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Modeling Demand for Money in Pakistan: An ARDL Approach

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Abstract

In this study we have estimated demand for money (M_2) function in Pakistan, over the period of 1980 Q1 to 2009 Q2, using ARDL method. The study corroborate support for the hypothesis of long-run equilibrium relationship between real money demand and a set of variables including real GDP, inflation, rate of interest, real effective exchange rate and foreign rate of interest. The result of F-test and negative sign of EC(-1) term, both suggest the presence of cointegration. The results are further approved by CUSUM and CUSUMSQ tests. The study concludes that the use of monetary policy could be effective in Pakistan because there is a stable long-run equilibrium relationship between money demand and the set of aforementioned variables. Inflation has a large impact on the demand for money in Pakistan, indicating towards the tendency of agents to hedge in physical assets.

Keywords: Demand for money; ARDL; Pakistan

JEL classification: E41, E44, E4

I. Introduction

The topic of money demand has been drawing the attention of economists from the classical period to the present era of modern economics. To start with the Quantity Theory of Money by Irving Fisher (1911), to Keynes's Liquidity Preference theory (1936), and Friedman's Modern Quantity Theory of Money (1956), up till now, economists have done considerable work on the determinants of money demand, its functional form and appropriate methodology for estimating it. The topic of money demand is important because money demand and supply conditions in the economy, together contribute towards inflation, level of production and fluctuations in the interest rate. To control these key variables, central banks alter money supply to the economy. The effectiveness of monetary policy is associated

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with the stability of money demand function in the economy. Bahmani (2008) explains the relationship between the monetary policy effectiveness and the demand for money by saying "The Quantity Theory of Money implies that if a change in money supply is to be transmitted to a change in price level or the level of production, the velocity of money must be stable. Because velocity is no more than a linear combination of money, price and output, the stability of velocity is reduced to testing for the stability of the linear relation among the three variables, or the demand for money." It means that an unstable money demand function will render the use of monetary policy ineffective. This study tries to make a comprehensive money demand function and then check for the hypothesis that the set of selected variables are mutually cointegrated i.e. the existence of long run equilibrium relationship. According to Bahmani-oskooee & Bohl (2000), cointegration does not necessarily imply stability. To check the stability of model, CUSUM and CUSUMSQ tests are performed to the residuals of the ECM equation.

In Pakistan a host of studies have taken up this topic. One of the most recent works is Qayyum (2005) using annual data from 1960-99. A flaw could be the use of annual data, as Ericsson (1998) concludes, "The frequency of observation may affect both the exogeneity and cointegration. If agents' decisions occur over a shorter time period than the data frequency, dynamics may be confounded and inferences about cointegration altered; (see Hendry 1992)[2]."

Inflation, interest rate and exchange rate usually change frequently, it is better to consider them as of short-term nature. Moreover, there is no reason in assuming that economic agents adjust their portfolios annually. Thus, by taking annual data Qayyum (2005) might have missed out the short-term fluctuations in the variables and may have the problems indicated by Ericsson (1998). Another issue is the use of Johansen cointegration method, which does not include short term dynamics in the estimation of long run coefficient estimates. Bounds testing approach or autoregressive distributed lag approach, (ARDL) developed by Pesaran et al (2001) is a better choice to test cointegration and error correction modeling because it includes the short run dynamics in the estimation of long run coefficient estimates (Bahmani 2008).

[2] Ericsson (1998) refers Hendry (1992) for this conclusion.

Bahmani (2008) supports the use of ARDL by saying that inclusion of short run dynamics is important for the stability of money demand equation[3].

In this paper, a remedy of these issues is taken by applying ARDL method to quarterly data. This methodology has been used by Khan and Sajjid (2005) for quarterly data from 1982 Q1 to 2002 Q4, but the execution of methodology raises questions. They have selected lag order 2 for VAR because of strong evidence of cointegration at that lag length. Which is a little inappropriate, lag order is selected on the basis of AIC or SIC and residuals that become serially uncorrelated. At that selected lag length further adjustments are made on the basis of AIC to find the order for ARDL equation and then the presence of cointegration is tested at that selected ARDL model. Also they have not provided results of some important tests like; RESET test for misspecification, JB-test for normality of the residuals, LM test for the serial correlation and chi-square test for heteroscedasticity. So, it is difficult to conclude anything about the validity of their results.

Other studies on the demand for money in Pakistan are; Ahmed and Khan (1990), Khan and Ali (1997), Qayyum (1994-98), Tariq and Matthews (1997), Qayyum (2001) and Khan (1994). Some other interesting works regarding the demand for money are; Bahmani (2008) for Middle East, Bahmani-oskooee (2002) for Korea, Hafer and Jansen (1991) for United States, Hafer and Kutan (1994) for China, Khalid (1999) for Asia and Sharifi-Renani (2007) for Iran.

The rest of the study is arranged as follows; section II presents model specification, section III is about Data. Section IV presents Methodology. Empirical results are given in section V and section VI provides the conclusion.

II. Model Specification

According to economic literature, the demand for money is typically for two reasons; (a) For transaction purpose, (b) As an asset in the portfolio (Ericsson 1998). Some theories also highlight the speculative and precautionary demand for money[4]. The general functional form the money demand will be:

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[3] Bahmani (2008) refers to Laidler (1993) who has emphasized the importance of inclusion of short run dynamics for the stability of the money demand equation.

[4] For detail discussion on money demand theories see Laidler (1993).

$$Lrm = f\,(Y, \pi, R, EX, F) \qquad (1)$$

$$Lrm = Ln\left(\frac{M_t}{P_t}\right)$$

All the variables except inflation (π), M and P are in natural log. M is money stock (M_2), here we are using a simple sum measure rather that a Divisia monetary aggregate because Tariq and Matthews (1997) shows that there is little evidence for the superiority of Divisia aggregates over simple sum aggregates in Pakistan. P is the price level, Y is the scale variable showing the level of economic activity, π is inflation, R is interest rate which shows the opportunity cost of holding money, EX is exchange rate and F is foreign interest rate.

Real GDP is taken as the scale variable, whereas inflation proxies the return on physical assets, call money rate is the opportunity cost of holding money[5]. In open economy money demand is also affected by variables like foreign interest rate and exchange rate[6]. A proxy for foreign interest rate may be US federal funds rate (used by Khan and Sajjid 2005) or London Interbank Offer Rate (LIBOR) for dollar deposits. In this paper, 6-month LIBOR (UK based) is used to account for foreign interest rate. Fed funds rate is an inappropriate measure here, because it depicts US monetary policy stance rather than foreign interest rate. Exchange rate is the real effective exchange rate (REER).

Equation (1) is usually estimated in double log form[7]. The general model will be of the form:

$$Lrm = \alpha_1 + \alpha_2 Y_t + \alpha_3 \pi_t + \alpha_4 R_t + \alpha_5 EX_t + \alpha_6 F_t + \varepsilon_t \qquad (2)$$

The coefficients of the variables in equation (2) represent the respective elasticities. Only the coefficient of inflation represents semi-elasticity of money demand. Inflation was not converted into natural log because of the presence of negative inflation in some quarters.

Economic theory suggests that α_2 should be positive because as the transaction level and economic activity in the economy increases the demand for real money balances also increases. If the magnitude of α_2 is close to 0.5

[5] For more on opportunity cost see Sriram (2001); Ericsson (1998); Hafer and Jansen (1991).
[6] For discussion and references see Sriram (2001); Khan and Sajjid (2005).
[7] See Sriram (2001); Ericsson (1998)

then it supports the square root law, if it is near 1 then monetarist's fixed rule is supported (Bahmani 2008). The α_3 is expected to be negative because rise in inflation will induce people to invest money, thus, the demand for money shall fall and demand for physical assets shall increase. For α_4 we expect the sign to be negative because an increase in the opportunity cost of holding money will decrease the demand for money. For α_5 the sign could be positive or negative, if an increase in exchange rate (i.e. depreciation of domestic currency) is perceived by the people as an increase in their wealth (because now their foreign currency holdings are worth more in terms of domestic currency) then they may increase the demand for domestic currency, hence, the coefficient will be positive. If, however, after increase in exchange rate people expect it to rise even further (i.e. domestic currency falls further) they will convert the holdings of domestic currency into foreign currency to protect themselves of the loss from depreciation of domestic currency, in this case the sign of the coefficient will be negative[8]. For α_6 the sign should be negative because as the interest rate on foreign assets increases the attractiveness on those assets increases and people will try to have more of these high yield assets. In order to do so they will convert their domestic money holding into foreign currency and then invest in foreign assets, this will reduce the demand for domestic currency and/or assets and increase the demand for foreign assets[9].

III. Data

The study is based on quarterly data from 1980 Q1 to 2009 Q2 for Pakistan. The quarterly data on real GDP is not available from the government agencies. So, we have taken quarterly real GDP data from Kemal and Farooq (2004), they have done quarterization by using direct method. The paper has provided quarterly real GDP series from 1971Q1 to 2002Q4. For the years after 2002 we use percentage quarterly seasonal factors of GDP provided by Kemal and Farooq (2004) to break the annual GDP series into quarters. Inflation is calculated from CPI. The data are collected from IFS CD-ROM and is converted to base year of 1980-81 because the quarterly real GDP series provided by Kemal and Farooq (2004) was in 1980 base year.

IV. Methodology

All the variables involved in this study are time series variables. Each of these variables could be stationary I(0) or non-stationary I(1) or I(2). If

[8] This is called currency substitution effect. See Khan and Sajjid (2005) for references.
[9] This is called capital mobility effect. See Khan and Sajjid (2005) for reference.

variables are non-stationary then applying simple OLS technique could lead to spurious regression. The suitable methodology is, to use cointegration analysis and error correction modeling. If a set of variables is found to be cointegrated, it means that these variables have a long run equilibrium relationship, and in the long run, they cannot wander arbitrarily without any relation among themselves. In this paper, we are trying to verify the hypothesis of long run equilibrium relationship between real money demand and the fore-mentioned variables.

The hypothesis of cointegration can be tested by using Johansen maximum likelihood procedure or by Bounds testing approach (i.e. ARDL) which was introduced by Pesaran et al (2001). In this paper, ARDL approach is used for at least three reasons; (1) Pre-unit root testing is not required, because, ARDL method can test for the presence of cointegration between a set of variables of order I(1) or I(0) or a combination of both. (2) In ARDL approach short-run dynamics are involved in the estimation of the long run coefficient estimates (Bahmani 2008). (3) In ARDL method exogeneity of the regressors is not an issue (Khan and Sajjid 2005). Our model under the ARDL approach is as follows:

$$\Delta Lrm_t = \sigma + \sum_{i=1}^{p} \beta_i \Delta Lrm_{t-i} + \sum_{i=0}^{p} \delta_i \Delta Y_{t-i} + \sum_{i=0}^{p} \gamma_i \Delta \pi_{t-i} + \sum_{i=0}^{p} \lambda_i \Delta R_{t-i} + \sum_{i=0}^{p} \eta_i \Delta EX_{t-i} + \sum_{i=0}^{p} \rho_i \Delta F_{t-i}$$
$$+\alpha_1 Lrm_{t-1} + \alpha_2 Y_{t-1} + \alpha_3 \pi_{t-1} + \alpha_4 R_{t-1} + \alpha_5 EX_{t-1} + \alpha_6 F_{t-1} + \varepsilon_t \quad (3)$$

By using this general model we can check for the presence of cointegration by testing the joint null hypothesis that coefficients of the lagged level terms are jointly equal to zero, against the alternative that they are not zero. We use F-test for this purpose.

$$H_0 : \alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = \alpha_5 = \alpha_6 = 0 \quad (4)$$

$$H_1 : \alpha_1 = \alpha_2 \neq \alpha_3 \neq \alpha_4 \neq \alpha_5 \neq \alpha_6 \neq 0 \quad (5)$$

Pesaran et al (2001) have showed that here F-test is non-standard, and has new critical values; a lower-bound critical value, if all the variables are assumed to be I(0) and an upper-bound critical value if all the variables are considered as I(1). Decision rule is that if the value of the F-test falls below the lower-bound critical value, we do not reject the null, and hence, there is no cointegration. If the value of F-test falls above the upper-bound critical value we do not accept the null, and hence, accept that variables are cointegrated. If the value of F-test falls between the two boundaries, the test is inconclusive. If cointegration is established we can find out long run elasticities by normalizing on α_1 as follows:

$$Lrm_{t-1} = \frac{\alpha_2}{\alpha_1} Y_{t-1} - \frac{\alpha_3}{\alpha_1} \pi_{t-1} - \frac{\alpha_4}{\alpha_1} R_{t-1} + \frac{\alpha_5}{\alpha_1} EX - \frac{\alpha_6}{\alpha_1} F_{t-1} \quad (6)$$

Another support for cointegration hypothesis comes from the negative sign of EC term in the error correction model in equation (7). From Bahmani-oskooee and Bohl (2000) we know that cointegration does not necessarily imply stability. To check the stability of our model we apply CUSUM and CUSUMSQ tests to the residuals of the ECM in equation (7).

$$\Delta Lrm_t = \sigma + \sum_{i=1}^{p} \beta_i \Delta Lrm_{t-i} + \sum_{i=0}^{p} \delta_i \Delta Y_{t-i} + \sum_{i=0}^{p} \gamma_i \Delta \pi_{t-i} + \sum_{i=0}^{p} \lambda_i \Delta R_{t-i} + \sum_{i=0}^{p} \eta_i \Delta EX_{t-i} + \sum_{i=0}^{p} \rho_i \Delta F_{t-i} + EC_{t-1} + \nu_t \quad (7)$$

Whereas EC term is formed as follows:

$$EC = Lrm - \frac{\alpha_2}{\alpha_1}(Y) + \frac{\alpha_3}{\alpha_1}(\pi) + \frac{\alpha_4}{\alpha_1}(R) - \frac{\alpha_5}{\alpha_1}(EX) + \frac{\alpha_6}{\alpha_1}(F) \quad (8)$$

V. Empirical Results

As a first step in ARDL procedure, we have to decide the lag length for the first differenced terms, because results of F-test vary depending upon the number of lags included in the model (see Bahmani 2008). We calculate F-statistic for equation (3) by imposing maximum of 7 lags on the first differenced terms. First eight values of the data set are reserved for lag formation, to ensure comparability. Table 1 shows the results of F-test at different lag lengths. Cointegration was found for lag 1 [5% upper bound critical value is 3.23. see Pesaran et al (2001) pp 300]. High value of F-test is no criteria of selecting lag length.

Table 1: F-statistic for Testing Cointegration

P	F
1	5.81
2	2.67
3	2.94
4	2.17
5	1.45
6	0.97
7	0.90

Upper bound 5% critical value = 3.23

The criterion for selecting lag length is AIC or SIC and LM test for serial correlation. That lag length is selected for which AIC or SIC is lowest and there is no serial correlation in the residuals. On the basis of results of AIC and LM test we have selected lag length of 2 (see table 2). At lag length of 2 AIC is highest and there is no serial correlation in the residuals. After selecting lag length of 2, we look for further improvements in the model and select that order for ARDL which gives lowest AIC. Our selected model is given in Table 3, Panel A. At this final model, we then conduct F-test and find the variables to be cointegrated. Value of F-test is 9.05 against the 5% critical value of 3.23.

Table 2: Statistics for Selecting the Lag Order of Money Demand Equation

P	AIC	SBC	$\chi^2_{(sc)}(1)$	$\chi^2_{(sc)}(4)$
1	-5.04	-4.60	0.69	8.78***
2	-5.08	-4.49	0.07	3.17
3	-5.05	-4.32	0.5	6.89
4	-5.07	-4.18	0.05	4.94
5	-5.04	-4.01	0.006	4.39
6	-5.002	-3.82	0.0005	4.84
7	-4.91	-3.58	0.80	6.60

$\chi^2_{(sc)}(1)$ and $\chi^2_{(sc)}(4)$ are LM statistics for testing no residual serial correlation against order 1 and 4. The symbols *, **, and *** denote significance at 0.01, 0.05 and 0.10 respectively.

Table 3: Full-Information Estimation of Equation (3)
Panel A: Short-Run Coefficient Estimates.

Variables	Lag Order		
	0	1	2
ΔLrm		0.134	0.273
		(1.60)[a]	(4.61)
Δ Y	0.269		
	(10.41)		
Δπ			
Δ R	-0.01		
	(-1.38)		
Δ EX	0.089	-0.123	0.06
	(1.48)	(-2.09)	(1.16)
Δ F			

a: values in parenthesis are t-values.

Panel A of table 3 shows the short run elasticities, most of them are significant showing that the variables included in the model have significant short run impact on the demand for money. The coefficient of the EC(-1) terms is negative and highly significant, which further strengthens the hypothesis of presence of cointegration.

Panel B: Long-run Coefficient Estimates and Diagnostics

C	Y	π	R	EX	F	Adj. R^2	$\mathbf{F^a}$	$\mathbf{EC_{t-1}}$	$\mathbf{LM^b}$	$\mathbf{RESET^c}$
-1.63 (-7.56)*	1.59 (4.67)	-3.97 (-3.39)	-0.059 (-1.30)	0.44 (2.91)	-0.058 (-1.36)	0.754	9.05	-0.129 (-7.58)	0.96	0.53

$\bar{R}^2 = 0.75$ DW= 1.87

AIC= -5.29 SIC= -5.07

$\chi^2_{(Het)} = 11.60\ (0.77)$ JB= 0.32 (0.84)

Notes: * Values in parenthesis are t-values. [a] The upper bound critical value of the F-statistic at 5% level of significance is 3.61. [b] LM is the Lagrange multiplier test for serial correlation. It has a chi-square distribution with one degree of freedom. The p-value for 0.96 is 0.32.[c] Reset is a test of functional form misspecification F-value is 0.53 with p-value of 0.43.

The panel B shows long run elasticities. Income elasticity is 1.59 which highly supports the monetarist's fixed rule. It means that if the GDP increases by one percent money demand increases by 1.59 percent. Inflation semi-elasticity is -3.97 showing that if quarterly inflation increases by 1 unit demand for money will be reduced by 4 percent, so meaning there by that central bank should also reduce the supply of money to maintain the equilibrium in the economy, because if supply remains the same and demand is reduced this excess supply of money will cause further inflation. When CMR increases by 1%, the demand for money also decreases by 0.06%. A 1% increase in real effective exchange rate increases the demand for money by 0.44%. It means that depreciation of domestic currency is perceived by the economic agents as an increase in wealth thus leading to increase in demand of domestic currency. Foreign interest rate shows an elasticity of -0.058 which means that as the foreign interest rate rises the demand for domestic currency decreases. The speed of adjustment is 13 percent per quarter. Negative sign shows that the system adjusts back towards the long run relationship. Also it shows that about 52 percent of the disequilibrium is removed within one year. All the results are significant and the signs are in conformity with the economic theory. There is no serial correlation, no specification bias, no hetero, and residuals are also normally distributed, as depicted by the test results.

Stability of the short run and long run coefficients can be seen by CUSUM and CUSUMSQ tests, Figure 1 and 2 shows CUSUM and CUSUMSQ respectively. These tests show that our model and its coefficient estimates are stable (see Bahmani 2008).

Figure: 1 Plot of Cumulative Sum of Recursive Residuals

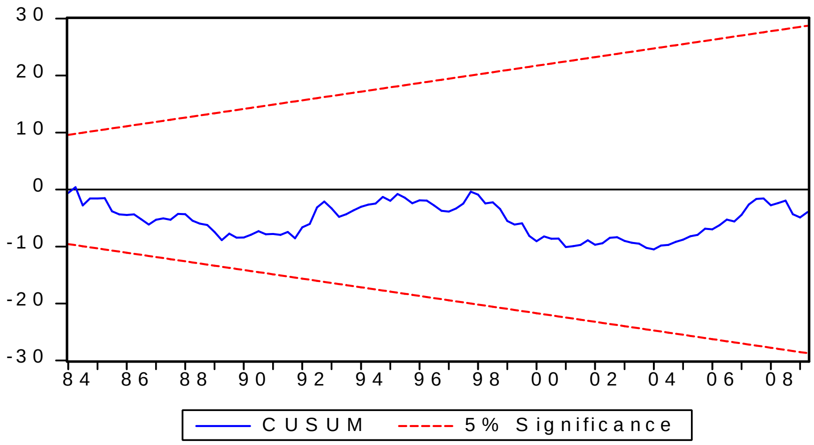
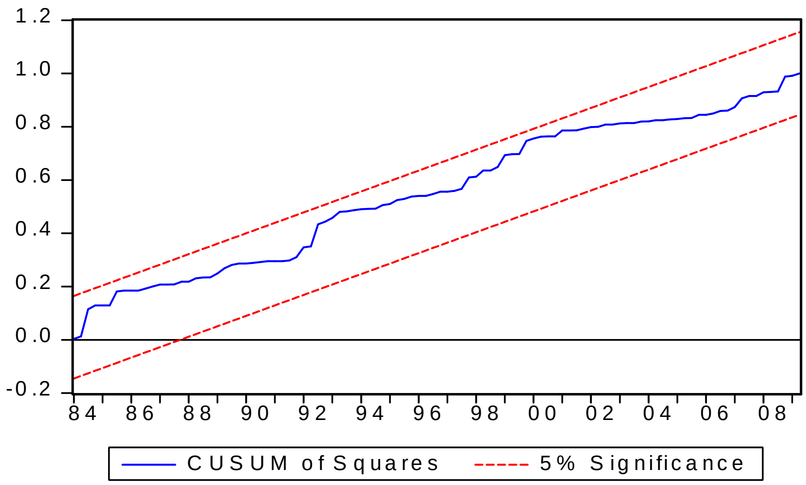
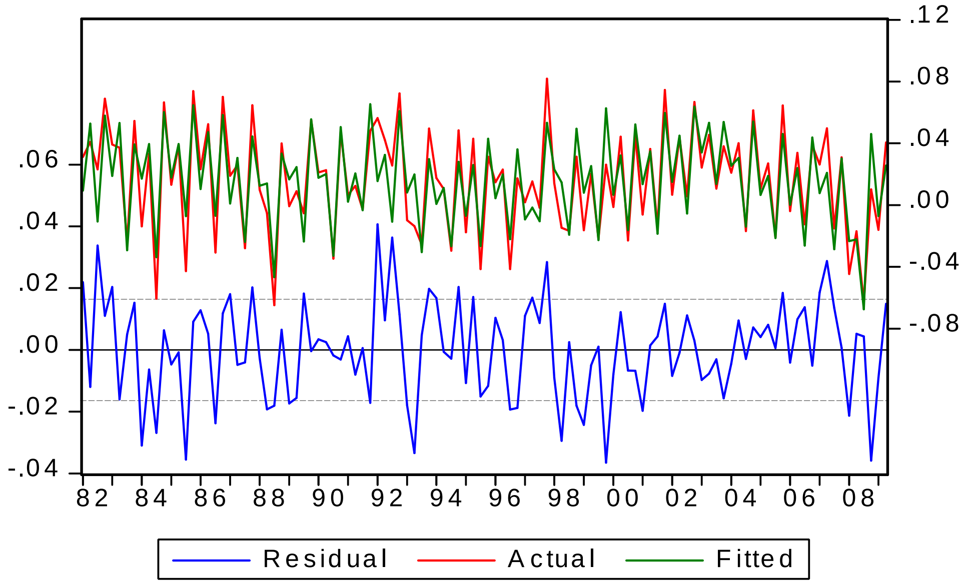


Figure: 2 Plot of Cumulative Sum of Squares of Recursive Residuals



To see how our model fits the actual values, we plot estimated ΔLrm and actual ΔLrm (Figure 3). The figure shows that our model has performed very well. It has captured the fluctuation and also their magnitude.

Figure: 3 Plot Showing Actual VS Fitted Values



VI. Conclusion

The study have used the bounds testing approach to error correction modeling and cointegration analysis, for verifying the hypothesis of long run equilibrium relationship between real M_2 and a set of explanatory variables including real GDP, inflation, interest rate, real effective exchange rate and foreign interest rate. We have found support for the hypothesis of cointegration both by means of F-test and negative coefficient sign for EC(-1) term. This relationship is stable in the long run, and indicates the absence of structural change in the model. This amounts to finding a stable velocity of money. Hence, we infer that monetary policy is effective in Pakistan for influencing level of inflation and/or level of output (as suggested by the quantity theory of money). Inflation semi-elasticity is very high, suggesting that in times when inflation is high people do not prefer holding money to protect them of the loss of purchasing power. Instead they hedge their positions by investing in physical assets rather than monetary assets. Increase in interest rates cause a decrease in demand for money. Increase in the real effective exchange rate increase the demand for domestic currency because of wealth effect. Foreign interest rate shows a small impact. It shows the awareness and ability of domestic agents to mobilize their capital from domestic to foreign assets. The negative sign also suggests that in the periods of rising foreign interest rates domestic currency may come under pressure because more people demand foreign currency. The speed of adjustment is high and significant. It suggests that the mobility and lack of rigidities in the money market, about 50 percent of the deviations from the long-run equilibrium are removed within one year. We conclude that the major hurdle for central bank in achieving the target M_2 levels in Pakistan is the variations in the rate of inflation (Qayyum 2005).

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