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Capital Flows and Money Supply: The Degree of Sterilisation in Pakistan

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1. INTRODUCTION

Under the current managed float exchange rate system; the central bank may respond to an exchange market disequilibria by changing either the international reserves or the exchange rates. Under such a regime, a major policy difficulty is the interaction between exchange rate policies and monetary policies. The monetary authorities intervene in the exchange market in response to undesired fluctuations in exchange rates,¹ could adversely affect monetary control and move the economy away from internal target such as price stability. Under such a policy dilemma, fully sterilised intervention² involves a pure swap of foreign and domestic assets, which have not effect on the money supply, received greater attention by the policy-makers in early 1980s, particularly, through the experience of West Germany [Obstfeld (1983)]. Ideally, it provides an independent policy tool to deal with the exchange rate without affecting the internal policy targets.

Moreover, it is argues that fully sterilised intervention insulate domestic policies completely from balance of payments considerations. Further, the effects of intervention on exchange rates are close to zero if intervention is completely sterilised. Given this conviction, it is hard to see why the central bank would intervene in the foreign exchange market and sterilised completely at the same time [Neumann (1984)]. It is further argued that sterilisation is capable to move exchange rates through either a portfolio or signaling channel. In developing countries, an intervention may not be used purely to stabilise exchange rate but to reduce its impacts of volatile exchange rates on price level.

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¹Official intervention in foreign exchange market occurs when the authorities buy or sell foreign currency against their own currency in order to affect the exchange rate.

²Sterilised intervention occurs when the authorities simultaneously take action to offset or sterilise the effect of the resulting change in official foreign assets holdings on the domestic monetary base.

In this paper, we specifically investigate how State Bank of Pakistan's interventions respond to exchange rate shocks in terms of the degree of sterilisation and its effectiveness on limiting the monetary impact of shocks and how foreign exchange reserves respond to changes in domestic credit. Previous empirical evidence, *inter alia*, Kouri and Porter (1974); Argy and Kouri (1974); Ujiie (1978); Connolly and Taylor (1989) and Kit Pasula (1994) measured the degree of sterilisation by utilising the simple monetary model of the balance of payments under the fixed exchange rate system.

Since 1973 the literature has stressed the importance of including the exchange rates and foreign interest rates as determinants of money demand. Tower (1975); Arango and Nadiri (1981);³ McNown and Wallace (1992); Bahmani-Oskooe and Rhree (1994); Bahmani-Oskooe (1996) and Bahmani-Oskooe and Techaratanachai (2001) have shown the existence of a relationship between money demand and exchange rates.⁴ Similarly, Arango and Nadiri (1981) and Booth and Chawdhury (1992) have stressed the importance of foreign interest rates as a determinant of money demand because of its effects on the desired stock of real cash balances and exchange rate expectations.

The objective of this paper is to estimate the domestic credit policy reaction function to determine the degree of sterilisation by combining the monetary model of the balance of payments and the recent developments in the money demand literature⁵ by employing Johansen (1988) multivariate cointegration technique for Pakistan.⁶

The remainder of the paper is organised as follows: Section 2 briefly describes the State Bank of Pakistan (SBP) sterilisation policy. Section 3 contains the model specification. Section 4 discusses the data description, econometric methodology and empirical results while summary and some concluding remarks are given in the final section.

2. STERILISATION POLICY OF THE STATE BANK OF PAKISTAN

In recent years,⁷ there is a sharp improvement in the SBP foreign exchange inflows. This increase in foreign exchange inflows placed upward pressure on the

³They argued that a depreciation of the domestic currency increases the value of foreign securities held by domestic individuals. If this increase is perceived as an increase in wealth, the demand for domestic cash balances may increase. Further, when the exchange rate is expected to depreciate the expected return from holding foreign money increases and the demand for domestic currency falls (as individuals substitute foreign money for domestic currency).

⁴For example, Bahmani-Oskooe and Techaratanachai (2001) argued that the exchange rate in addition to income and interest rate is included as other determinant of money holdings.

⁵Which incorporates real exchange rates and foreign interest rates as additional arguments of the money demand function.

⁶Using quarterly data covering the period 1982Q3 to 2001Q2.

⁷October 2001 onwards. For further detail see SBP *Annual Report* for FY02.

value of the Rupee/Dollar exchange rate, which appreciated over 8 percent. The appreciation in the rupee value has been considerably larger if the SBP had not intervened in the interbank foreign exchange market, purchasing US dollar to prevent rupee from appreciating.⁸ This massive injection of the rupee liquidity in the banking system by SBP has serious repercussions for the monetary policy, banking sector stability and inflationary expectations in the economy. Thus, it is necessary for the central bank to stabilise changes in foreign exchange reserves and intervene in the foreign exchange market simultaneously.

On post September 11, 2001, the foreign exchange reserves of the SBP sharply increased. Under this situation, the central bank attempt to prevent changes in net foreign assets from affecting reserve money by implementing offsetting changes in net domestic assets. During FY02, the retirement of Rs 287 billion worth of government securities with SBP more than offset the impact of SBP intervention in the foreign exchange market. Consequently, the growth of reserve money was held down to 9.6 percent despite sizeable foreign exchange purchases of SBP⁹. During the first quarter of FY03, SBP purchased 1.28 billion US dollar from foreign exchange market that led to an equivalent injection of Rs 67 billion. Meanwhile, the government raised Rs 127 billion from commercial banks and used these funds to retire SBP debt. In overall terms, SBP holding of Government of Pakistan (GOP) securities fell by Rs 78 billion (see Table 1). This includes a total of Rs 10.7 billion worth T-bills that were off-loaded via open market operations.

Table 1

Sterilisation during Third Quarter of Fiscal Year 2003 (Rs Billion)

	Impact on	
	Net Foreign Assets	Net Domestic Assets
Interbank US Dollar Purchases		
(Including Export of Currencies)	76	–
SBP Holding GOP Securities	–	–78
Net Impact	76	–78
Net Impact on Reserve Money	–	–2

Source: *State of Pakistan's Economy*: First Quarterly Report for fiscal year 2003.

The immediate cost of sterilisation will be the difference between falling SBP earnings from lower T-bills holdings and the returns on SBP investment of foreign currency reserves due to the falling T-bills rate. The fall in SBP profit led lower transfers to the government. Hence, the shortfall in government non-tax revenue

⁸SBP increased its official reserves through the purchase of US Dollar in order to maintain exchange rate.

⁹See State Bank of Pakistan, *Annual Report* for Fiscal Year 2002.

receipts by at least Rs 20 billion. The SBP T-bill holdings declined for Rs 485 billion in June FY01 to Rs 119 billion in September 2002. This massive decline of Rs 366 billion is not entirely attributed to sterilisation. In fact, T-bills worth of Rs 197 billion were adjusted against special debt repayment account with SBP. This implies that T-bill holdings due to sterilisation alone actually fell by Rs 169 billion.

Thus we may conclude that given the nature of external shock that prompted abrupt foreign exchange inflows, there was a little option for SBP to intervene in the forex market, and sterilise its impact on monetary policy, banking system and inflationary expectations. Moreover, sterilisation policy always involves direct costs, but the choice of sterilisation instrument simply shifts these costs on the concerned economic agents including the commercial banks, the SBP and the government.

3. MODEL SPECIFICATION

To examine the degree of sterilisation, it is necessary to derive a domestic credit policy reaction function. The reaction function can be derived from two equations, which summarise the monetary approach to the balance of payments.

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

$$M_t^s = \kappa(D + R)_t \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad (2)$$

In Equation (1), money demand (M^d) is a function of real income (Y), real exchange rate (Q), domestic interest rate (i) and foreign interest rate (i^*). The parameters $\beta_1, \beta_2, \beta_3, \beta_4$ are assumed to be constant elasticities and A a scale factor.

In Equation (2), money supply (M^s) is composed of money multiplier (k) of domestic (D) and foreign components (R) of monetary base. From Equation (2) we obtain $D_t = \frac{1}{\kappa}(M_t^s) - R_t$ which demonstrates the link between domestic credit and foreign exchange reserves. When the central bank buys foreign currency from the foreign exchange market, R goes up. The rise in R can be sterilised by reducing the central bank's credit holdings (D). If the change in R is fully matched by an offsetting change in D , there is no change in M^s . Assuming monetary equilibrium where $M^d = M^s$, we have

$$D_t = \frac{1}{\kappa}(M_t^d) - R_t \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad (3)$$

Taking logarithms of Equation (3) we obtain

$$\ln D_t = \ln M_t^d - \ln \kappa - \ln R_t \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad (4)$$

Using logarithms of Equation (1) and substituting in Equation (4) we get the following equation

$$\ln D_t = \ln A + \beta_1 \ln Y_t + \beta_2 \ln Q_t + \beta_3 i_t + \beta_4 i_t^* - \ln \kappa - \ln R_t + u_t \quad \dots \quad (5)$$

We can write Equation (5) in the following estimatable form

$$d_t = \beta_0 + \beta_1 y_t + \beta_2 q_t + \beta_3 i_t + \beta_4 i_t^* + \beta_5 m_t + \beta_6 r_t + u_t \quad \dots \quad (6)$$

Where lower case letter represents the logarithms of variables involved in Equation (5), $\beta_0 = \ln A$ and m_t is the logarithm of money multiplier and u_t is the error term.

The coefficient of r_t i.e. β_6 is called the sterilisation coefficient. It measures the thrust of monetary policy to sterilise the impact of international reserve flows on monetary base. The sterilisation coefficient ranging in value from zero (no sterilisation) to -1 (full sterilisation). If the sterilisation coefficient (β_6) is zero, then no sterilisation takes place. If $\beta_6 = -1$, sterilisation is complete. But when the results of regression are such that $-1 < \beta_6 < 0$, sterilisation is conducted incompletely by the SBP.

Equation (6) may be subject to simultaneous bias. However, using multivariate cointegration techniques, we can obtain unbiased long-run elasticities of the determinants of money demand and monetary base.

4. DATA DESCRIPTION, ECONOMETRIC METHODOLOGY, AND EMPIRICAL RESULTS

For the empirical analysis we employed quarterly data ranging from 1982Q3 to 2001Q2. Quarterly data of GDP (y) was not available, hence was generated quarterly observations from annual observations.¹⁰ International reserve (r) excluded gold are defined in domestic currency. Domestic credit (d) is calculated by taking the difference between the central bank reserve money and gross foreign assets. For domestic (foreign) interest rate i (i^*), interbank call money rate and United States Federal Fund Rate is used respectively. Money multiplier (m) is obtained from dividing reserve money by M_2 . Real exchange rate is calculated as $q = s + p^* - p$, where s is the annual average exchange rate (IFS line rf) and p^* (p) are respectively the US and Pak WPI.¹¹ All the data are taken from various issues of *International Financial Statistics (IFS)*. Except domestic (foreign) interest rate all other are expressed d in logarithmic form.

Time series data on most of the macroeconomic variables tends to be non-stationary in levels. For meaningful results, the difference between the variable and its lag should be stationary. Generally, a nonstationary series becomes stationary when difference d , time is said to be integrated of order d ; represented as $X_t \sim I(d)$,

¹⁰Quarterly observations for GDP are generated from the annual GDP data, following the methodology developed by Goldstein and Khan (1976).

¹¹Whole Sale Price Index (1995=100).

and combination of these variables are cointegrated when one or more linear combinations are detected.

In this study, Augmented Dickey-Fuller (ADF) test is used to determine the stationarity and degree of integration of the variables. Lagrange Multiplier (LM) test is used for the white noisiness of the residuals. The results of ADF test are reported in Table 2.

Table 2

Unit Root Test

Variable	Trend	Lags	ADF Statistics	Diagnosis
D	no	4	-1.5994	I(1)
Δd	no	0	-4.5743*	
y	no	2	-2.5129	I(1)
Δy	no	1	-5.3032*	
q	no	7	-2.7963	I(1)
Δq	no	9	-3.9092	
i	no	1	-3.0998	I(1)
Δi	no	2	-10.0109*	
i^*	no	3	-1.1615	I(1)
Δi^*	no	2	-5.2942*	
m	no	1	-1.4575	I(1)
Δm	no	1	-9.0498*	
R	yes	4	-2.3660	I(1)
Δr	yes	2	-6.5965*	

*,** Indicate significant at 1 percent and 5 percent level respectively.

The critical values are given by Mackinnon (1991).

It appears from the Table 2 that, in levels all the variables are non-stationary while the first difference of these variables become stationary, indicating that $X_t (= d, y, q, i, i^*, m, r) \sim I(1)$.

To check for the linear combination between the variables the Johansen (1988) and Johansen and Juselius (1990) multivariate cointegration technique is used. To this end, two likelihood ratio tests based on trace of the stochastic matrix (λ -trace) and based on maximal eigenvalue of the stochastic matrix (λ -max) are used.

In the likelihood ratio tests, the null hypothesis that there are at most r (where $r=0, 1, \dots, 7$) cointegrating vectors is tested against the alternative of $r+1$ cointegrating vectors. The results of Table 3 indicate that the null hypothesis of no cointegration is rejected and there exist at most 6 cointegrating vectors based on λ -trace and at most 2 significant cointegrating vector based on λ -max. This implies that there exist a long-run relationship between domestic credit, real income, real exchange rate, domestic interest rate, foreign interest rate, money multiplier and international reserves.

Table 3

Results of Cointegrating Analysis
Series X_t ($= d, y, q, i, i^*, m, r$) and lag 4

Hypothesis	Eigenvalue	λ_{trace}	95%		λ_{max}	95%
			CV	Alternative		CV
$r = 0$	0.827596	181.9279*	131.70	$r = 0$	121.2979*	46.45
$r \leq 1$	0.602470	160.6318*	102.14	$r \leq 1$	63.6514*	40.30
$r \leq 2$	0.356275	96.98037*	76.07	$r = 2$	30.3934	34.40
$r \leq 3$	0.279852	66.58701*	53.12	$r = 3$	22.6526	28.14
$r \leq 4$	0.259822	43.93444*	34.91	$r = 4$	20.7596	22.00
$r \leq 5$	0.189614	23.17482**	19.96	$r = 5$	14.5069	15.67
$r = 6$	0.118052	8.667920	9.24	$r = 6$	8.6679	9.24

Critical values come from Osterwald-Lenum (1992). Also see Banerjee, *et al.* (1993), Table 8.7, p. 276.

*, ** Indicate significant at 1 percent and 5 percent respectively. CV= critical values.

To determine the sign and magnitude of the long-run elasticities in Equation 6, the cointegrating vectors have been normalised on d . The normalised vector corresponds with the maximum eigenvalue and the results are reported in Table 4. These result show that apart from real exchange rate all other variables are statistically significant at the 1 percent level of significance and possessed expected signs. The coefficient of international reserves (r) is positive and significant, indicating some sterilisation.

Table 4

Significant Cointegrating Vector Normalised on d

d	y	q	i	i^*	m	r	Constant
1.000000	-1.224174	-0.009355	-0.065653	0.064893	1.852724	0.277556	-1.531449
	(0.04790)	(0.09721)	(0.02478)	(0.01488)	(0.38488)	(0.04329)	(1.14143)
	(-25.5569)	(-0.09623)	(-2.6494)	(4.3611)	(4.8138)	(6.4116)	(1.3417)

Note: Figures in parentheses represent the standard errors and t -values respectively.

The degree to which the SBP sterilises the foreign exchange reserves is equal to $(1-\beta_6)$, which is approximately equal to 0.72. This implies that the SBP sterilises 72 percent of capital inflows during the period of study.

Estimation of Error-correction Model

The performance of the domestic credit policy reaction function can be improved by introducing short-run dynamic into the static model. According to Granger (1987) representation theorem, if a cointegrating relationship exists between a series of $I(1)$ variables, then a dynamic error-correction representation also exists. The general form of the error-correction model can be written as

$$\Delta d_t = \alpha + \sum_{i=1}^{k-1} \beta_i \Delta d_{t-i} + \sum_{i=0}^{k-1} \gamma_i \Delta y_{t-i} + \sum_{i=0}^{k-1} \delta_i q_{t-i} + \sum_{i=0}^{k-1} \theta_i i_{t-i} + \sum_{i=0}^{k-1} \eta_i i^*_{t-i} + \sum_{i=0}^{k-1} \tau_i \Delta m_{t-i} + \sum_{i=0}^{k-1} \lambda_i \Delta r_{t-i} + \phi \varepsilon_{t-1} + \mu_t \quad (i = 1, 2, \dots, 4) \quad \dots \quad (7)$$

where the error-correction term ε_t is given by

$$\varepsilon_t = d_t - \hat{d}_t$$

ϕ reflects the speed of adjustment towards the long-run equilibrium value, which is determined by the normalised cointegrating coefficients given in the Table 4. All the variables in regression Equation (7) are $I(1)$ stationary. Hence the conventional t -statistics based on OLS method can be used to derive inference on the magnitudes of the estimated coefficients.

Using Hendry’s general to specific methodology (starting with 4 lags) Table 5 represents the parsimonious error-correction model, where the conventional t -statistics are given in parentheses.

Table 5

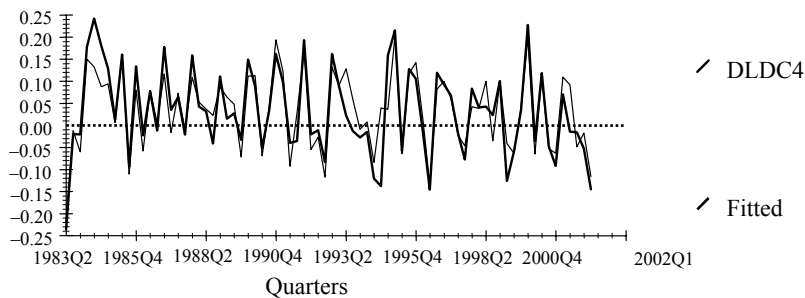
Error-correction Model for Domestic Credit Reaction Function

Independent Variables	Coefficients	t -statistics
Constant	-0.20110	-0.96246
Δd_{t-2}	0.078380	1.2487
Δy_{t-1}	-0.66128	-3.2154*
Δq	0.10804	5.9656*
Δi_t	0.0096578	3.5088*
Δi_t^*	0.021666	2.0630**
Δm_t	-1.3868	-1.06914*
Δm_{t-1}	0.22450	1.8698**
Δr_t	-0.12486	-7.3741*
ε_{t-1}	-0.10924	-4.1473*
R^2	= 0.770703	R^2 adj = 0.73943
S.E	= 0.051188	F -stat(9, 66) = 24.6480*
FF[F (1,65)]	= 0.76285	NO[χ^2 (2)] = 16.0593
HS[F(1,74)]	= 0.36930	SC[F(4,62)] = 0.13904
DW. stat	= 1.8483	Predictive Failure (1,66) = 0.38661

** and * represents significance at the 5 percent and 1 percent level of significance respectively. FF, NO, Het and SC represents Ramsey’s RESET test of functional form, Jarque-Bera’s normality test, test of heteroscedasticity based on ARCH test and serial correlation test based on Lagrange Multiplier test. These tests are distributed as F -stat and χ^2 with d..f is given in parentheses.

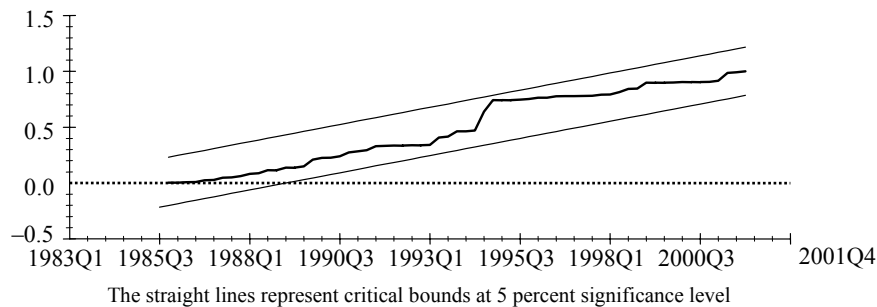
The results from the estimated error-correction model are presented in Table 5. All the estimated coefficients are significantly different from zero at the 5 percent level of significance except the coefficient of changes in domestic credit lagged by two periods (Δd_{t-2}). The error-correction term possessed expected sign and statistically significant. However, the size of the error-correction term is -0.10924 , which implies that about 11 percent adjustment towards long-run equilibrium takes place in one quarter. The short-run elasticities are smaller than the long-run elasticities. Furthermore, the coefficient of foreign exchange reserves is -0.12486 , which suggest that the SBP sterilises 88 percent of capital inflows in the short-run. Moreover, when the estimated values of Δd_t are fitted against the actual values, it perform well in terms of tracking the cyclical nature of the movements in Pakistan represented by the Figure 1.

Fig. 1. Plot of Actual and Fitted Values.



The estimated error-correction model was found to be stable not only in terms of Chow forecast test but also in terms CUSUM of squares test. Figure 2 plots the CUSUM of squares of recursive residuals

Fig. 2. Plot of Cumulative Sum of Squares of Recursive Residuals.



CUSUM of squares path lies within the bands, indicating no structural change at the 5 percent level.

5. SUMMARY AND CONCLUSIONS

In this study an attempt has been made to develop and estimate the domestic credit policy reaction function to analyse the monetary implications of interventions and sterilisation policy in Pakistan using quarterly data ranging from 1982Q3 through 2001Q2. By employing Johansen multivariate cointegration technique, this paper has considered the degree of sterilisation that the Pakistan has used in controlling capital flows.

The degree to which a change in international reserves affects domestic credit is measured by the coefficient β_6 . The rate at which the SBP sterilises international reserve flows is measured by $(1-\beta_6)$. The evidence suggests that Pakistan sterilises around 72 percent of international reserve inflows in the long-run while 88 percent in the short-run during the period of study.

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