (iii) the banking sector (unremunerated reserve requirements). Capital outflows in the wake of the global financial crisis and large scale OMO purchases to meet the normal expansion in RM in the following years (up to 2012-13) led to some moderation in the share of foreign assets in the total assets of the Reserve Bank; however, this ratio has started rising in recent years. The Standing Deposit Facility (SDF), which has been announced in the Union Budget 2018-19, once operationalised, will significantly enhance the sterilisation capacity by removing the collateral constraint that the Reserve Bank occasionally faced in the past.

IV. Estimating the Effectiveness of Sterilised Interventions

As noted earlier, central banks that intervene in the foreign exchange market typically calibrate the extent of sterilisation to modulate base money expansion in sync with the normal requirements of a growing economy and its monetary policy stance. In the Indian context also, forex market intervention is offset to the extent required through changes in net domestic assets so as to ensure that the base money expansion remains consistent with the growth in nominal GDP.

The extent and effectiveness of sterilisation operations undertaken by a central bank are empirically measured by computing sterilisation and offset coefficients, both varying between 0 and -1. The sterilisation coefficient measures the extent by which the NDA of a central bank change in response to a change in NFA. Typically, while a value of -1 represents complete sterilisation, *i.e.*, no impact of surplus capital inflows on the monetary base, a value of 0 implies that forex intervention is not sterilised at all by the central bank.

As discussed earlier, sterilisation operations undertaken by a central bank can widen the interest rate differential if such operations are undertaken through open market sale of securities, which, in turn, could result in higher capital inflows, thereby leading to an adverse feedback loop. If interest sensitive capital flows are large (or the sensitivity of capital flows to widening interest rate differentials is high),

Table 4: Estimates of Sterilisation Coefficient

Sr. No.	Author	Time Period	Method	Estimates
1	Patnaik (2004)	Monthly data (April 1993-December 2003)	Error Correction Model	(-0.82)
2	RBI (2004)	Monthly data (April 1994-September 2003) and (October 1995-September 2003)	Vector Auto Regression	(-0.92) and (-0.65)
3	Ouyang and Rajan (2008)	Quarterly data (1990:Q1 – 2004:Q4)	Two stage least squares	(-1.1)
4	Sen Gupta and Sengupta (2013)	Monthly data (January 1990 - August 2010)	Ordinary Least Squares	(-0.21) to (-0.61)

Notes: 1. The estimate of the extent to which addition to NFA is sterilised by the central banks is termed offset coefficient (in Sr. No. 1 study).
2. NDA and NFA variables defined differently in both estimates (in Sr. No. 2 study).
3. Sterilisation coefficient is estimated for three sub-periods (in Sr. No. 4 study).

and if open market sales, as the key instrument of sterilisation, harden yields, then the sterilisation effort could become ineffective. The offset coefficient captures this combined effect, *i.e.*, the extent to which a decrease in NDA due to open market sales is offset by an increase in net foreign assets driven by sterilisation-induced higher yields. If sterilisation operations result in a widening of interest rate differential, the change in net domestic assets can be fully offset through a change in net foreign assets. In this scenario, a value of -1 for the offset coefficient represents the complete ineffectiveness of the central bank in sterilising capital flows, *i.e.*, complete attenuation of monetary control. Thus, an offset coefficient of -1 would tantamount to perfect capital mobility, while a value of 0 would imply no capital mobility, which is also consistent with the impossible trinity, according to which fixed exchange rate, perfect capital mobility and independent monetary policy are mutually incompatible.

In the Indian context, several studies have estimated the "sterilisation coefficient", but there are very few studies that have estimated the "offset coefficient", notable exceptions being Pattanaik (1997) and Ouyang and Rajan (2008). While the former found the offset coefficient to be in the range of -0.31 and -0.33, the latter estimated it to be between -0.79 and -0.84. These findings indicate that the offset coefficient has increased in India over time given that the exposure of the economy to short-term portfolio debt flows has increased gradually through successive increases in FPI limits on Government securities, state development loans (SDLs) and corporate bonds reflecting increasing openness of the capital account. Moreover, the yield differential has remained significantly favourable for India in the post global crisis period because of the persistently low interest rates in advanced economies.

Using monthly data for over a 20-year period from July 1997 to October 2017, the sterilisation and offset coefficients are estimated by a modified money demand function and a modified equation on capital flows using the two-stage least squares (2SLS) method (Annex). The estimated sterilisation coefficient is -1.03 while the offset coefficient is -0.83, which are consistent with the findings of Ouyang and Rajan, *op. cit*, (Table 4).

Conclusion

Sterilised intervention in India has not only ensured that the reserve money growth remains consistent with the requirements of the growing economy but also that money market rates remain aligned with the operating target of the monetary policy, no matter how significant and persistent the liquidity impact of forex interventions may be. The estimated large offset coefficient, however, suggests that the impossible trinity poses a challenge to the effective conduct of monetary policy. Forex market intervention requires a continuous assessment of exchange market conditions (in terms of intervention preventing volatility), liquidity conditions (arising out of forex operations) relative to system wide demand for liquidity, G-sec market conditions (in

terms of sensitivity of yields to OMOs) and forward market conditions (in terms of forward premia getting influenced by forward purchases/sales).

Many EMEs have successfully managed the impossibility trinity by adopting country and time-specific suitable mix of sterilisation, exchange rate flexibility and CFMs. In the foreseeable future, India may have to persevere with the past strategy which has stood the test of time, even while further strengthening the arsenal for sterilisation.

References:

Sen Gupta, Abhijit and Rajeshwari Sengupta (2013): "Management of Capital Flows in India", ADB South Asia Working Paper Series, No. 17, March.

Ouyang, Alice Y. and Ramkishen S Rajan (2008): "Reserve Stockpiling and Managing its Monetary Consequences: the Indian Experience", Macroeconomics and Finance in Emerging Market Economies, February.

Bank for International Settlements (2013): "Market volatility and foreign exchange intervention in EMEs: what has changed?", BIS Papers No. 73, October.

Ljubaj, Igor and Ana Martinis and Marko Mrkalj (2010), "Capital Inflows and Efficiency of Sterilisation – Estimation of Sterilisation and Offset Coefficients", Croatian National Bank Working Paper No. 24, April.

Patnaik, Ila (2004): "India's Experience with a Pegged Exchange Rate", India Policy Forum, 2004, Vol 1, Issue 1.

Pattanaik, Sitikantha (1997): "Targets and Instruments for the External Sector with an Open Capital Account", Economic and Political Weekly, October 4.

Reserve Bank of India (2004): Report on Currency and Finance, 2002-03.

Annex

Estimation of Sterilisation and Offset Coefficients

The empirically observed inter-dependence between capital flows and liquidity conditions, and the liquidity management reaction function of a central bank that proactively responds to these dynamics consistent with the monetary policy stance, together provide the underlying framework for estimating the sterilisation and offset coefficients. As explained in the article, while a change in NDA responds to change in NFA (*i.e.*, sterilisation of the liquidity impact of increase in NFA through open market sales that reduce NDA), a change in NFA also responds to change in NDA (*i.e.*, when open market sales harden yields, that may attract higher capital inflows, leading to increase in NFA). While the first relationship can be explained through a central bank liquidity management reaction function (interchangeably, also referred to as the monetary policy reaction function or the augmented money demand function), the second relationship can be explained as a net capital flows (net of current account deficit in this case) equation having country-specific determinants, including NDA. This interdependent structure could be modelled as:

Liquidity management reaction function: $\Delta \text{NDA} = \alpha + \beta \text{NFA} + \mu_i X_i \quad \ldots (1)$

Net capital flows equation: $\Delta \text{NFA} = a + b \text{NDA} + c_i Y_i \quad \ldots (2)$

When estimated empirically, β and b represent the sterilisation coefficient and the offset coefficient, respectively (Ljubaj *et al*, 2010). When $\beta = -1$, there is complete sterilisation and when $\beta = 0$ there is no sterilisation. Similarly, when $b = -1$, sterilisation is completely ineffective (because, sterilisation induced decline in NDA attracts fully offsetting increase in NFA through higher yields). In turn, when $b = 0$, sterilisation is fully effective. In the above two equations, X_i and Y_i represent other country specific variables that may influence NDA and NFA, respectively. For empirical estimation in this article, X_i include (i) nominal GDP (quarterly data interpolated to monthly), because as per the standard money demand specification, NDA may increase with higher nominal GDP, (ii) spread between the policy rate and the weighted average call money rate (DS), because liquidity management aims at keeping the latter close to the policy rate, and (iii) money multiplier (ratio of broad money to base money) (Mul), because multiplier may change due to change in CRR or currency/deposit ratio, both of which could alter reserve money from the liability (or components) side, requiring offsetting changes on the assets (sources side). In the second equation, Y_i include (i) nominal GDP (quarterly data interpolated to monthly), because higher real growth may attract capital flows, (ii) interest differentials measured as the spread of the call rate over the effective federal funds rate (IF), because foreign capital in search of higher yields is generally sensitive to interest rate differentials, (iii) real effective exchange rate (REER), because it provides information to the foreign investors on the expected change in nominal exchange rate to correct for misalignment, if any, and (iv) money multiplier (ratio of broad money to base money) (Mul), because of the same argument as in the first equation. Monthly data for the period July 1997 to October 2017 are used. In view of the inter-connectedness between the two equations, a two stage least squares (2SLS) method of estimation is applied. Recognising the endogenity problem between NDA and NFA in both equations, relevant instrument variables are used in estimation, *i.e.*, REER and IF in the first equation for NFA (given high correlation between them) and DS and GS (*i.e.*, quantum of secondary market operations in government securities) in the second equation for NDA (given high correlation between them).

(Contd...)

All variables are considered in their first difference form (12-month variation), which ensures that the selected variables are stationary as per the Augmented Dicky Fuller (ADF) and Phillips-Perron test statistics (Table 1).

Table 1: Tests for Stationarity of the Variables

Variable	Model	Augmented Dickey-Fuller Test statistic	Phillips Perron Test statistic
NDA	No intercept, no trend	-1.77 (.073)	-3.90 (.000)
NFA	No intercept, no trend	-1.85 (.061)	-2.49 (.012)
GDP	Intercept	-3.49 (.009)	-2.89 (.048)
DS	Intercept	-6.14 (.000)	-9.69 (.000)
Mul	Intercept	-3.85 (.003)	-3.85 (.003)
IF	Intercept	-5.18 (.000)	-9.59 (.000)
REER	Intercept	-3.76 (.004)	-3.83 (.003)
GS	Intercept	-5.29 (.000)	-8.14 (.000)

Note: Figures in parentheses are the p-values

GDP, REER and GS are taken in log form. Net domestic assets and net foreign assets are adjusted for valuation changes and are scaled by the log of base money of the previous year. AR terms have been used in both equations (Table 2). Newey-West correction method has been used in view of serial correlation in errors in the capital flows equation.

Table 2: Estimation of Sterilisation and Offset Coefficients

Dependent Variable: NDA		
	Coefficient	p-value
Modified Money Demand Equation		
Constant	86.02	0.00
NFA	-1.03	0.00
GDP	58.25	0.73
Mul	-239.52	0.00
DS	0.31	0.59
AR(1)	0.66	0.00
AR(3)	0.14	0.03
Instrument Variables	IF	REER
Adjusted R^2		0.94
DW Statistic		2.00

Dependent Variable: NFA		
	Coefficient	p-value
Modified Capital Flows Equation		
Constant	67.45	0.00
NDA	-0.83	0.00
GDP	133.59	0.41
Mul	-200.41	0.00
REER	294.33	0.00
IF	-0.10	0.88
AR(1)	0.68	0.00
AR(2)	0.15	0.03
Instrument Variables	DS	GS
Adjusted R^2		0.95
DW Statistic		2.00

(Contd...)

When estimated, both the sterilisation coefficient and the offset coefficient emerge statistically significant, correctly signed, and their magnitudes are similar to estimates presented in recent other studies available for India. While the sterilisation coefficient of -1.03 may point to full sterilisation, when seen along with the offset coefficient of -0.83, that would establish the dynamic interactive process through which reserve money expands in the economy. Even when full sterilisation is ensured, that attracts higher NFA, which leads to expansion in reserve money. Given that the money supply process is endogenous, *i.e.*, demand for money is fully met to ensure that the weighted average call rate remains close the policy repo rate, what is more important to recognise from the policy standpoint is the high value of the offset coefficient (rather than the sterilisation coefficient), which signifies rising ineffectiveness of sterilisation with growing openness of the capital account.

Empirically estimated values of sterilisation coefficients and offset coefficients are highly sensitive to model specifications and the sample period. For example, in the both the estimated equations in Table 2, some of the variables are not statistically significant, even though one may expect them to be among the list of determinants of changes in NDA or NFA. Therefore, instead of viewing the estimated sterilisation and offset coefficients as precise, what is more important to infer from the empirical findings presented here is that sterilisation effectiveness drops when openness to capital flows increases or large-scale sterilisation is conducted on a sustained basis, which may pose a challenge for the independent conduct of monetary policy.