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Reserve Accumulation and Sterilized Intervention in the
Foreign Exchange Market in Bangladesh: An Empirical analysis

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Abstract

The main intention of the paper is to investigate the extent of sterilization of Bangladesh Bank to offset the monetary expansionary effect of reserve accumulation in the foreign exchange market. To this end, the paper estimates a credit reaction function by applying Johansen cointegration technique and Vector Error Correction (VEC) model. Monthly data has been used for the period 2003-2013. The paper finds that there exist a long run relationship between NDA and NFA which statistically significance at 10 percent level. The long run elasticity between NFA and NDA shows an extent of sterilized intervention about 11 percent in the foreign exchange market. The short run estimated coefficient and error correction of the credit reaction function from VEC model reveal that the speed of adjustment of NDA is 5.4 percent which means that NDA moves towards equilibrium by adjusting 5.4 percent in every month.

Keywords: Foreign Exchange Reserves, Sterilization, VEC.

Introduction

Over the last several years, there has been a tremendous increase in foreign exchange reserves in Bangladesh Bank (BB). This reserve accumulation is concerned for conducting effective monetary policy of BB, because an increase in foreign exchange reserves directly affects the asset side of the balance sheet of the BB[2]. High level of reserve accumulation through non sterilize foreign exchange market intervention sometimes destabilizes the path of money supply which is anchored at desired level to maintain price stability. Thus sterilized intervention is required to stabilize anchored money supply at target level to achieve policy goals which are fixed in the monetary programming.

BB has frequently intervened in foreign exchange market since 2003 to shield exchange rate at desired level. Consequently, foreign exchange reserves increased remarkably and stood at USD18 billion in December 2013 and USD20 billion in April 2014. Although BB uses monetary instruments to sterilize the expansionary monetary effects of reserve accumulation, it is still a challenge for BB to conduct effective monetary policy for achieving price stability. Figure- 1 and -2 plots the programmed and actual movements of net foreign asset and broad money for the period FY05-FY13 respectively, which show that net foreign assets (NFA) and broad money (M2) hardly meet their target level due partly to lack of proper sterilize intervention. Monetary Policy Statement, July-December 2013 chalk out the economy of Bangladesh faced a different set of challenges for FY13. Robust foreign remittance and export growth along with sluggish import growth led to a sharp growth of NFA which needed to be sterilized. So it is necessary to know for the policy maker how sterilized intervention is conducted in this growing interaction between monetary and exchange rate policy.
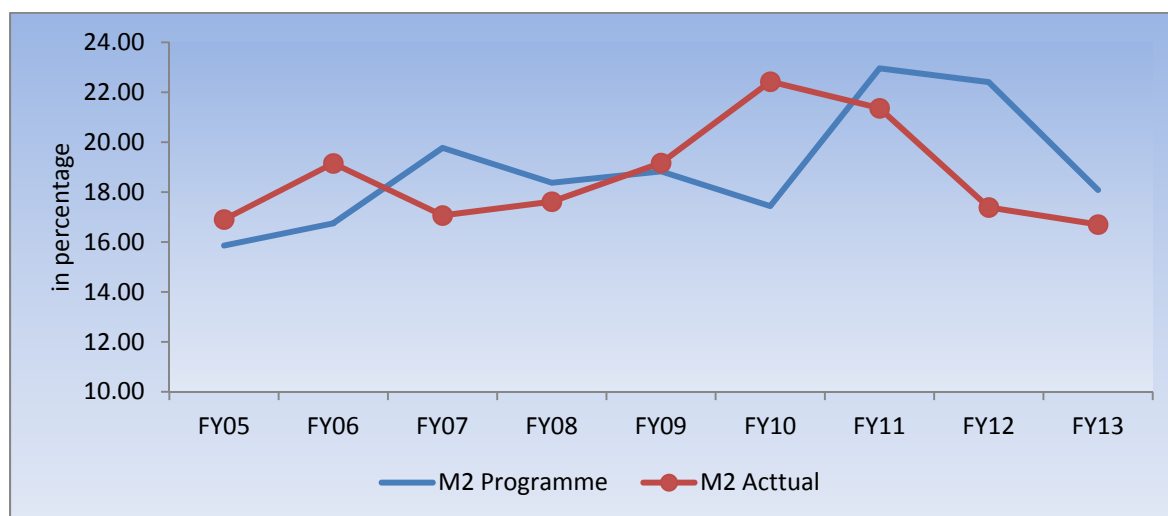
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[2] A highly stylized version of a central bank's balance sheet is Net foreign assets (reserves) + net domestic assets = Reserve money (currency +deposits of DMBs).

Figure 1: Trends in movement of programmed and actual NFA during FY05-FY13.
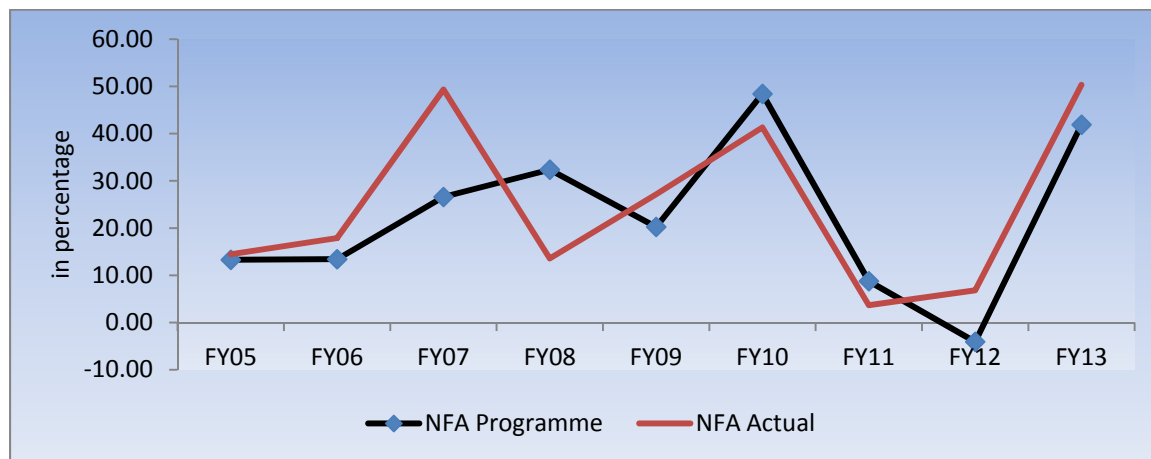
Figure 2: Trends in movement of programmed and actual M2 during FY05-FY13.

Two types of intervention, non- sterilized and sterilize intervention, are found in the foreign exchange market by the Central Bank. The purchases of foreign currency by the central bank lead to an increase in NFA and an equivalent increase in reserve money (RM), which known as non-sterilized intervention. At the same time, these monetary expansionary effects of reserve accumulation can be neutralized by reducing the domestic component of monetary base i.e., net

domestic asset (NDA). This process is known as sterilized intervention[3]. In sum, sterilization refers to action taken by a country's central bank to offset a change in net foreign assets (NFA) (e.g., reserve accumulation) by either changing its net domestic asset (NDA) (e.g, selling bonds) or somehow adjusting its reserves.

In absence of sterilization, there is also some conflict between foreign exchange market liquidity and monetary policy. To accomplish both its monetary and exchange rate targets, monetary authority usually resorts to sterilization. It is widely agreed that sustained unsterilized intervention can produce undesirable side effects, including rising inflationary pressures, conflict between the exchange rate and monetary policy objectives, asset-price bubbles. So, sterilized intervention in the foreign exchange market is essential for implementing appropriate economic policy (fiscal, monetary and exchange rates). In this regard, the paper investigates the nature of sterilized intervention of BB in the foreign exchange market.

BB holds adequate level of reserves to cover imbalances in the balance of payment, to maintain confidence in the external value of Taka, to meet foreign debt obligations, minimize exchange rate volatility and finally, to earn optimal return from reserves. Available instruments that are used for liquidity management by the BB are: Bangladesh Bank Bill, Repo and Reverse Repo operation, CRR and Islamic bonds. On the other hand, BB implements monetary policy by setting the RM as the operating target and M2 as an intermediate target in the monetary policy framework. In order to maintain RM at the desired level in line with targeted M2 growth, BB uses direct and indirect monetary policy tools[4] .The net effect of these tools on RM is explained in Annexure Box-1.

Against this backdrop the main objective of the paper is to investigate the extent of sterilized intervention in the foreign exchange market of Bangladesh Bank to offset the monetary expansionary effect of reserve accumulation. The extent of sterilization is analyzed by estimating

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[3] Sterilized intervention is a combination of two transactions. First, the central bank conducts a non-sterilized intervention by buying foreign currency with home currency. This results in the increase in the monetary base. Then the central bank sterilizes the effect on the monetary base by selling a corresponding quantity of home currency denominated bonds to soak up the initial increase in the monetary base.(Obstfeld and Rogoff (1996) chapter 8).

[4] Direct tools are interest rate control, credit ceiling and directed lending policy. Before 1990, BB used these tools. Indirect tools include CRR, SLR, repo and reverse repo, open market operation through govt. t-bill and BB-bill auction and intervention (sale and purchase of foreign currency) in the foreign exchange market.

credit reaction function. For estimating the credit reaction function, we apply Johansen Cointegration technique and Vector Error Correction (VEC) model. The monthly data has been used for the period 2003-2013.

The remainder of the paper is organized as follows: Following the introduction, section II presents the review of literature, section III portraits the development of reserve accumulation and foreign exchange market intervention, and section IV analyses model specification, variable definition and methodology. Analysis of the Estimated Results represent in section V. Finally, section VI gives the conclusion.

Section II: Review of Literature
Many studies have been taken on sterilized interventions in Asian countries. But, no study, so far has not been taken regarding this issue in Bangladesh. However, the relevant studies in this respect are summarized below:

Prabheeh et. al (2009) investigates the extent and effectiveness of sterilization policies of the Reserve Bank of India (RBI) to offset the monetary expansionary effect of reserve accumulation during 1993-2007. The empirical data show that the RBI sterilizes around 90 percent of reserve accumulation and the reserve accumulation does not lead to an increase in domestic interest rates. They conclude that the RBI effectively carried out sterilized intervention policies, without losing the monetary policy autonomy.

Muhammad (2007) analyzes the response of the State Bank of Pakistan (SBP) to foreign exchange inflows for the period of 2001:01 to 2006:8. He estimates sterilization and offset coefficients by using vector autoregression (VAR) model. He finds that the offset coefficient is very small and insignificants (0.16) implying that changes in credit resulted in very minimal offsetting flows. The study also finds that the SBP only partially sterilized inflows with a magnitude of coefficient at (0.50) confirming the stylized facts.

Hamed (2012), investigates the sterilization policy and degree of monetary independence of the Central Bank of Iran. The results show that the sterilization coefficient is less than 10 percent. This coefficient proofs that monetary authorities were unsuccessful in sterilizing the inflationary effect of changes in net foreign assets of the central bank. On the other hand, the compensation coefficient is about -0.12 which indicates that the low degree of capital mobility and high grade of monetary independence is required for implementing the sterilization policy.

Muhammad (2010) examines the Pakistan's central bank response to foreign exchange inflows, for the period 2001:01 to 2007:06, to strike a balance between competing goals of internal and

external equilibriums to draw lessons for its conduct going forward. The result indicates that for the period SBP fully sterilized its foreign exchange interventions. He also finds that changes in SBP's domestic credit were counter cyclical as it was negative relation with the output gap and the change in domestic credit has positive relation with changes in inflation.

Ramon (1996) analyzes the relative importance of foreign and domestic influence in explaining fluctuations in foreign assets, the degree of sterilization and its effectiveness in limiting the monetary impact of shocks, and how foreign assets respond to changes in domestic credit by using a four-variable vector autoregression model in Korea and Taiwan over the period 1981.1-1994.12. The analysis reveals that sterilization is an important element of the response to shocks to foreign assets in both economics. In particular, monetary authorities do not appear to be prepared to accept fluctuations in the exchange rate and the money supply that may result from changes in foreign assets, but more readily accept fluctuations in these variables that result from domestic credit shocks.

Muhammad et. al (2011) focuses on estimation of monetary policy reaction function and degree of sterilization for the sample comprising of Pakistan, Korea, Philippines and Japan by using quarterly data ranging from 1980-1 to 2007-2. The study shows that during the sample period all the central banks of these countries have conducted a strong sterilization policy, but did not fully sterilized the capital inflow. In all the economics whether they are agriculture or non-agriculture they sterilized their capital inflows in the long run. Short run adjustment towards the long run equilibrium shows high value of adjustment for Korea and Philippines while for Pakistan its coefficient shows very little adjustment. On the other hand, Korea and Philippines has shown comprehensive adjustment policies towards long term adjustment.

Alice et al (2006) assess the extent of de facto sterilization and capital mobility by using monthly data between mid 1999 and late 2005. They find that China has been able to successfully sterilize most of these reserve increases thus making it a reserve sink such as Germany was under the Bretton Wood system. Recursive estimation of offset coefficients, however, finds evidence of increasing mobile capital flows that may undercut China's ability to continue high levels of sterilization.

Joshua et al (2008) investigates the changing pattern and efficacy of sterilization within emerging market countries as they liberalize markets and integrate with the world economy. They estimate the marginal propensity to sterilize foreign asset accumulation associated with net balance of payments inflows, across countries and over time. They find that the extent of

sterilization of foreign reserve inflows has risen in recent years to varying degrees in Asia as well as in Latin America, consistent with greater concerns about the potential inflationary impact of reserve inflows. They find that sterilization depends on the composition of balance of payments inflows.

Sahadevan K.G, (2001) examines the impact of central bank's intervention on exchange rate and future monetary policy in the Indian context. The estimates of the intervention and sterilization equations indicate that the central bank sterilizes a major portion of reserve flow and purchases US$ when its price in terms of rupee is low and vice versa. The estimates of the money supply process show that purchases (sale) of US$ are correlated with expansionary (contractionary) monetary policy in the future. The result from the Granger test of causality indicates that intervention does not have any significant causal relationship with monetary variables and exchange rate.

Mansour Layal, (2012) investigates the effectiveness of hoarding international reserves and sterilization in dollarized and indebted countries such as Turkey and Lebanon by measuring the sterilization coefficient and offset coefficient. The result shows that despite their theoretical practice of sterilization policy, economic constrains of these countries contribute to weaken the efficacy expected from monetary policies. Finally, the study concludes that country which basically suffers from economic constraints; sterilization of international reserves becomes a source of macroeconomic vulnerability.

An analysis of cross countries experience of managing foreign capital inflows shows that Hungary carry out complete sterilization whereas Korea, India and Pakistan opted for partial sterilization (table-1).

Table-1 Cross Countries Comparison of Sterilization

Countries	Sterilization coefficient	Sample Period	Data Frequency
India	-0.83	1994-2003	Monthly
Pakistan	-0.87	July2000-December 2003	Monthly
Korea	-0.90	1980-1989	Monthly
Hungary	-1.00	1992-1997	Monthly

Source: Asad Jan, Ather Elahi and M.A.Zahid (2005).

The above mentioned studies explain the extent of sterilization in different countries. However, there is a dearth of studies examining on this issue in the context of Bangladesh. To fill up this gap we have taken this empirical study to examine the extent of sterilization in Bangladesh.

Section III: Developments of Reserve Accumulation and Foreign Exchange Market Intervention

Over the last few years there has been a remarkable increase in foreign exchange reserves. Figure-3 shows that foreign exchange reserve was US$276 million in FY1980-81, increased to US$1602million in FY1999-00 and reached a high level of US$15315 million in FY2012-13. It stood at USD18 and USD20 billion in December 2013 and May 2014 respectively which is about six months of import. It was only 1.7 months of import cover in FY2000-2001. The reserve as percent of GDP also increased to 28 percent in December 2013 from 20.03 percent in FY2012-13 and 3.93 percent in FY1999-00.[5]

Figure-3: Trends in International Reserves during 1980-2013
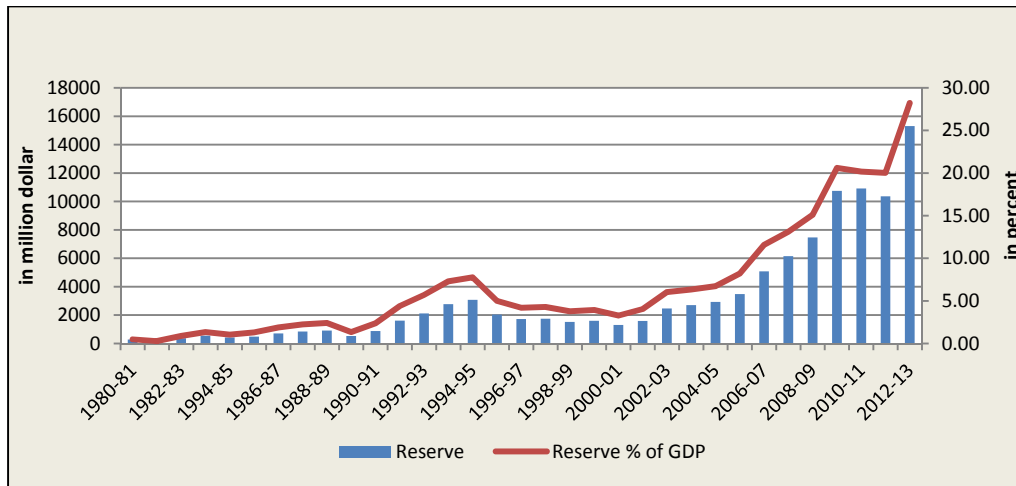
Source: Annual Report (various issues), BB.

There is a link between foreign exchange reserve and RM. An increase in international reserves directly affects the RM which consists of two assets: NFA and NDA. Figure-4 shows that the movement of NFA and NDA is in opposite direction. It implies that BB changes NDA to offset the effect of an increase in NFA.

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[5] The source of reserves accumulation is export earnings, investment income, remittances, foreign borrowings, foreign aid and grants and the demand for reserves are import payment, ACU payment, foreign exchange market intervention, repayment of debt obligations.

Figure-4: **Movements of NDA and NFA during 1990-2013**
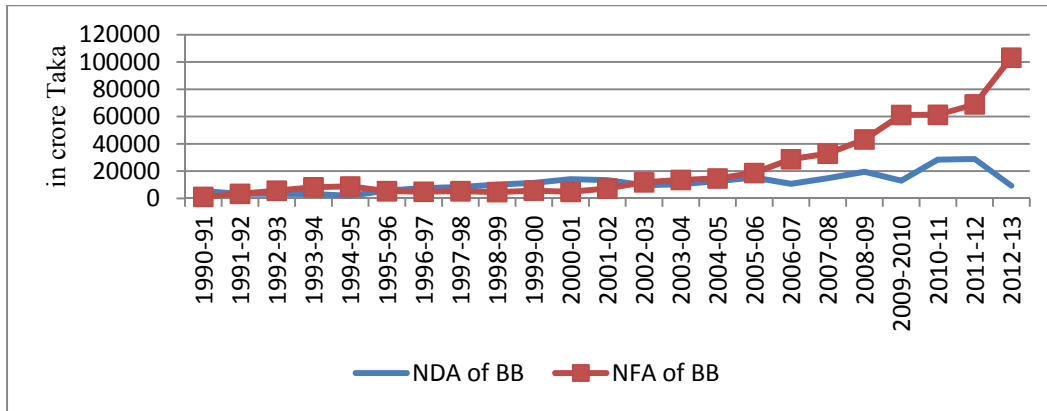
It is mentioned that BB implements monetary policy by setting the RM as the operating target and M2 as an intermediate target in the monetary policy framework. The general perception is that if BB has enough control over RM, it can implement effective monetary policy. Islam (2008) finds that BB has control over RM. The source of RM and their movements which affects the degree of controllability of RM partially depends on the sterilization intervention by the BB. Thus it is important to identify the extent of sterilization intervention.

The trends analysis of the share of NFA and NDA in RM indicate that both are unpredictable. Figure-5 reveals the percentage contribution of NFA and NDA to RM and shows that before FY03 there was a mixed trend in the contribution of NFA and NDA to RM. After FY03 the contribution of NFA in RM is higher than that of NDA.

Figure-5 **Movement of Share of NFA and NDA in Reserve Money during 1991-2013**
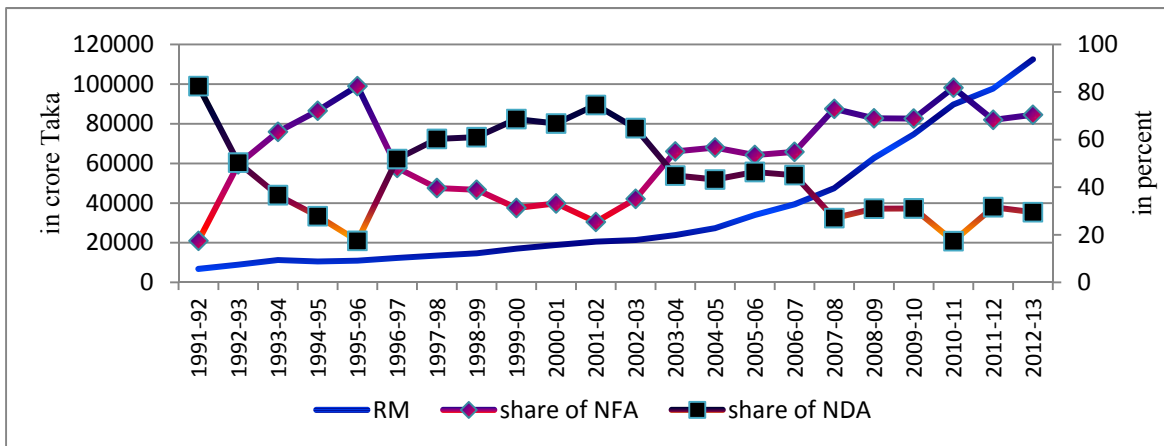
The unpredictability of NDA and NFA also reflected in their volatility. The volatility, as measured by standard deviation, is reported in Table-2 which shows that there was a low volatility in NFA as compared to NDA during FY04-FY13. On the other hand, there exists a high volatility in the movement in NDA. In this circumstance it is difficult to control RM for implementing monetary policy as desired direction.

Table-2 : Trend and Volatility in NFA and NDA

Year	NFA		NDA	
	Mean	std	Mean	std
FY04	0.86	1.50	1.11	9.17
FY05	0.80	5.34	1.87	11.10
FY06	2.18	6.62	2.42	7.09
FY07	3.70	4.65	-1.34	8.51
FY08	1.19	4.53	3.27	17.22
FY09	2.34	5.73	2.99	10.74
FY10	3.03	4.74	-0.79	20.01
FY11	0.05	2.37	6.03	12.80
FY12	1.07	4.69	-1.02	13.19
FY13	3.45	2.46	-7.80	16.98

Source: Author's own calculation based on data available in Monthly Economic Trends, BB.

Among the source of NDA, the dominating part is BB's claims on government which is also volatile. The volatility is originating from government borrowing for financing fiscal deficit which changed RM beyond its targeted level. On the other hand, the movement of NFA depends on export growth, import growth, inflow of remittance and foreign assistance and the movement of these variables is erratic. So from the above analysis we conclude that it is a great challenge for BB to control over RM. In the IMF country report (no 14/149) June 2014 also point out that although BB met the reserve money target in the face of high reserve accumulation over the past few years, this has required a stepping up of sterilization operations.

Bangladesh has experienced significant inflow of foreign exchange during the period under study which has affect on foreign exchange market. If this increasing trend of the inflow of foreign exchange continues, Taka will appreciate and export sector will loss competitiveness in the international market. In order to shield appreciation of Taka recently, BB mop up excess supply of foreign exchange through intervention in the foreign exchange market. Consequently, it helped to build up foreign exchange reserves which push up NFA of BB. At the same time,

equivalent amount of local currency inter in the market which should be counteract by pushing down NDA to keep on money supply in programmed path. Table-3 shows that BB bought a record of USD4539 million from the market to halt appreciation of Taka against USD during FY2013. The table also shows that there is a positive relationship between foreign exchange buying and change of NDA in the banking system. The estimated correlation coefficient is 0.26 between USD buying and change of NDA during 2003-2013.

Table-3: Trends in Buying and Selling in Foreign Exchange market in Bangladesh

Year	Buying (in million USD)	selling (in million USD)	net buy (in million USD)	NDA change (in crore taka)*
2002-03	503.9	-	503.9	11021.1
2003-04	314	-	314	13404.9
2004-05	64.7	459.5	-394.8	19420
2005-06	79.99	416.09	-336.1	25935.2
2006-07	649.5	-	649.5	19959.9
2007-08	202.5	735.5	-533	32375.7
2008-09	1484.2	98.5	1385.7	37558.9
2009-2010	2161	61.5	2099.5	46923.8
2010-11	316.5	1279	-962.5	73964.9
2011-12	157	776	-619	68344.3
2012-13	4539	-	4539	51829.8

Source: Monthly Economic Trends, BB, Forex Reserve and Treasury Management Department, BB.
Note: Net buy = buy-sell.,   - no selling and * = NDA in the banking system.

In order to maintain RM at the programmed level and to manage overall liquidity in the banking system, BB uses many instruments which include CRR, repo, reverse repo, BB bill, and Islamic bonds (Annexure Table 1). Besides, net policy action on liquidity movement also depends on auction of Government T-bill and Government bond[6]. BB also purchase/sale G-T/B with DMBs for maintaining liquidity in banking system (secondary trading). Although BB uses many instruments to manage overall liquidity in the banking system, equivalent amount of taka against foreign exchange buying (net) from the market is not soak up.

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[6] These are short-term and long term obligations issued by BB on behalf of the Government. The objectives of these securities are two-fold. The first is to provide a mechanism for financing government deficit, and managing excess liquidity prevailing in the market.

Section IV: Model Specification, Variable Definition and Methodology

a. Model Specification

Economic literature shows that foreign exchange and domestic monetary markets are interrelated. The contemporaneous relationship between NDA and NFA show the extent of sterilization. In order to estimate the extent of sterilization, the paper estimates the following credit reaction function:

$$\Delta NDA_t = \beta_0 + \beta_1 \Delta NFA_t + \beta_2 \Delta IP_t + \beta_3 \Delta ER_t + \beta_4 \Delta \text{repo rate}_t + E_t \text{ ------------------------ (1)}$$

In equation (1) NDA denotes net domestic assets, NFA is net foreign assets, ER is nominal exchange rate (Taka per US dollars). $\beta_1, \beta_2, \beta_3, \beta_4,$ are the parameters which to be estimated. β_0 is the intercept and E_t is the error term. Δ denotes change and t stands for time. All variables in equation (1) expressed in logarithmic form. The coefficient of NFA (β_1) measure the extent of the sterilization and it takes a value between 0 and -1. When $\beta 1=0$ it implies absence of sterilization which means that an increase in reserves leads to an equivalent increase in monetary base i.e any change in NFA will entirely be reflected in money supply. Conversely, if $\beta_1 = -1$, then it implies full sterilization of the monetary effect of reserve accumulation. This means that every unit of foreign exchange purchased by the central bank (the increase in NFA) through its intervention in the foreign exchange market which increased money supply will be neutralized and thus, the increased money will be withdrawn (decrease of NDA) from the market and consequently, the change in money supply will be equal to zero. If β_1 takes a value between 0 and -1 then it implies partial sterilization.[7]

b. Variable Definition

Net Domestic Assets (NDA): NDA consists of domestic credit (public sector and private sector) plus nets other items.

Net Foreign Assets (NFA): NFA consists of the NFA of DMBs and NFA of BB. The NFA is expected to negatively affect NDA when the central banks are engaged in sterilization.

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[7] The model can be expressed as $\Delta NDA = \beta \Delta NFA + \Delta Z$ where z is the value of all exogenous variables relevant to monetary policy such as output, repo rate, domestic exchange rate etc. On the other hand, $\Delta M2 = \Delta NDA + \Delta NFA$ $=> \Delta M2 = \beta \Delta NFA + \Delta Z + \Delta NFA$ $=> \Delta M2 = \Delta Z \text{-------}$(if $\beta = -1$) implies money supply is determined by the exogenous variable and $\Delta M2 = \Delta Z + \Delta NFA \text{-----}$(if $\beta=0$) implies any change in NFA will entirely be reflected in M2 or monetary base.

Industrial production (IP): IP is taken as proxy for GDP due to unavailability of monthly GDP series. A positive relationship is expected between NDA and IP because an increase in output requires high demand for domestic credit.

Repo rate: Repo rate is the policy rate. Repo operation is an arrangement between BB and DMBs through which liquidity will inject / absorb in the banking system. When repo is issue liquidity will inject and when it matured liquidity will absorb.

Exchange Rate (ER): ER is measured Taka per US dollars for end of month (nominal exchange rate).

c. Data and Methodology:

The credit reaction function is estimated by using monthly data from 2003:07 to 2013:06. The sample period is chosen to see the extent of sterilized intervention for floating exchange rate regime which started from 2003. The monthly data have been collected from Economic Trends of Bangladesh Bank, Annual Report of Bangladesh Bank, Bangladesh Bank Quarterly and Bangladesh Economic Review, of Ministry of Finance. To estimate the credit reaction function, we use Johansen cointegration technique and Vector Error Correction (VEC) model.

V. Analysis of the Estimated Results
Plots of the variable (figure-6) show that all variables are most likely to have unit root.

Figure-6
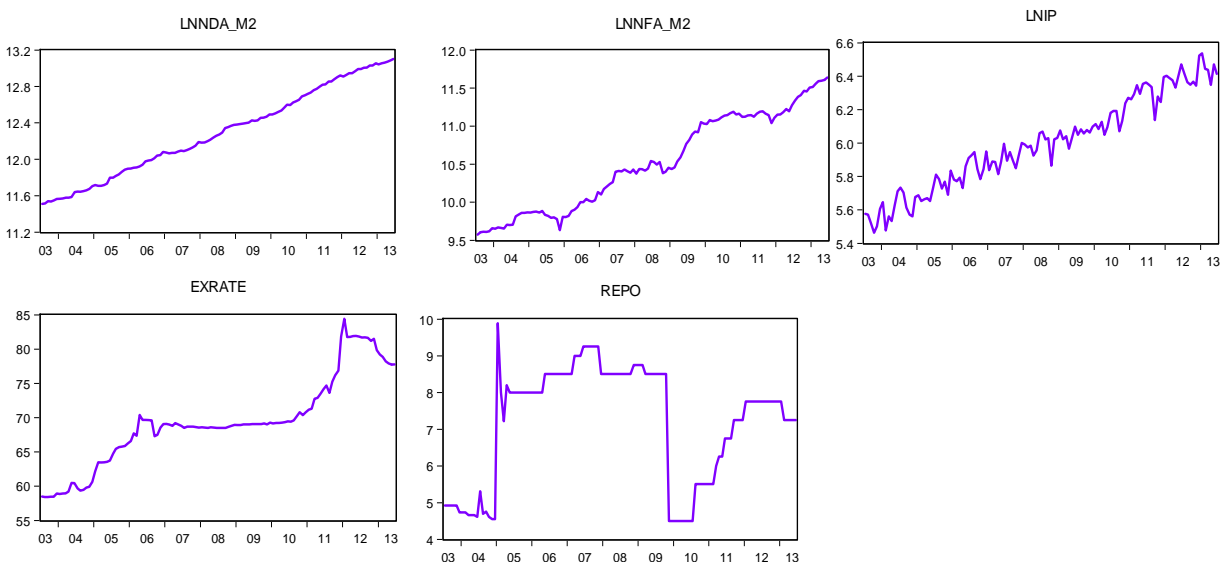
Source: Monthly Economic Trends, BB, Annual Report of BB and Bangladesh Bank Quarterly, BB.

The Phillips –Perron (PP) tests has been applied for unit root test and the results are reported in table-4. All variables are non-stationary I(1) in its level and they are stationary I(0) in first difference.

Table-4 : Phillips-Perron unit root tests

Variables	In level			In first difference		
	Model A			Model A		
	Test statistics	5% critical value	Integration	test statistics	5% critical value	Integration
NDA	0.24	2.88	I(1)	11.72	2.88	I(0)
NFA	0.15	2.88	I(1)	4.47	2.88	I(0)
repo	2.32	2.88	I(1)	12.49	2.88	I(0)
IP	0.91	2.88	I(1)	30.33	2.88	I(0)
Exrate	1.28	2.88	I(1)	9.41	2.88	I(0)
	In level			In first difference		
	Model B			Model B		
	test statistics	5% critical value	Integration	test statistics	5% critical value	Integration
NDA	2.74	3.45	I(1)	11.68	3.45	I(0)
NFA	3.04	3.45	I(1)	4.47	3.45	I(0)
repo	2.25	3.45	I(1)	12.49	3.45	I(0)
IP	7.44	3.45	I(0)	30.13	3.45	I(0)
Exrate	1.28	2.88	I(1)	9.41	2.88	I(0)

Note: Model A includes intercept and Model B includes both intercept and trend. The null hypothesis states that the variables have a unit root. Source: Monthly Economic Trends, BB, Annual Report of BB and Bangladesh Bank Quarterly, BB.

Since all variables are I(1) at level, the next step is to see whether the variables are cointegrated or not. We apply Johansen cointegration test, for cointegration. Two lag lengths are selected as per Schwartz Bayesian Criteria (SBC). To make the cointegration test more general, we check for both intercept and trend & intercept .

Table-5 : Johansen Co-integration test

Null Hypotheses	Alternative Hypotheses	Test Statistics	5% critical value	Conclusion
with intercept				
Trace Statistic Test				
r=0	r>0	87.54	69.81	one Co-integrating Relationship both at 5% levels
r≤1	r>1	34.55	47.85	
Maximum Eigen Value Statistic Test				
r=0	r=1	52.98	33.87	one Co-integrating Relationship both at 5% levels
r=1	r=2	21.03	27.50	
With intercept and trend				
Trace Statistic Test				
r=0	r>0	115.10	88.80	one Co-integrating Relationship

r≤1	r>1	60.65	63.87	at 5% levels
Maximum Eigen Value Statistic Test				
r=0	r=1	54.45	38.33	One Co-integrating Relationship at 5% levels
r=1	r=2	28.87	32.12	

Source: Monthly Economic Trends, BB, Annual Report of BB and Bangladesh Bank Quarterly, BB.

The results of the Johansen cointegration test are reported in table-5. In both cases with intercept & intercept and trend the trace statistics and maximum eigen value test suggest that there is at least one cointegration relation at 5 percent level of significance between the variables. Therefore, the long-run relationship exists in the system.

Since the variables are co-integrated, VEC model is appropriate for estimating credit reaction function.[8]

Estimation of Credit Reaction Function

We estimated the credit reaction function equation- (1) in a VEC framework to check the long run relation and short run adjustment.

Estimated Normalized Co integrated Credit Reaction Function

$lnNDA = -0.11\ lnNFA + 1.24\ lnip - 0.004 exrate - 0.007\ repo + 0.007\ trend$ ………………..(2)

s.e = (0.06)   (0.15)   (0.002)   (0.004)   (0.002)

The estimated coefficient (β) of credit reaction function results show that there exist a long run relationship between NDA and NFA which statistically significance at 10 percent level. The estimated coefficient of NFA is -0.11. It indicates that the long run elasticity of NFA for the NDA is 11 percent. It also indicates extent of sterilized intervention in the foreign exchange market.

The short run estimated coefficient and error correction of the credit reaction function from VEC model are presented in table-5. From the results, we find that the speed of adjustment of NDA is 5.4 percent which indicates that NDA moves towards equilibrium by adjusting 5.4 percent in every month. The short run estimated coefficient of NFA is 0.05 which is significance at 10 percent level. It appears the short run extent of sterilized intervention (about 5 percent) in foreign exchange market.

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[8] When variable are integrated and if one of their co-integrated vector is not zero ($β_{ik} \neq 0$) then applying VAR by differencing is inappropriate (Enders, 2004)

Table-5 : Vector error correction estimation

	ΔlnNDA	ΔlnNFA	Δlnip	Δexrate	Δrepo
ect (E-1)	**-0.054321**	0.077520	0.809578	2.398058	-0.520818
	(0.03386)	(0.11927)	(0.15139)	(2.11212)	(1.89421)
ΔlnNDA	-0.067936	-1.275828	-0.149875	6.938400	6.783427
	(0.10516)	(0.37043)	(0.47018)	(6.55966)	(5.88289)
ΔlnNFA	**-0.051198**	-0.197005	-0.294174	-2.911271	-0.291188
	(0.03053)	(0.10755)	(0.13651)	(1.90447)	(1.70798)
Δlnip	-0.069558	0.190866	0.329382	1.31764	0.133998
	(0.03294)	(0.11604)	(0.14728)	(2.05479)	(1.84279)
Δexrate	-5.08	-0.000221	0.006684	0.063947	0.109497
	(0.00168)	(0.00591)	(0.00751)	(0.10472)	(0.09392)
Δrepo	-0.002168	0.002256	-0.016968	0.062081	-0.226319
	(0.000183)	(0.00646)	(0.00819)	(0.11431)	(0.10252)
Constant (c)	0.017189	0.031500	0.003712	0.275156	-0.023986
	(0.00354)	(0.01249)	(0.01585)	(0.22112)	(0.19831)

Note: Figure in parenthesis indicates standard error and ect = error correction term.

Section VI: Conclusion

The main objective of the paper was to analyze the extent of sterilized intervention in foreign exchange market of BB to offset the monetary expansion by the reserve accumulation in BB's balance sheet. The extent of sterilization is estimated by applying Johansen Cointegration technique and Vector Error Correction (VEC) model.

The paper finds that there exist a long run relationship between NDA and NFA which statistically significance at 10 percent level. The long run elasticity between NFA and NDA shows an extent of sterilized intervention about 11 percent in the foreign exchange market.

The analyses of sterilized intervention in Asian countries point out that the extent of sterilized intervention in Bangladesh is lower than that of Asian countries (table-1). Regarding this lower sterilized intervention, the paper opines that BB's intervention in the foreign exchange market mainly to resist the appreciation of Taka.

Sometimes the extent of sterilized intervention depends on the objectives of monetary policy. If the aim of monetary policy of BB is to maintain the exchange rate at desired level then this lower level of sterilization may not be concerned. On the other hand, if the aim is to maintain price level, this lower level of sterilization may be concerned for BB. Since there is a policy dilemma

of intervention in foreign exchange market, i.e., at the same time it is not possible to achieve price stability and to resist appreciation of taka. So the extent of sterilization of BB may be concerned for achieving price stability in the long run.

Besides, sterilization operations incur some costs. BB uses reverse repo to mop up excess liquidity from the banking system and reverse repo rate is the cost for BB. Considering sterilization cost and policy objectives, speed of sterilization may be geared up by the BB.

References:

Alice Y Ouyang, Ramkishen S. Rajan &Thomas D. Willett (2006). China as a Reserve Sink: The evidence from offset and Sterilization Coefficients. Retrieved from http:// www.rfets.go.jt.

Asad Jan, Ather Elahi and M.A.Zahid (2005). Managing Foreign Exchange Inflows: An Analysis of Sterilization in Pakistan. *The Pakistan Development Review* 44:4 Part II(Winter 2005) pp.777-792.

BB: Bangladesh Bank, Annual Report (various issues).

BB: Bangladesh Bank, Economic Trends (various issues).

BB: Bangladesh Bank, Bangladesh Bank Quarterly (various issues).

BB, Monetary policy statement, July-December 2013.

Calvo, G. and Reinhart, s.,(2002).Fear of Floating", *The quarterly Journal of Economics*, 12: 379-408.

Enders, Walter (2004). *Applied Econometric Time Serie*s, 2nd Edition, Chapter 6, pp-330, John Willy &Sons, New Delhi.

Hamed Taheri (2012).Assessing the Sterilization Policy of the Central Bank in Iran. Retrieved from http:// www.cbi.ir

IMF*:* International Monetary Fund, IMF Institute 2007, Financial Programming and Policies.

IMF*:* International Monetary Fund, country report No 14/149, June 2014.

Islam, Md. Ezazul (2009). Monetary Transmission Mechanism and Monetary Policy in Bangladesh. A Ph. D Dissertation, Submitted to Jahangirnagar University, Dhaka, October 2009.

Islam, Md. Ezazul (2008). Money Supply Process in Bangladesh: An Empirical Analysis. WP 0805, Policy Analysis Unit Bangladesh Bank.

Islam Md. Aminul (2010). Monetary Policy and Money Supply Process in Bangladesh: An Analytical Review.. A Dissertation of MA, Submitted to the Institute of Governance Studies, BRAC University, Dhaka, December 2010

.Sahadevan, K.G (2001).Foreign Exchange Intervention and Future Monetary Policy: Some Empirical Evidence on Signaling Hypothesis. ganga.iirnl.ac.in

Mansour Layal (2012). Hoarding of International Reserves and Sterilization in Dollarized and Indebted Countries: An Effective Monetary Policy? Documents de travail working papers WP 1208.http://www.gate.cnrs.fr.

MoF: Ministry of Finance, Economic Review (various issues).

Waheed Muhammad (2007). Central Bank Intervention, Sterilization and Monetary Independence: The case of Pakistan. MPRA, 2007.

Waheed Muhammad (2010). Foreign Exchange Intervention and Sterilization: An Investigation of State Bank of Pakistan's Reaction Function. MPRA, 2010.

Muhammad Saim Hashmi, Changsheng, Muhammad mahroof Khan, Mohsin Bashir & Faheem Ghazanfar (2011). Monetary Policy Reaction Function and Sterilization of Capital Inflows: An Analysis of Asian Countries. *Asian Social Science* Vol. 7, No. 9, September 2011.

Obstfeld, M., and K.S. Rogoff (1996). Foundations of International Macroeconomics. The MIT press.

Prabheesh. K. P amd Mlathy .D (2009). International Reserve Accumulation and Money Dynamics: An Empirical Investigation in Indian Context.. The paper presents in the 11th annual conference of money and finance in the Indian economy, Indira Gandhi Institute for Development, Research, Bombay, India, January 2009.

Ramon, Moreno (1996). Intervention, Sterilization and Monetary Control in Korea and Taiwan. *Federal Reserve Bank of Sanfrancisco Center forPacific Basin (FRBSF) Economic Review* 1996, No.3.

Robert Lavigne (2008). Sterilized Intervention in Emerging-market Economics: Trends, Costs and Risks. Bank of Canada Discussion Paper 2008-4 March (2008).

Box-1

Net Policy Tools Effect on RM		
Name of Policy Tool	Increase(+)	Decrease(-)
1. **Repo** Issue Maturity	+	-
2. **Reverse repo** Issue Maturity	-	+
3.**G –T bill/bond** Issue Maturity	-	+
4. **BB bill** Issue Maturity	+	-
5.**Foreign exchange market intervention** Purchase Sale	+	-

Source: Islam, (2009).

Table-1 : Trends in rates of Instruments for liquidity management

Year	CRR	Govt.-T bill				repo	Reverse repo
		28-day	**91-day**	**182-day**	**364-day**		
1985	5.00	-	-	-	-	-	-
1986	5.00	-	-	-	-	-	-
1987	5.00						
1988	10.00	-	-	-	-	-	-
1989	10.00	-	-	-	-	-	-
1990	10.00	-	-	-	-	-	-
1991	7.00	-	-	-	-	-	-
1992	6.00	-	-	-	-	-	-
1993	5.00	-	-	-	-	-	-
1994	4.00	-					
1995	4.00	-	-	-	-	-	-
1996	4.00	-	-	-	-	-	-
1997	4.00	-	-	-	-	-	-
1998	4.00	8.31	-	-	-	-	-
1999	4.00	7.51	8.46	8.87	8.87	-	-
2000	4.00	6.05	6.35	7.06	7.06	-	-
2001	4.00	6.33	6.84	7.10	7.10	-	-
2002	4.00	4.81	5.25	5.50	5.73	-	-
2003	4.00	7.00	8.82	9.27	9.90	4.9	3.67 (4.83)
2004	4.00	3.99	5.00	5.99	6.30	4.63	2.5 (2.84)
2005	5.00 (1.10.2005)	6.60	5.45	6.75	7.00	8.00	4.5 (4.63)
2006	5.00	7.10	7.43	7.75	8.30	8.00	6.04 (6.29)
2007	5.00	7.32	7.60	7.89	8.48	8.50	6.50
2008	5.00	7.5	7.74	7.97	8.48	6.50	6.50
2009	5.00	-	7.93	8.16	8.60	8.5	6.50
2010	5.5(15.5.2010) 6.00(15.12.2010)	-	2.42	3.51	4.24	4.5	2.5
2011	6.00	-	6.75	7.00	7.30	6.75	4.75
2012	6.00	-	11.37	11.40	11.40	7.75	5.75
2013	6.00		8.45	10.23	10.36	7.25	5.25

Source: Bangladesh Bank Quarterly & Annual Report, BB, Figure in parenthesis shown (3-9 day rate)
28-day T-bill auction has been suspended from July, 2008.
- Not available.