RAE REVIEW OF APPLIED ECONOMICS
Vol. 13, Nos. 1-2, (January-December 2017)

CAPITAL MOVEMENT AND STERILIZATION POLICIES IN PAKISTAN: EVIDENCE FROM FREE FLOAT EXCHANGE RATE REGIME

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Abstract: *In this paper, we evaluated the Central Bank response to capital movement using monthly data from August 2000 to December 2013 and Johansen cointegrating approach. The objective was to estimate magnitude of sterilization policies the Central Bank implemented during recently adopted free float exchange rate regime. Results provide evidence of long run cointegrating vectors among the variables of interest. Normalized cointegrating vector shows partial sterilization, that is the Central Bank mitigated fifty four percent effect of foreign capital inflows on domestic monetary base. This may reflect the Central Bank fear of negative effects of unsterilized capital inflows on domestic macroeconomic indicators.*

JEL Classification*: E4, E5, N2.*

Keywords*: Central Bank, Sterilization, Net Domestic Assets*

1. INTRODUCTION

Emerging market economies reserve accumulation went up during 2000 to 2004 due to their current account surplus. This resulted relevant countries' central bank foreign exchange intervention to avoid appreciation of their currencies (Mohanty and Turner, 2005). Pakistan's foreign exchange reserves also increased substantially during the same period due to its alignment with Western countries in theirwar on terror. Sanctions imposed on the country after it went nuclear on 28th May, 1998 were lifted and foreign aid suspended during the decade of 1990s due to collapse of the Union of Soviet Socialist Republic (USSR) was resumed. As a result Pakistan's foreign exchange reserves which stood at US $ 1513.23 million rose to US $ 3640.03 million by end of 2001. Foreign exchange reserve further went up to US $ 8078 million in 2002 thus registering 121.92 percent growth within one year.

The unprecedented rise in Pakistan foreign exchange reserve accumulation continued till 2007. However, capital started flowing out due to assassination of country's first female prime

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ministerand ensuing political turmoil and unrest under President Musharraf. Within one year reserves fell from US $ 14044 million in 2007 to 7192.24 million in 2008. Subsequent years saw increase in foreign exchange reserves due to external borrowing and devastating floods in 2010, 2011 and 2012 followed by decline due to debt repayment to International Monetary Fund in 2013.

Foreign exchange reserve accumulation has implications for domestic macroeconomic indicators. It helps recipient country to bridge saving investment gap, enable highly indebted countries' to meet their external obligations and precautionary needs and maintain stable exchange rate (Calvo *et al.* 1994 and 1996; Lee, 1996; Khan, 1996; Altýnkemer, 1998; Khan and Ahmed, 2005; Aizenman and Glick, 2009; Zhang, 2010; and Rizvi *et al.* 2011). Unsterilized foreign exchange reserve accumulation results in; increase in money supply, exchange rate appreciation, rise in prices, reduction in export competitiveness, increased speculative activities, financial market disruption, and the Central Bank inability to conduct an independent monetary policy (Calvo *et al.*, 1994; Lee, 1996; Ljubaj *et al.* 2010; Zhang, 2010; Altýnkemer, 1998).

Monetary authorities most often sterilize their foreign exchange interventions to avoid negative effects of reserve accumulation on domestic macroeconomic indicators. For sterilized intervention policy to be effective and successful it must be coordinated with monetary policy. However, such coordination may not be possible due to; (a) conflict between exchange rate and monetary policy objectives, (b) distraction risk, and (c) wrong signaling to market agents.

Given foreign exchange reserve behavior and constraints monetary authorities face insulating domestic monetary base from the effects of foreign capital inflows, this paper aims to estimate sterilization coefficient from monetary policy reaction function for Pakistan. Sterilization coefficient indicates monetary authorities' ability to mitigate the effects of foreign capital inflows on domestic monetary base. Larger sterilization coefficient is consistent with monetary authorities' larger control on capital inflows and theirability to conduct an independent monetary policy and vice versa. It also enables us to evaluate efficacy of the Central Bank's intervention in domestic financial market.

Earlier studies estimating sterilization coefficient for Pakistan are limited in their scope. They have either focused on both managed float and free float or only free float for small sample period. For example Hashmi *et al.* (2011) estimated sterilization coefficient for Pakistan, Japan, Korea and Philippine using quarterly data from 1980Q1 to 2007Q1. Similarly, Jan *et al.* (2005) estimated sterilization coefficient for Pakistan from July 2000 to December 2003, Qayyum and Khan (2003) from 1982Q3 to 2001Q2 and Waheed (2010) from January 2001 to June 2007. Contrary to these studies, this paper primarily focuses upon free float and utilizes Johansen-Juselius cointegration approach for estimating sterilization coefficient for Pakistan using monthly data from August, 2001 to December, 2013.

Rest of the paper proceeds as: in section 2 we discuss sterilization channel followed by discussion on capital movement and monetary policy in Pakistan in section 3. Literature review is given in section 4. Model derivation and discussion is given in section 5 and section 6 provides details about data used in the paper. Discussion on results is given in section 7 and section 8 concludes.

2. CHANNELS OF STERILIZATION

The surge in foreign capital inflows has both positive and negative effects on domestic macroeconomic indicators. Monetary authorities of the recipient countries' most often intervene in foreign exchange market and purchase foreign currency against domestic currency (Sarno and Taylor, 2001; and Neely, 2000). Such foreign exchange interventions could either be sterilized or unsterilized. Unsterilized intervention affects domestic monetary base by extent of purchase and sale of foreign exchange reserves. Sterilized intervention however, neutralizes the effects of changes in foreign assets on domestic monetary base. However, the effectiveness of sterilized interventions has always remained a controversial issue in empirical literature on capital inflows as it is not considered direct monetary policy tool. It works through portfolio balance channel, signaling or expectation channel, coordination channel and noise trading or market micro structural channel.

Portfolio Balance Channel (PBC) holds that investors have choice to invest their wealth either in domestic money, domestic bonds or foreign assets. The choice of holding wealth between domestic and foreign assets depends on expected returns and risk associated with them. It works effectively (a) when domestic and foreign assets are imperfect substitutes and (b) Ricardian equivalence does not hold. Further, PBC assumes that investors are risk averse and require risk premium to hold foreign assets.

Expectation or Signaling Channel on the other hand, holds that sterilized interventions would affect exchange rate even if foreign and domestic bonds are perfect substitutes. Sterilized intervention indirectly impacts market price of domestic currency by changing market agents' expectations (Musa, 1981). It is based on two assumptions (a) the Central Bank has proper information about market and monetary policy and (b) monetary authorities intervention stance is only source of information for market agents. Thus the Central Bank through its foreign exchange interventions provides information about change in monetary policy stance to market participants and thus influence their expectations. In addition to actual interventions, policy announcements could also convey signal and influence market agents' expectations about exchange rate. To be effective, intervention intentions must be pronounced quite often and must be credible. Incredible pronouncements will convey wrong information and will result increase in exchange rate volatility.The essence of signaling channel lies in the fact that sterilized interventions or/and announcements should aim to provide signals/information about exchange rate fundamentals or stance of monetary policy (Mussa, 1981). Financial integration, availability of superior information to the Central Bank and consistent and credible monetary policy are prerequisites for effective sterilization policy through signaling channel. Further the sterilization measures must be carried out in coordination with foreign exchange market participants and monetary authorities of other countries, (Sarno and Taylor, 2001). Failure to do so provides rationale for coordination channel.

Coordination channel is mainly based on scholarly work of Taylor (1995a and 1995b) and Sarno and Taylor (2001). It presumes that sterilized intervention through coordination channel can be effective when the traditional signaling and portfolio balance channel fail to deliver. Unlike signaling channel, coordination channel assumes equal access of both Central Bank and market agents to information which implies that central banks do not have superior information

than economic agents in an economy. Same like signaling channel, coordination channel also assumes that for sterilized intervention to be successful, it must be detected by foreign exchange market participants (Fatum, 2010).

To understand coordination channel, assume a situation in which coordination failure has resulted deviation of exchange rate from the level consistent with underlying macroeconomic fundamentals or equilibrium level and foreign exchange market participants are reluctant to take risk of entering into the market and force exchange rate realignment.In such a situation, the central bank has to play a coordinating role (Sarno and Taylor, 2001; Reitz and Taylor, 2008). Monetary authorities have to announce publically detectable intervention that builds foreign exchange market participants' confidence and encourage them to re-enter the market to revert the deviated exchange rate to its equilibrium level. Such an action of the Central Bank if coordinated with market agents brings exchange rate realignment. However, for coordination channel to be effective, it is important that intervention must be detected by foreign exchange market participants. Hence the effects of detected intervention through coordination channel are stronger than undetected intervention.

Market microstructure is fourth channel of transmission/sterilization. Contrary to coordination channel that focuses upon foreign exchange market participants familiar with macroeconomic fundamentals, noise trading channel focuses on non-fundamentalists. The non-fundamentalists also called chartists or technical analysts see foreign exchange market from technical perspective. Instead of macroeconomic fundamentals, non-fundamentalists follow herd behavior (Popper and Montgomery 2001, Schmidt and Wollmershauser, 2004) which results noise trading and pushes exchange rate away from its equilibrium level. In such a situation, noise-trading channel recommends the central bank's intervention to reverse exchange rate in direction warranted by macroeconomic fundamentals. For intervention to be effective, it must remain undetected and increase exchange rate volatility to manipulate non-fundamentalist traders (i.e. noise traders or chartists) to second-guess strength and duration of (from monetary authorities perspective) undesirable exchange rate trend (Fatum, 2010). Hence if intervention works through noise-trading, effects of undetected interventions will be stronger than those of detected interventions.

3. CAPITAL MOVEMENT AND MONETARY POLICY IN PAKISTAN

Pakistan forex reserves have remained volatile during the period under study. During initial years, Pakistan witnessed massive capital inflows followed by contraction in later years. There was external account surplus of US $ 2.7 billion in June 2001 compare to US $ 0.3 billion in previous year. The rise in surplus was due to KERB premium collapse; channeling of foreign workers remittances through banking channel; better relations with major international creditors; and re-profiling of country's external debt by Paris Club due to successful population growth fund negotiations. Surplus external account swamped the market with foreign currency and the Central Bank has to intervene to avoid appreciation of domestic currency. The Central Bank purchased net foreign assets of Rs. 234 billion end Fiscal Year (FY hereafter) 2000 and neutralized its effect on domestic monetary base by reducing net domestic assets by Rs. 287 billion.

Surplus balance of payments (BoP hereafter) in FY 2001 further increased to US $ 2.7 billion in FY 2002 and reached to US $ 4.6 billion in end-June FY 2003. As a result the Central

Bank reserve reached to US $ 9997 million. The central bank actively intervened in foreign exchange market to avoid appreciation of domestic currency against the US $. The intention was to maintain competitiveness of domestic exporters in international market. The central bank transactions amounted to RS 236 billion out of which Rs 206.3 billion were sterilized. As a result, reserve money registered growth of only Rs 84.9 billion and exchange rate appreciated by 3.9 percent end-June 2003.

Liquid foreign exchange reserves of the country registered increase of US $ 1609 million and reached to US $ 12, 328 million end-June 2004. Drop in liquid reserves was due to weakness in external account owing to exceptional outflows than from weakness in foreign exchange inflows. In fact total inflows of $ 25.6 billion during FY 2004 were higher than inflows of US $ 25.2 billion in previous fiscal year. A sharp increase in outflows due to current account deficit and external debt payment put pressure on domestic currency to depreciate. In a bid to reduce depreciating pressure, the Central Bank reduced its purchase of foreign currency and was in fact net seller of foreign exchange in last quarter of FY 2004. Over all the central bank purchased US $ 897 million in FY 2004 compare to US $ 4546 million last fiscal year. Broad money registered growth of 19.6 percent during the year. Net Domestic Assets (NDA) contributed Rs. 364.3 billion compare to Rs 8.4 billion last year. However, Net Foreign Assets (NFA) contributions to broad money totaled Rs 43.5 billion compare to Rs 308.9 billion in previous year. Hence the monetary authorities neutralized drop in NFA contributions to broad money growth by increasing its domestic components that is NDA.

Rise in prices, increase in oil imports and speculative forward buying behavior put pressure on domestic currency to depreciate. The Central Bank intervened in the market and footed import bill amounting US $ 2.6 billion end-June FY 2005. Over all the central bank remained net supplier of forex reserves which dropped by US $ 629 million to US $ 10.482 billion end-June FY 2005. This brought some stability to rupee-dollar parity that stabilized around Rs 59.50 per US $ after reaching Rs 61.30 per US $ in November, 2004. Overall money supply registered 19.3 percent growth which amounted to Rs 479 billion. Monetary authorities neutralized the effect of drop in State Bank of Pakistan (SBP) NFA on domestic money supply by increasing its domestic component. NDA contributed Rs 425.3 billion and rest of Rs 53.7 billion were contributed by NFA.

The country's foreign exchange reserves increased by US $ 520 million due to rise of US $ 969 million in SBP forex reserves. The Central Bank selling of foreign currency amounted to US $ 9 billion more than two third of which was used for lumpy oil payments. The Central Bank met substantial part of this market support through interbank forex purchases that stood at US $ 6.1 billion end-June 2006. Injection of foreign currency brought some stability to domestic currency that depreciated by 0.87 percent and closed at Rs 60.2138 per US $ end-June 2006. In real terms domestic currency appreciated due to rise in domestic prices. Money supply increased by Rs 450.1 billion during the entire year. NFA and NDA each contributed Rs. 51.5 billion and Rs 398.6 billion to total money growth. Hence, monetary authorities neutralized the effect of sale in forex reserves on money growth by increasing NDA.

Pakistan's forex reserves increased by US $ 2.524 billion due to rise of US $ 2.580 billion in SBP reserves mostly accumulated in second half of FY 2007. As a result liquid reserves of

the country increased from $ 13.1 billion to $ 15.6 billion. Increase in forex reserve brought some stability to exchange rate parity that depreciated by 0.25 percent depreciation compare to 0.87 percent in preceding year. Phenomenal rise of Rs 658.2 billion (19.3 percent growth) in M2 due to changes in NFA more than offset the visible slowdown in net domestic assets of the banking sector which reduced excess demand pressure in the economy and shifted Central Government budget financing towards non-bank sources. Sharp rise in net foreign assets however, did not cause proportional rise in reserve money due to fiscal authorities' retirement of SBP loan and the Central Bank sterilization measures. In fact rise in reserve money due to increase in NFA (of Rs 159.1 billion) was partially neutralized through retirement of government loan worth Rs 80.6 billion to SBP and the central bank repo sale of government securities of Rs 61.8 billion.

The country's foreign exchange reserves experienced fall of US $ 5.1 billion and reached to US $ 11.4 billion end-June 2008 due to rise in current account deficit and substantial fall in financial account surplus. As a result, exchange rate depreciated by 11.5 percent during the year. Reserve money increased by 21.5 percent during the year. Slow growth in reserve money due to drop in NFA was offset by 46.9 percent increase in NDA. Similarly, broad monetary aggregates registered growth of 15.3 percent and totaled Rs 624 billion during the year. Reduction of Rs 317.4 billion (slightly higher than fall of Rs 307 billion in SBP NFA) in M2 due to NFA was neutralized by increase in NDA totaling Rs 941.4 billion. Government borrowing from SBP reached to Rs 688.7 billion end-June 2007. As a result stock of market treasury for replenishment (MRTBs) with SBP increased from Rs 452.1 billion end June 2007 to Rs 1053 billion end-June 2008. Repo rate remained volatile during the entire year due to squeeze of market liquidity because of fall in NFA and increase in rupee injection due to rise in government borrowing.

External account of the country showed volatile behavior during the fiscal year 2009 due to varying behavior of its components. During July-October 2008, current account deficit deteriorated due to higher imports and fall in financial inflows. As a result, country's forex reserves depleted and domestic currency depreciated by 16.3 percent against US $ in foreign exchange market. The deficit was so severe that it impacted country's ability to meet its external obligation and given global financial constraints, the country was left with no option but to resort to International Monetary Fund for averting BoP crisis. However, BoP turned in surplus in second half of fiscal year 2009 despite SBP's oil support of US $ 9.2 billion and Eurobond payment of US $ 500 million. Surplus BoP occurred due to inflows from IMF (US $ 3.9 billion), Asian Development Bank (US $ 1.5 billion), International Development Assistance (US $ 708 million) and logistic support (US $ 913 million). Broad money (M2) increased by Rs 448 billion. Drop in NFA contribution of Rs 150 billion to M2 supply was more than offset by increase in NDA totaling Rs 598 billion. As a result overall outstanding stock of Market Related Treasury Bills increased to Rs. 1107.9 billion end-June 2009 from Rs 1053.1 billion in preceding year.

The country's forex reserves increased by US $ 4.1 billion and reached to US $ 16.9 end-June 2010 due to fall in trade deficit, substantial increase in remittances, inflows from the IMF and rise in encashment of SDR quota. Despite rise in forex reserves, the Central Bank net market interventions declined from US $ 3.3 billion in FY 2009 to US $ 263 million end June

2009 due to shift of oil payments to interbank market. As a result domestic currency parity against US $ remained stable and depreciated only by 4.8 percent during the entire sample period compared to 15.7 percent in the preceding year.

Foreign exchange reserves of the country further improved during fiscal year 2011 and reached to US $ 18.2 billion compare to US $ 16.9 billion last year due to surplus current account and financial account. SBP's net purchase of hard currency due to surplus external account and absence of oil payments contributed stability to rupee-dollar parity and nominal exchange rate depreciated by 0.7 percent during the entire year. Overall broad money registered increase of Rs. 911 billion. NFA and NDA each contributed Rs 235 billion and Rs. 682 billion to overall broad money growth. Hence we conclude that substantial increase in broad monetary aggregate due to NFA was offset by slow growth in NDA.

Pakistan's liquid foreign exchange reserves declined from US $ 18.2 billion in FY 2011 to US $ 15.3 billion end-June 2012 due to; (a) SBP's market support; (b) fall in multilateral inflows from US $ 5.3 to US $ 3.7 billion and (c) 5.8 billion external debt servicing. As a result Pakistan exchange rate depreciated by 9.1 percent against US $ compare to nominal depreciation of 0.7 percent last year. Fall of Rs 235 billion in broad money supply due to depletion of country's forex reserves was compensated by increase of Rs 1200.2 billion (Rs 682 billion previous year) in NDA during the year.

Fall in country's forex reserves witnessed during FY 2012 also continued during FY 2013 due to US $ 2.0 billion external account deficit and repayment of US $6 billion external debt to IMF and other International Financial Institutions. As a result domestic currency depreciated and surpassed the value of Rs 99.1 per US $ on 28th June, 2013. The Central bank increased its NDA by Rs 1477.3 billion (compare to Rs 1200.2 billion in preceding year) to neutralize the effect of fall in broad money due to decline of Rs. 263.3 billion in NFA.

4. LITERATURE REVIEW

Central Banks are fully authorized to fully, partially or not to sterilize effects of foreign capital inflows on domestic monetary base. Despite frequent use, sterilization measures have always remained controversial in empirical literature. Proponents of sterilization policies argue that it is an additional instrument available to monetary authorities to conduct an independent monetary policyin financially integrated world. Opponents of sterilization policies on the other hand, argue that such policies may be successful in short run but cannot be sustainable in long run without necessary macroeconomic adjustments. Despite their pros and cons,monetary authorities around the world have frequently followed sterilized interventions for mitigating effects of foreign capital inflows on domestic macroeconomic indicators.

Altınkemer (1998) estimated Central Bank of Republic of Turkey monetary policy reaction function from 1990 to 1994. He divided the entire sample into two sub-samples February 1990 to October 1993 and April 1994 to June 1998. Ordinary least square estimates show sterilization coefficient of 1.04 and 0.93 for first and second sample period respectively. Aizenman and Glick (2009) found significant increase in sterilization coefficient for selected Asian and Latin American countries. Further the sterilization coefficient for Foreign Direct Investment (FDI) was lower than for current account surpluses and other non-FDI inflows. Cumby and Obstfeld

(1981) empirically studied Banco de Mexico monetary policy reaction function during 1970s and found that monetary authorities' sterilized effects of reserve flows on domestic monetary base at least during second half of the decade. The estimated model showed 30 to 50 percent offset coefficient in the same quarter. However, long run offset coefficient ranged between 50 to 76 percent. Siklos (2000) used OLS method and found almost full sterilization of capital inflows by Central Bank of Hungary during 1990-1995.

Qayyum and Khan (2007) applied Johansen cointegration method on quarterly data from 1982Q3 to 2001Q1 and found monetary authorities in Pakistan sterilized 72 percent effect of foreign capital inflows on domestic monetary base. Hashmi *et al.* (2011) also applied same method on quarterly data from 1980Q1 to 2007Q1. The estimated sterilization for Pakistan was 0.83. Jan *et al.* (2005) on the other hand, used monthly data from July 2000 to December 2003 and ordinary least square method for estimating sterilization coefficient for Pakistan. The result show partial sterilization and sterilization coefficient of 0.875. Waheed (2010) followed Generalized Method of Moment for estimating sterilization coefficient from monthly data ranging between January 2001 and June 2007. Theresults indicate that monetary authorities sterilized 69 percent effect of foreign capital inflows on domestic monetary base.

Wu (2006) evaluated People's Bank of China sterilization policy using cointegration approach and found that monetary authorities sterilized 41 percent effect of changes in capital inflows on domestic monetary base. Ouyang *et al.* (2006) also estimated sterilization coefficient for China applying two stage least square method on monthly data between mid 1999 to late 2005. They estimated three different specifications using perfect foresight, static and forward looking expectations and found sterilization coefficient averaging in range of 0.92 and 0.87. Recursive estimates of sterilization coefficient ranged from0.5 during 2003 to almost unity by end of the year. Furthermore, the recursive estimate of sterilization coefficient was stable at 0.9 from early 2004 and onwards. Zhang (2010) also studied degree of sterilization in China using quarterly data from 1995 to 2010 and two stage least square method. Results indicate sterilization coefficient averaging between 0.793 and 0.934.

5. MODEL SPECIFICATION

There are two approaches to evaluate the central banks' sterilization policies. First approach developed by Kouri and Porter (1974 hereafter KP) is based on a net capital flow equation and examines how changes in NDA influence capital inflows from abroad. KP (1974) synthesizes Branson (1968) stock equilibrium approach to capital flows and Mundell (1968) monetary approach to balance f payments. The model focuses on mechanism through which small economy financial market equilibrium is achieved. It assumes three kinds of financial assets in the economy including domestic bonds, foreign bonds and money base. Moreover, the model postulates stationary expectations about exchange rate and price level. In such an economy, allocation of financial wealth among alternative financial assets is determined by stock of wealth, income, domestic and foreign interest rates and other exogenous variables. This allocation works through market mechanism of demand and supply of base money, domestic bonds and foreign bonds which gives rise to a system of 11 structural equations of demand and supply of these assets.

Cumby and Obstfeld (1981) developed the second approach and it estimates sterilization coefficient from Central Bank's monetary policy reaction function. This approach evaluates

only the magnitude of sterilization policy of a central bank to neutralize the impact of exchange rate intervention on monetary base. In other words, this approach studies how the central bank of a country responds to changes in domestic monetary base brought about by capital inflows. It does not take into account the effects of sterilized intervention on capital flows which is measured by offset coefficient.

Contrary to Kouri and Porter (1974) and Cumby and Obstfeld (1981),we use monetary approach to balance of payment and derive monetary policy reaction function for examining the Central Bank sterilization policy. Assume:

$$M_t^d = AY_t^{\beta_1} Q_t^{\beta_2} \exp(-\beta_3 i_t + \beta_4 i_t^*) + u_t \tag{1}$$

$$M_t^s = D_t F_t \tag{2}$$

In equation (1), money demand (M_t^d) is associated with domestic real income, real exchange rate (Q_t), domestic interest rate (i_t) and foreign interest rate (i_t^*). *A* is a scale factor. The slope parameters β_1, β_2, β_3 and β_4 are assumed constant elasticities.

Equation (2) shows that money supply consists of two components namely domestic credit and foreign exchange reserves. Following empirical exchange market pressure literature, we assume money multiplier to be constant. Taking logarithm of equation (1) and (2) yields:

$$LnM_t^d = LnA + \beta_1 LnY_t + \beta_2 LnQ_t - \beta_3 Lni_t + \beta_4 Lni_t^* + u_t \tag{3}$$

$$LnM_t^s = LnD_t + LnF_t \tag{4}$$

Equation (3) and (4) can be written in small letters as:

$$m_t^d = \beta + \beta_1 y_t + \beta_2 q_t - \beta_3 i_t + \beta_4 i_t^* + u_t \tag{5}$$

$$m_t^s = d_t + f_t \tag{6}$$

Equation (6) can be written as:

$$f_t = m_t^s - d_t \tag{7}$$

Equation (7) provides a link between domestic component (d_t) and foreign component (f_t) of monetary base. It indicates that any increase in foreign component of monetary base must be accompanied with equal and opposite change in its domestic component for money supply to remain unchanged.

Equating money demand to money supply and rearranging the resulting equation for domestic component of monetary base yields:

$$d_t = \beta + \beta_1 y_t + \beta_2 q_t - \beta_5 (i_t - i_t^*) - \beta_6 f_t + v_t \tag{8}$$

$$\beta_5 = \beta_3 + \beta_4 .$$

Assuming $id_t = (i_t - i_t^*)$, we can write equation (8) as:

$$d_t = \beta + \beta_1 y_t + \beta_2 q_t - \beta_5 id_t - \beta_6 f_t + v_t \quad (9)$$

Where lower case letters represent logarithms of variables used in equation (9). Equation (9) is a monetary policy reaction function most often used in empirical studies evaluating Central Banks' response to foreign capital inflows. Domestic credit (d_t) is Central Bank's policy variable in thisfunction and f_t denotes foreign assets. Monetary policy reaction function establishes negative relationship between d_t and f_t. An increase in f_t must be accompanied with an equal decrease in d_t and vice versa for monetary base to remain unaffected. β_6 is sterilization coefficient and ranges between 0 and -1. $\beta_6 = -1$ implies complete sterilization and $\beta_6 = 0$ suggests no sterilization. $0 < \beta_6 < -1$ is consistent with partial sterilization. β_1 is expected to be positive because an increase in manufacturing production index (mpi_t) cause net domestic assets to rise (Ljubaj *et al.* 2010). β_5 is uncertain a priori. $\beta_5 < 0$ if $i_t > i^*_t$. This means a higher domestic interest rate attracts foreign capital flows and thus forces monetary authorities to pursue strong sterilization in sense of reducing net domestic assets to maintain domestic monetary base unchanged (Ljubaj *et al.* 2010). $\beta_5 > 0$ if $i_t < i^*_t$. Higher foreign interest rate resultscapital outflow and thus force the Central Bank to increase NDA to maintain same level of money supply in the economy (KP, 1974). Real exchange rate coefficient (β_2) is expected to be positive because monetary authorities tend to increase domestic credit to depreciate domestic currency with a view to maintain country's competitiveness in international market (Cumby and Obstfeld, 1981).

6. DATA

Monthly data from 2000M08 to 2013M12 is used. The choice of sample is motivated by Pakistan's change in exchange rate regime from managed float to free float on 17th July, 2000 and its alignment with Western countries in their war against terror that resulted massive capital inflows and the Central Bank's frequent interventions in foreign exchange market. Our objective in this paper is to check whether such intervention were sterilized or unsterilized. All data is taken from International Monetary Fund International Financial Statistic CD ROM and is used in log form. Manufacturing production index is used to proxy national income due to unavailability of latter at monthly level. Linear interpolation and X12 ARIMA seasonally adjustment programme was used for filling up missing values and seasonal adjustment of MPI. Other variables include net domestic assets, net foreign assets, interest rate differential and real exchange rate. Real exchange rate refers to nominal exchange rate adjusted with foreign to domestic price ratio. Interest rate differential (id_t) is a difference between the US three month commercial paper rate and Pakistan call money rate ($id_t = i^*_t - i_t$).

7. RESULTS

We use Johansen (1988) and Johansen and Juselius (1990) multivariate cointegration and error correction approach for estimating number of cointegrating relationships and normalized cointegrating vector among variables of interest (in our case id_t, mpi_t, nda_t, and q_t). Prior to estimating number of cointegrating relationships and normalized cointegrating vector, we test if variables of interest are nonstationary $I(1)$ in levels and stationary at first difference $I(0)$

using Augmented Dickey Fuller (ADF) test. ADF tests statistics in levels and first difference with constant and constant plus trend specification are reported in table 1. It appears that all variables are nonstationary in levels. However, first difference results indicate stationary of all variables except net domestic assets (nda_t) at least in one specification.Net domestic assets on the other hand, are nonstationary even in first difference and require second differencing to become stationary. Despite differing order of integration, linear combination of nonstationary variable is still expected to yield stationary series (MacDonald, 1993).

Table 1
ADF Test in log level and log first difference

	Log Levels		*Log First Difference*	
Variable	*Constant*	*Constant +Trend*	*Constant*	*Constant +Trend*
id_t	-1.296	-2.519	-3.707	-3.701
mpi_t	-1.845	-1.161	-3.593	-3.905
nda_t	0.125	-3.198	-2.147	-2.107
nfa_t	-2.464	-2.062	-2.859	-3.331
a_t	-0.343	-1.405	-3.474	-3.361
5% critical values	-2.882	-3.440	-2.882	-3.443

Note: a denotes 5 percent significance level. One sided 5 percent critical values are taken McKinnon (1996).

Johansen-Juselius multivariate cointegrating method is sensitive to chosen lag length (Banerjee *et al.*, 1993). Therefore, we estimated unrestricted vector autoregression system for 15 lags and calculated different information criterion for up to 11 lags to find out optimal lag length.

Table 2
Lag Length Criterion

Lag	*LogL*	*LR*	*FPE*	*AIC*	*SC*	*HQ*
0	707.4850	NA	3.01e-11	-10.03550	-9.930441	-9.992807
1	1770.450	2034.819	1.10e-17	-24.86358	-24.23322*	-24.60742*
2	1791.972	39.66105	1.15e-17	-24.81388	-23.65824	-24.34426
3	1808.944	30.06472	1.30e-17	-24.69920	-23.01826	-24.01611
4	1851.510	72.36332	1.02e-17*	-24.95015*	-22.74392	-24.05360
5	1871.715	32.90538	1.10e-17	-24.88165	-22.15012	-23.77164
6	1885.494	21.45580	1.31e-17	-24.72135	-21.46453	-23.39788
7	1898.882	19.88955	1.58e-17	-24.55545	-20.77334	-23.01852
8	1913.178	20.21912	1.90e-17	-24.40254	-20.09514	-22.65214
9	1931.686	24.85330	2.16e-17	-24.30980	-19.47710	-22.34593
10	1970.343	49.14967	1.87e-17	-24.50490	-19.14691	-22.32757
11	2005.177	41.80136*	1.73e-17	-24.64539	-18.76211	-22.25460

Note: * indicates lag order selected by the criterion. LR refers to sequential modified Likelihood Ratio test statistic (each test at 5% level). FPE, AIC, SC and HQ denote Final Prediction Error, Akaike Information Criterion, Schwarz Information Criterion and Hannan-Quinn Information Criterion respectively.

It appears from the table that log likelihood ratio test suggest a VAR of 11 lags. Final Prediction Error (FPE) and Akaike Information Criterion (AIC) provide evidence of four lags.

Schwarz and Hannan-Quinn suggested optimal lag length is 2. Based on FPE and AIC, we used four lags while estimating equation 9 using Johansen cointegration approach.

As a preliminary, we tested number of cointegrating vectors for 11 lags on the basis of LR test. The results were not satisfactory. We therefore, tested the number of cointegrating vectors for

Table 3
Johansen Cointegration Test

λ_{Trace} *Rank Test*			
$H_0 : r = r_0$	$H_1 : r \geq r0$	λ_{Trace}	*95% Critical Values*
$r = 0$	$r \geq 0$	76.697	69.819
$r \leq 1$	$r \geq 1$	31.702[a]	47.856
$r \leq 2$	$r \geq 2$	18.047	29.797
$r \leq 3$	$r \geq 3$	6.979	15.495
$r \leq 4$	$r \geq 4$	1.433	3.842
λ_{Max} *Rank Test*			
$H_0 : r = r_0$	$H_1 : r = r_0 + 1$	λ_{Trace}	*95% Critical Values*
$r = 0$	$r \geq 1$	44.995	33.877
$r \leq 1$	$r \geq 2$	13.655[a]	27.584
$r \leq 2$	$r \geq 3$	11.069	21.132
$r \leq 3$	$r \geq 4$	5.545	14.265
$r \leq 4$	$r \geq 4$	1.433	3.841

Note: a denotes 95% significance level. *r* shows number of cointegrating vectors or cointegrating relations. Null and alternative hypothesis are denoted by H_0 and H_1.

4 lags on the basis of FPE and AIC. Results of the cointegrating vector test are reported in table 3. It seems that null of one cointegrating vector cannot be rejected on the basis of both trace and maximum eigen value test statistics.

Table 4
Normalized Cointegrating Vector

nda_t	*Constant*	id_t	mpi_t	nfa_t	q_t
1.000	-9.409	-0.349	-0.913	0.541	0.888
		(-4.492)	(-2.148)	(3.986)	(1.313)

Note: a denote 5 percent significance level.

Table 4 shows normalized cointegrating vector estimates. Results indicate that all variables except real exchange rate have significant effect on domestic component of money supply. Positive interest rate differential estimate showsthat higher interest rateabroad results capital outflow.Such an outflows result squeeze in domestic monetary base and thus have negativeeffect on economic growth and stability of domestic financial system. The Central Bank partially increases its net domestic assets to neutralize drop in domestic monetary base due to capital outflow.It can also be interpreted that capital outflows put pressure on domestic currency to depreciate. The Central Bank in order to avoid inflationary pressure of domestic currency

depreciation intervenes in interbank market and sales foreign currency reserves. The Central Bank then partially offset drop in domestic monetary base due to sale of its foreign currency by increasing its NDA. Similarly positive estimate of domestic real income is consistent with theoretical predictions and implies that the Central Bank increases its NDA for meeting out increase demand for real money arising from increase real economic activity in the country. Net foreign asset (nfa_t) estimate of 0.541 is substantially lower than the estimate obtained by Qayyum and Khan, (2003); Jan *et al.* (2005); Waheed, (2010) and (-0.69); Hashmi *et al.* (2011). Their estimate of sterilization coefficient are -0.72, -0.70, -0.69 and -0.83 respectively. Our estimate of NFA suggests partial sterilization. It indicates that the Central Bank sterilized 54 percent effect of capital outflows on domestic monetary base during recently adopted free float. Low sterilization coefficient is consistent with increased financial integration of the country with rest of world. In such a situation it would be difficult for the Central Bank to conduct an independent monetary policy and fiscal policy is the only tool available to relevant authorities for bringing desired changes in domestic macroeconomic indicators.

8. CONCLUSION

In this paper, we estimated monetary policy reaction function for Pakistan using Johansen multivariate cointegration approach. Objective was to evaluate the intervention policy and to test if the Central Bank sterilized fully, partially or not at all the effect of changes in NFA on domestic monetary base during recently adopted free float. Results indicate partial sterilization of effects of capital outflows on domestic monetary base. Over all the Central bank neutralized fifty four percent effect of capital outflows on domestic monetary base. Low sterilization coefficientmay imply impotency of the Central Bank to conduct an independent monetary policy and fiscal policy is the only instrument available to relevant quarters for bringing desired changes in domestic macroeconomic indicators. Other relevant determinants of domestic component of monetary base are manufacturing production index and interest rate differential.

Note

1. Table 2 and 3 taken from our earlier work titled domestic credit and capital flows in Pakistan.

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