

## **Exchange Rate Determination in Pakistan: Role of Monetary Fundamentals**

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This paper examines the role of monetary fundamentals in the determination of Pak-rupee vis-à-vis US-dollar exchange rate using quarterly data over the period 1982Q2-2008Q2. Based on the Johansen (1988) and Johansen-Juselius (1990) cointegration approach there exist one significant cointegration vectors between the exchange rate and the monetary fundamentals. The long-run cointegrating coefficients are generally consistent with the predictions of Frankel's interest rate differential variant of the monetary exchange rate model. The results of the adjustment coefficients suggest that disequilibrium is corrected by changes in exchange rate, relative money and inflation differential in the short-run. To examine the short-run dynamics in a system-wide context we have applied persistence profiles approach and the results indicates that the effect of system-wide shocks initially declines rapidly but decays slowly thereafter and completely dies out after 9 quarters. These results are consistent with non-linear adjustment and monetary factor being the main source of exchange rate volatility

### **1. Introduction**

Exchange rates have attained great prominence in macroeconomic policy discussions since the breakdown of the Bretton Woods system of fixed exchange rate in the early 1970s. Movements in exchange rates may influence macroeconomic fundamentals such as interest rates, prices, wages and unemployment, level of output and investment decisions in the economy. This may result in a macroeconomic

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disequilibrium that would lead to exchange rate devaluation to correct for external imbalances (Parikh and Williams, 1998 and Feridun, 2005). A stable exchange rate may help enterprise and financial institutions in evaluating the performance of investments, financing and hedging and reducing their operational risks (Nieh and Wang, 2005, Rahman and Hossain, 2003 and Khan and Qayyum, 2007).

It can be argued that exchange rate affects the economy through influencing a country's macroeconomic stability and affecting the size of its external sector. Unfortunately, in the past Pakistan's performance is not much impressive on both fronts (Ahmed, 2009). The economy of Pakistan has experienced a number of problems during the Seventies, Eighties and Nineties.<sup>3</sup> A prominent feature of these problems was the inappropriate policy measures with respect to the exchange rate. The government of Pakistan pursued a fixed exchange rate policy until December 1981, which in part caused the over-valuation of Pak-rupee and thereby a drastic decline in exports. The fall in exports results a decline in foreign exchange reserves, led to serious economic repercussions<sup>4</sup>. This policy was partly responsible for low productivity level, increased poverty and excessive government intervention in the economy.<sup>5</sup>

In January 1982, the appreciation of the US dollar in international markets forced the government of Pakistan to adopt a managed floating exchange rate regime based on a trade-weighted basket of currencies of Pakistan's major trading partners. The rationale for this switch in

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<sup>3</sup> Pakistan suffered from external shocks during the 1970s, 1980s and 1990s because of the high external debt burden and debt servicing. Over the period 1978 to 1984 the foreign real interest rate rose sharply over 9%. Since 1984 it has reached on average over 16% annually (Khan, 1996). Furthermore, fixed and highly over-valued exchange rate; large budget deficit; inappropriate monetary expansion, high inflationary pressure, ever increasing debt burden and debt servicing, and price controls posed serious threat to the Pakistan's economy.

<sup>4</sup> For example, trade gap led to external borrowing, which has reached to over 40% of the GDP in 1996 and expected to grow up to 70% of the GDP by the first decade of the 21<sup>st</sup> century (Khan, 1996).

<sup>5</sup> Khan (1986) has noted that during the late 1970s and early 1980s Pakistan suffered from various external shocks that were quite severe. The balance of payments picture was highly uncertain from year to year; increase in the level and variability of inflation and built up of a significant amount of foreign debt. High and increasing debt service ratio resulted in an increasing drain on foreign exchange resources as well as imposing constraints to the macroeconomic policymakers. These shocks adversely affect the stability of exchange rate and hitting the economy to a large extent.

exchange rate regime was that the trade share-weighted float would be responsive to the changing trade flows among major trading partners and bilateral currency fluctuations. The managed floating exchange rate was expected to induce a greater geographical and commodity diversification of exports. But since the implementation of managed float regime, output and balance of payments have experienced wide fluctuations and inflation has been consistently high.<sup>6</sup>

To contain balance of payments deficit, the government constantly relied on the policy of devaluation and rupee had continuously lost its value against major foreign currencies.<sup>7</sup> The persistent loss in the strength of Pak-rupee vis-à-vis other currencies may cause balance of payments crisis because of depletion in foreign exchange reserves and forcing the authorities to intervene in the foreign exchange markets to stabilize the domestic currency. As a result, the private sector capital continuously outflows (Bhatti, 2001). In a highly integrated world the direction of exchange rate changes on macroeconomy is rather complex and requires a detailed analysis.

In order for analyzing the role of fundamental factors involved in determining exchange rate, many models and their modifications have been proposed.<sup>8</sup> However, the monetary model of exchange rate determination emerges as the dominant theoretical paradigm in

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<sup>6</sup> As Akhtar and Malik (2000) noted that during 1980 to 1995, the 5-year average share of 4 major trading partners of Pakistan including USA, UK, Japan, and Germany, has remained in the narrow range of 31-39 per cent. These countries accounted for an average 53-68 percent of total trade deficit of Pakistan during the same period. They further stated that export commodity diversification remains weak; textile yarn and its manufactures dominate and constitute 72 to 85 percent of total exports to each of the four countries during 1990-1995.

<sup>7</sup> The rupee lost its value by nearly 500 percent from Rs. 9.9/\$ in 1982 to almost Rs. 60/\$ and exports has not risen a fraction as much. Devaluation increased the cost of rupee conversion. For example, in 1995/6 external debts servicing grew by 0.5% in US dollar terms, the total interest and principal payments increased by 15.5% in rupee terms. Since 1997/8 debts servicing was lowered by 8% and the rupee costs were higher by 17.2% on account of a weaker rupee (Zaidi, 2006). From 1993-2000, furnace oil price rose by 292% due to devaluation, high imported prices increased domestic, oil, petroleum and electricity prices, and due to dollarization, the rupee further depreciated consistently (Ibid, 2006, p. 181). It is also to be noted that cumulative real depreciation of the Pak-rupee during 1982-96 ranged from 47% vis-à-vis US-dollar to 65% vis-à-vis Japanese-Yen. Moreover, Pakistan trades with UK, Germany, and Japan in terms of their respective currencies rather than dollar.

<sup>8</sup> There is wide variety of exchange rate models, including purchasing power parity (PPP), traditional flow, monetary and portfolio balance models of exchange rates.

exchange rate studies since the demise of the fixed exchange rate regime since early 1970 (Neely and Sarno, 2002 and Schroder and Dornau, 2002). In the 1970s and early 1980s, the monetary approach dominated the literature on exchange rate determination.<sup>9</sup> The monetary approach to exchange rates hypothesizes that the nominal exchange rate is determined solely by contemporaneous supplies of money between the two trading nations. Countries that follow relatively expansionary monetary policies usually face a depreciation of their currencies and countries that follow relatively restrictive monetary policies experiencing an appreciation of their currencies. The theory, therefore, predicts a proportional relationship between exchange rates and relative money supplies of trading nations over a long period of time. This makes the monetary model of exchange rate an attractive theoretical as well as empirical tool for understanding the fluctuations in exchange rates over time. It also provides a long-run benchmark for the nominal exchange between two currencies and sets the criterion for determining whether a currency is overvalued or undervalued (Rapach and Wohar, 2002). Thus, the monetary approach to exchange rate determination has far-reaching implications for the conduct of monetary and exchange rate policies. Since exchange rate management is at the centre of many financial stabilization plans and monetary approach provides theoretical basis for the external adjustment policy. It also plays a role in the choice between money supply, exchange rate and inflation targeting in the design of the monetary policy.

Despite the simplicity and theoretical appeal, there is inconclusive evidence regarding the monetary approach to exchange rate determination. Monetary approach is silent on the issue regarding the process of convergence towards the long-run equilibrium. Recently many researchers emphasize to measure the speed of adjustment towards long-run equilibrium (Coakley and Fuertes, 2000). The slow speed of adjustment and a very high volatility of exchange rate in the short-run are central to the exchange rate misalignment. The consensus suggests a speed of reversion of about 15 percent per annum, equivalent to half-lives of around 3 to 5 years (Boyd and Smith, 1999 and Engle and Morley, 2001). The root cause of slow speed of adjustment is that the

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<sup>9</sup> The reviews of this literature can be found in McDonald (1988) and McDonald and Taylor (1992).

nominal exchange rate does converge at a much slower rate than that of monetary fundamentals. Much of the existing literature on exchange rate dynamics have employed orthogonalized impulse response functions to measure the impact of shocks to individual variables. However, one major drawback of this approach is that the impulse functions are not uniquely identified (Coakley and Fuertes, 2000). Pesaran and Shin (1996) proposes the persistent profiles approach to measure the system-wide shocks rather than individual variable shocks. This approach focuses on analysis of the effect of system-wide shocks on equilibrium relations within a cointegration framework.<sup>10</sup> Unlike the standard approach, it does not require any exogeneity property of the variables involved in the monetary approach and provides information on the shape of the whole adjustment path (Helg and Serati, 2000).

A large body of literature concerning the empirical validity of the monetary exchange rate models has been accumulated. The earlier comprehensive survey of the studies carried out during the 1970s and 1980s can be found in Levich (1985), Frenkel and Mussa (1985), MacDonald (1988), and Isard (1988), while the most current survey is provided by MacDonald and Taylor (1992, 1995). These surveys provide inconclusive evidence regarding the validity of the monetary approach to exchange rate determination despite its theoretical appeal. For example, Meese and Rogoff (1983) demonstrated that, at short horizons, random walk forecast of the exchange rate generally outperforms alternative models drawn from economic theory, including purchasing power parity (PPP), uncovered interest parity (UIP) and simple version of the monetary and portfolio balance models of exchange rates (Faust *et al.*, 2003). However, a number of studies provide evidence for the long-run validity of the monetary model as well as its out-of sample forecasting performance for a number of key currencies (MacDonald and Taylor, 1991, 1993, 1994, Chinn and Meese, 1995, Mark, 1995, MacDonald and Marsh, 1997, Kouretas, 1997, Diamandis *et al.*, 1998, Groen, 2000, 2002, Mark and Sul, 2001 and Rapach and Wohar, 2001, among others). Recent findings of Groen (2000, 2002) and Mark and Sul (2001) again revive hope in the ability of monetary fundamentals to track nominal exchange rates.

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<sup>10</sup> For further detail see Pesaran and Shin (1998).

The empirical literature on exchange rate determination that deals with the developing countries is relatively sparse because most of the existing monetary exchange rate models have been mainly tested for industrialized countries. The application of the monetary approach to exchange rate determination in the context of developing countries include Odedokun (1997) for sub-Saharan Africa, Lyons (1992) and Edward (1983) for Peru, Fry (1978) for Afghanistan, Chinn (1998) for East Asian Countries, Kletzer and Kohli (2000) for India and Yunus (2001) for five South Asian Countries and Khan (2007) for Pakistan. This is partly due to the fact that developing countries left the exchange rate determination to the market forces until recently.<sup>11</sup> Restrictions on capital mobility and domestic financial transactions in developing countries create a very different economic environment for exchange rate determination as well as dynamics for testing the generalized monetary approach to exchange rates. An empirical test of such models in countries with binding restrictions on international capital flows and underdeveloped and repressed financial sector can help to understand the role of monetary and exchange rate policies in the developing world (Kletzer and Kohli, 2000). These studies suggest that the major determinants of the level of exchange rate include money supply, national income, interest rates, inflation, trade balance and fiscal deficit.<sup>12</sup>

The behaviour of exchange rate and its responses to nominal and real shocks as a part of macroeconomic adjustment process has great relevant for policymakers in Pakistan, which has recently shifted to a market-based exchange rate regime. Pakistan opted for a managed floating exchange rate system in January 1982. In July 2000, the exchange rate policy shifted from a managed float to free flexible exchange rate.<sup>13</sup> Besides changes in exchange rate regime, trade and financial sector liberalization and loosening of restriction on capital inflows during the past one and half decades have reduced many

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<sup>11</sup> Although forty developing countries have adopted an independently floating exchange rate regime since the beginning of the 1980s

<sup>12</sup> Hooper and Mortan (1982) extend the basic monetary model by incorporating trade balance and fiscal deficit as an arguments.

<sup>13</sup> Adjustment to parity is made through the movements in domestic price level in a fixed exchange rate regime, while in the case of managed floating exchange rate, parity reversion take place through the movements in exchange rates (Froot and Rogoff, 1995).

distortions.<sup>14</sup> These structural changes may force the nominal exchange rate to converge towards the long-run equilibrium path. It is therefore interesting to examine the behaviour of monetary fundamentals in the process of exchange rate determination in Pakistan.

The empirical evidence associated to Pakistan on this issue is still sparse (Haque and Montiel, 1992, Chisti and Hasan, 1993, Afridi, 1995, Siddiqui *et al.*, 1996 and Zakaria *et al.*, 2007). These studies mainly focused on the determination of real exchange rate following the model developed by Edwards (1988). Most of these studies concentrated on the external fundamentals, such as terms of trade, ratio of remittances and official transfer to GDP. On the other hand, the studies conducted (for example, Chishti and Hasan, 1993; Bhatti, 1996, 2000; Liew *et al.*, 2004; Tang and Butiong, 1994; Yunus, 2000, Ahmed and Khan, 2002 and Qayyum *et al.*, 2004, Khan and Qayyum 2007, 2008) have tested nominal exchange rate determination focusing only on the PPP hypothesis or some of its variants. In Pakistan, the majority of studies focused either on the real exchange rate determination or testing the PPP hypothesis. These studies failed to examine short-run dynamics of exchange rate, which provide important information about the speed of adjustment towards the long-run equilibrium path. Despite a strong need of examining the role of monetary fundamentals in the determination of exchange rate, no comprehensive study so far has been carried out on this important and challenging issue in Pakistan. Furthermore, no serious efforts have been made to measure the speed of adjustment in the system-wide context in Pakistan. The present study attempts to fill the gap.

Given the paramount importance of exchange rate dynamics in the macroeconomic adjustment process, this paper seeks the answer of the following questions:

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<sup>14</sup> Since 1991, foreign exchange controls have been gradually liberalized. Individual and firms resident in Pakistan were allowed to hold foreign currency bank accounts and freely move the currency into and out of the country. Companies with foreign direct investment (FDI) were allowed to remit profits and capital without any prior approval of the State Bank of Pakistan. In 1994, the rupee becomes fully convertible on current account transaction. Elimination of Hundi/Hawala system, establishment of inter-bank market and adoption of free floating exchange rate policy since July, 2000, among others.

- (1) How well does the monetary fundamental explain fluctuations in nominal exchange rate in Pakistan?
- (2) At what speed nominal exchange rate converge to its long-run equilibrium level?

The rest of the paper is organized as follows: Section 2 outlines theoretical model, persistence profiles approach in cointegration framework and data. The interpretation of empirical findings is given in section 3, while some concluding remarks are given in the final section.

## 2 Theoretical Model, Methodology and Data

### 2.1 Theoretical model

The monetary model of exchange rates is an extension of the quantity theory of money demand (Diamandis *et al.*, 2000). The monetary exchange rate model postulates that exchange rates are determined by the demand for and supply of money across countries. The basic contention of the monetary approach is that the monetary policy is an important determinant of the behaviour of exchange rate. The central feature of the monetary exchange rate model is that it combines the purchasing power parity (PPP) theory with the quantity theory of money. Theoretical literature suggest that the long-run equilibrium relationship of the exchange rate is determined by the relative money supply, relative real income, interest rate differential and inflation differential. Following Nieh (2005), the conventional monetary model of exchange rate can be expressed by the following equation.

$$s_t = \beta_0 + \beta_1(m_t - m_t^*) - \beta_2(y_t - y_t^*) + \beta_3(i_t - i_t^*) + \beta_4(\pi_t - \pi_t^*) + u_t$$

$$\beta_1 > 0, \beta_4 > 0, \beta_2 < 0, \beta_3 < 0 \quad (1)$$

Where  $s_t$  indicates the nominal exchange rate.  $m_t, y_t, i_t$  and  $\pi_t$  are respectively, money supply, real income, nominal interest rate and inflation rate, while  $u_t$  is the error term. Asterisk indicates the corresponding foreign variables. Except for the interest rate and inflation rate, all the variables are transformed with natural logarithms. These



variables are often referred to as exchange rate fundamentals and these fundamentals may predict and explain the behaviour of exchange rate. The monetary exchange rates model hypothesizes the increase in domestic money supply will reduce the relative purchasing power of the Pak-rupee and thus push the Pak-rupee toward depreciation. Moreover, the greater the economic growth of Pakistan, the more products needed by Pakistani people. This accelerates the demand for domestic currency. In an attempt to decrease the real money balances, domestic residents will decrease their expenditures in order to increase their real money balances. This will reduce the price level until money market equilibrium is achieved. Then via PPP channel, an appreciation of the domestic currency will ensure that equilibrium is restored (Hallwood and MacDonald, 1994).<sup>15</sup> An increase in domestic interest rate relative to global levels, leads to depreciation of domestic currency by creating excess money supply. Because high interest rate decreases the amount of money demand, making the domestic currency relatively abundant.<sup>16</sup> Hence  $\beta_3$  should be positive according to monetarist (Hallwood and MacDonald, 1994). However, Dornbusch (1976) and Frankel (1979) predict that when the domestic interest rates are higher than the global levels, foreign investors will invest more in the domestic financial market. This increases capital inflow and will tend to appreciate the domestic currency. Hence  $\beta_3$  should be negative.<sup>17</sup> The increase in both interest rate and exchange rate may refer as “Double Rise of Domestic Currency”. Finally, an increase in the expected inflation results, an agents switching from domestic currency to bonds and physical assets. Thus the demand for money decreases causing a depreciation of domestic currency. Hence the coefficient of the inflation rate differential (i.e.  $\beta_4$ ) is expected to be positive.

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<sup>15</sup> The prediction of negative coefficient for relative income is opposite to what the Mundel-Fleming approach predicts. In the Mundel-Fleming model, a higher real income will increase imports; this will worsen the trade balance and will require a depreciation of the domestic currency in order to restore equilibrium. On the other hand, when interest rates of Pakistan are higher than the global levels,

<sup>16</sup> This is in contrast to the Keynesian model with perfect capital mobility, in which a higher interest rate differential causes capital inflows, which appreciates the domestic currency.

<sup>17</sup>  $\beta_3$  takes positive or negative value, is an empirical question and testable hypothesis.

## 2.2 Persistence Profiles and Short-Run Dynamics

To analyze the short-run dynamics of equilibrium relations, consider the following  $m$ -dimensional unrestricted VAR( $L$ ) model:

$$x_t = \sum_{i=1}^L \Phi_i x_{t-i} + c_0 + c_1 t + u_t \quad t = 1, 2, \dots, T \quad (2)$$

where  $x_t$  is an  $m \times 1$  vector of jointly determined variables,  $c_0$  and  $c_1$  are  $m \times 1$  vectors of unknown coefficients,  $\Phi_i (i = 1, 2, \dots, L)$  are unknown  $m \times m$  matrices of autoregressive parameters and  $u_t$  is unobserved vector of shocks satisfying the assumptions  $E(u_t) = 0$ ,  $E(u_t u_t') = \Sigma \forall t$ ,  $E(u_t u_{t-j}') = 0 \forall j \neq 0$ , with  $\Sigma$  an  $m \times m$  constant positive-definite matrix. The system in equation (2) can be reparameterized in vector error-correction (VEC) form as:

$$\begin{aligned} \Delta x_t &= \sum_{i=1}^{L-1} \Gamma_i \Delta x_{t-i} - \Pi x_{t-1} + c_0 + c_1 t + u_t & t = 1, 2, \dots, T \\ \Pi &= I_m - \sum_{i=1}^L \Phi_i & \Gamma_i &= - \sum_{j=i+1}^L \Phi_j & i = 1, 2, \dots, L-1 \end{aligned} \quad (3)$$

Assuming  $x_t$  to be first difference stationary, if  $\text{rank}(\Pi) = \rho < m$ , the  $m \times m$  matrix  $\Pi$  can be expressed as  $\Pi = \alpha \beta'$  where  $\alpha$  and  $\beta$  are  $m \times \rho$  matrices of full column rank. In this context  $\beta$  is the cointegrating matrix and  $z_t = \beta' x_t$  is an  $\rho \times 1$  long-run equilibrium vector representing  $\rho$  cointegrating relations.

To analyze the response of the equilibrium relations  $z_t$  to particular shock, one can use simple adaptation of the orthogonalized impulse response approach based on the Cholesky decomposition of the covariance matrix of innovations ( $\Sigma = TT'$ ). However, this approach is sensitive to the ordering of the variables in the cointegrating VAR and to the choice of the matrix  $T$ . Alternatively, one can use the variance-based persistence profiles approach due to Pesaran and Shin (1996) which measure the effect of system-wide shocks on the equilibrium

relations. The main features of these time profiles are that they are uniquely identified since their estimation does not require prior orthogonalization of the vector of shocks.<sup>18</sup>

Pesaran and Shin (1996) proposed the following unscaled measure of persistence profiles to examine the effect of system-wide shocks on cointegrating relations:

$$H_z(n) \equiv V(z_{t+n} | I_{t-1}) - V(z_{t+n-1} | I_{t-1}) \quad n = 0, 1, 2, \dots \quad (4)$$

where  $V(z_{t+n} | I_{t-1})$  is the variance of  $z_{t+n}$  conditional on the information set  $I_{t-1}$ . In the context of equation (3) this is given by

$$H_z(n) \equiv \beta' B_n \sum B_n' \beta \quad n = 0, 1, 2, \dots \quad (5)$$

where  $B_j = \sum_{i=0}^j A_i$  ( $j = 0, 1, 2, \dots$ ) and  $A_i$  are the  $m \times m$  coefficient matrices of the MA( $\infty$ ) representation of  $\Delta x_t$ . The matrices  $B_j$  satisfy the following recursive relation with the matrices  $\Phi_j$  of the VAR( $L$ ) model:

$B_j = \Phi_1 B_{j-1} + \Phi_2 B_{j-2} + \dots + \Phi_L B_{j-L}$  for  $j = 1, 2, \dots, \infty$  with  $B_0 = I_m$  and  $B_j = 0$  for  $j < 0$ . The diagonal elements of the matrix  $H_z(n)$  are the system-wide impulse responses of the cointegrating relations  $z_t = \beta' x_t$ . The persistence profiles of the  $j$ th cointegrating relation  $z_j = \beta' x_t$  is then given by

$$h_{z_j(n)} = \frac{H_{z_j(n)}}{H_{z_j(0)}} = \frac{\beta_j' B_n \sum B_n' \beta_j}{\beta_j' \sum \beta_j} \quad n = 0, 1, 2, \dots \quad (6)$$

which by construction has unit value at the time of impact when  $n = 0$ . It should tend to zero as  $n \rightarrow \infty$  if  $\beta_j'$  is indeed a cointegrating vector. Pesaran and Shin show that the maximum likelihood estimates of these

<sup>18</sup> For further detail see Coakley and Fuertes (2000).

persistence profiles are  $\sqrt{T}$  consistent with a limiting normal distribution.

The persistence profile can be given different interpretations. First, the unscaled persistent profiles can be regarded as the variance of the reversion in the  $n$ -step-ahead forecast of  $z_t$ , i.e.  $H_z(n) = V(v_{t+n})$ , where  $v_{t+n} = E(z_{t+n} | I_t) - E(z_{t+n} | I_{t-1})$ . When the system has just one cointegrating vector,  $\beta'$ , there is formal correspondence between the persistence profiles and the impulse response function of the cointegrating relation. The persistence profile approach can be applied to analyze the short-run dynamics of the monetary model of exchange rate in the wake of a shock. We formulate a VEC model as in equation (3) with  $x_t = [s_t, (m_t - m_t^*), (y_t - y_t^*), (i_t - i_t^*), (\pi_t - \pi_t^*)]'$  to investigate the exchange rate dynamics.

Quarterly data over the period 1982Q2 to 2008Q2 is used for the analysis. Quarterly data on GDP for Pakistan is not available. We use Goldstien and Khan (1976) methodology to generate quarterly observations for GDP. Data on money supply (M2 definition), call money rate, federal fund rate, consumer price index and GDP for Pakistan and United States is retrieved from International Financial Statistics CD-ROM (2008).

### 3. Empirical Analysis of the Monetary Model of Exchange Rate

#### 3.1 The Unit Root Test

To examine the time series properties of the data we employ Augmented Dickey Fuller (ADF) unit root test on the series in both levels and first differences. To capture the effects of seasonality, seasonal dummies ( $D$ ) have been included in the ADF test. Table 1 reports the unit root results.

**Table 1: Results of Unit Root Test**

Series	C + D		C	
	Log-level	Log-difference	Log-level	Log-difference
$s_t$	-1.413 (1)	-9.071 (0)*	-1.675 (0)	-8.808 (0)*
$(m - m^*)_t$	-1.867 (4)	-5.627 (1)*	-1.605 (2)	-5.385 (1)*
$(y - y^*)_t$	-1.671 (1)	-7.924 (0)*	-1.613 (1)	-7.507 (0)*
$(i - i^*)_t$	-2.790 (1)	-13.39 (0)*	-2.631 (1)	-13.16 (0)*
$(\pi - \pi^*)_t$	-2.875 (3)	-11.140 (2)*	-3.360 (3)*	-7.703 (3)*
Critical Values	5% (-2.89)		1% (-3.49)	

indicate significance at the 5 percent level. Number in brackets shows lag length. C and D stands for constant and seasonal dummies respectively.

It is evident from Table 1 that all the series are non-stationary in their log-levels and stationary in their first log-differences. Thus we conclude that  $X_t = [s_t, (m_t - m_t^*), (y_t - y_t^*), (i_t - i_t^*), (\pi_t - \pi_t^*)] \sim I(1)$ .

### 3.2 Cointegration Analysis

Since all the variables entered in the monetary exchange rate model are integrated to order  $I(1)$ , it is possible to test for the existence of cointegration between the exchange rate, relative money supply, relative real output, interest rate differential and inflation differential.

The Johansen (1988) and Johansen and Juselius (1990) procedure is applied to estimate the vector autoregression (VAR) model containing five dimensional vectors  $X_t = [s_t, (m_t - m_t^*), (y_t - y_t^*), (i_t - i_t^*), (\pi_t - \pi_t^*)]$  and to determine the cointegrating rank  $\rho$ . The VAR model is specified with initially 6 lags and sequentially tested down using general-to-specific methodology. The final lag length is selected when the estimated VAR passes all the diagnostic checks and the whitened of the

residuals. Based on this criterion we select 3 lags for VAR.<sup>19</sup> We select a VAR model with constant to enter unrestrictedly following the procedure developed by Johansen (1992). We do not include a linear trend in the model because the inclusion of a linear trend could be viewed as a weaker form of the long-run monetary model (see for example, Rapach and Wohar, 2002).

The diagnostic checks in the form of vector statistics reported in Table 2 suggest that the residuals are white noise. However, normality is rejected.<sup>20</sup> This implies that VAR model is satisfactorily a close approximation to the actual data generating process.

**Table 2: Vector Test Statistics**

Series: $s_t, (m_t - m_t^*), (y_t - y_t^*), (i_t - i_t^*), (\pi_t - \pi_t^*)$		
	Test Statistic	p-value
Vector Portmanteau (12)	272.086	-
Vector AR 1-5 test: F (125,300)	1.2539	0.061
Vector Normality test: $\chi^2$ (10)	64.932	0.000
Vector hetero test: F (450,650)	0.932	0.791

Note: Misspecification tests are against the alternative hypothesis – residual autocorrelation (AR), Skewness and Kurtosis (normality), ARCH and heteroscedasticity (Hetero). Hendry (1995) provides a description of these tests.

The model constancy test statistics are obtained by recursive estimation of the VAR model. For each of the equations, one-step ahead residuals +/-2SE in the first five parts of

<sup>19</sup> We also introduced two intervention dummies D98 and D00 for nuclear tests and free floating exchange rate regime respectively. Our preliminary results suggest that all the dummies remain insignificant. Therefore, we left out these dummies variables from the model.

<sup>20</sup> Cheung and Lai (1993) and Gonzola (1994) have demonstrated the robustness of the Johansen procedure to non-normality.

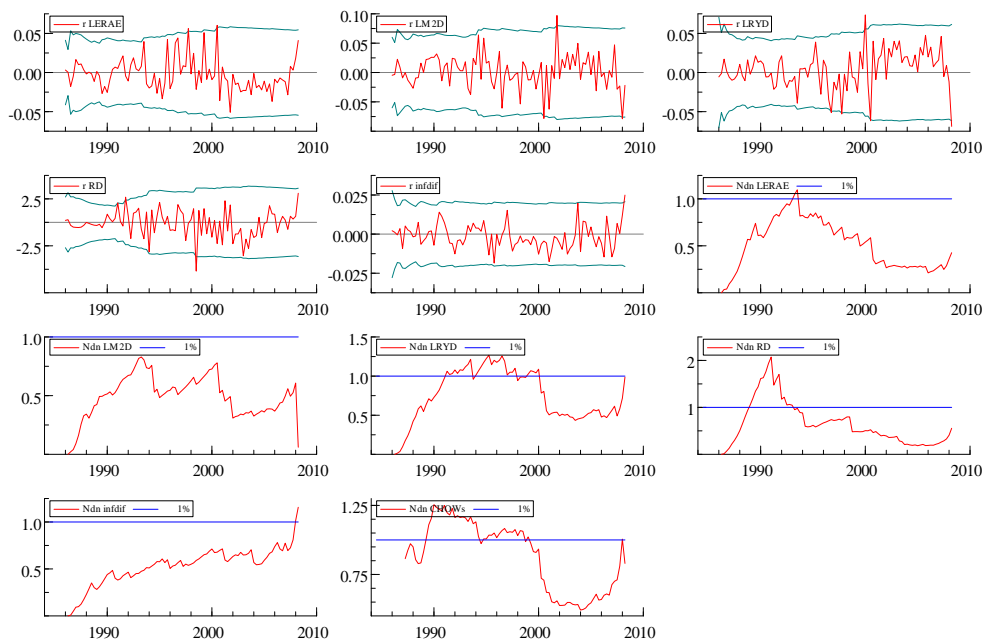
**Figure 1: Parameter Constancy Test**

Figure 1 and Chow breakpoints are shown in the second five parts, while Ndn Chows are shown in the last part of the Figure. These Chow statistics are scaled by their critical values at the 1 percent level. As can be seen from the Figure, the Chow test does not reject the hypothesis of parameter stability for exchange rate equation. It implies that the estimated parameters of the VAR model are constant.

The results presented in Table 3 (panel A) reveals that there is cointegration relationship between exchange rate and monetary fundamentals because the null hypothesis of no cointegration is rejected using either maximum eigenvalues ( $\lambda$ -Max) or trace ( $\lambda$ -Trace) statistics. Both tests favours the existence of cointegration between exchange rate, relative monies, relative real income, interest rate differential and the inflation differential with cointegrating rank is 2 based on trace test and one based on maximum eigenvalue test.

**Table 3: Cointegration Tests of the Monetary Exchange Rate Model**Series:  $s_t, m_t - m_t^*, y_t - y_t^*, i_t - i_t^*, \pi_t - \pi_t^*$ 

Panel A: Cointegration Test					
Null Hypothesis	$\rho = 0$	$\rho \leq 1$	$\rho \leq 2$	$\rho \leq 3$	$\rho \leq 4$
Maximum Alternative	$\rho = 1$	$\rho = 2$	$\rho = 3$	$\rho = 4$	$\rho = 5$
$\lambda$ -Trace	80.48 (0.005)*	47.87 (0.048)**	24.44 (0.188)	9.97 (0.288)	0.29 (0.592)
$\lambda$ -Max	32.61 (0.067)***	23.43 (0.159)	14.47 (0.341)	8.68 (0.239)	0.29 (0.592)
Panel B: Standardize Eigenvector (Beta Matrix)					
	Vector 1	Vector 2	Vector 3	Vector 4	Vector 5
$s_t$	1.000	-0.116	0.700	-405.46	0.047
$m_t - m_t^*$	-0.415	1.000	-1.019	-54.080	0.053
$y_t - y_t^*$	1.761	-2.364	1.000	-785.93	0.041
$i_t - i_t^*$	0.007	-0.270	0.004	1.000	0.001
$\pi_t - \pi_t^*$	-27.635	-1.150	12.800	-691.14	1.000
Panel C: Standardized Adjustment Coefficient (Alpha Matrix)					
	Vector 1	Vector 2	Vector 3	Vector 4	Vector 5
$s_t$	-0.048	-0.009	-0.034	-4.0999e-005	-0.014
$m_t - m_t^*$	0.049	-0.001	0.091	1.31316e-005	-0.013
$y_t - y_t^*$	0.031	0.015	0.029	8.7239e-005	-0.002
$i_t - i_t^*$	0.025	1.00	1.129	-0.006	-0.398
$\pi_t - \pi_t^*$	0.020	-0.002	-0.011	-2.2243e-005	-0.004

Note: Values in brackets are the probability; taken from Mackinnon-Haug-Michelis (1999). \*, \*\* and \*\*\* indicates significant at the 1%, 5% and 10% level of significance.





The adjustment coefficients along with the standard errors in parenthesis are:

$$\begin{array}{lll} \Delta s_t = -0.05 & \Delta(m_t - m_t^*) = 0.05 & \Delta(y_t - y_t^*) = 0.03 \\ (0.01) & (0.02) & (0.03) \\ \Delta(i_t - i_t^*) = -0.25 & \Delta(\pi_t - \pi_t^*) = 0.02 & \\ (0.91) & (0.005) & \end{array}$$

As can be seen from the results reported in equation (8), the exchange rate is determined by the relative money supply, relative real income, interest rate differential and inflation differential. All the coefficients are consistent with the predictions of interest rate differential variant of monetary exchange rate model. The positive coefficient of relative money supply suggests that a one percent increase in the domestic money supply relative to foreign money results in 0.42 percent increase in the nominal exchange rate, thus depreciating the Pak-rupee. This disproportional depreciation of domestic currency may interpret as an evidence of currency substitution. This result confirms the earlier findings by Khan (2008). The income elasticity with respect to nominal exchange rate is in accordance with the predicted responses in the monetary model of exchange rate. This empirical evidence verifies the predictions that an increase in domestic real income relative to foreign real income increases demand for real money balances leading to a monetary contraction. Consequently, a fall in the price level appreciates nominal exchange rate. The coefficient of the relative income is equal to -1.76 which is quite consistent with the evidence for other developing countries. For example, Odedokun (1997) estimates the elasticity of domestic-foreign elasticity of income for a panel of sub-Saharan economies to be above -2.00 and Edward (1983) estimates it to be -2.9 for Peru. Chinn's estimates (1998) of income elasticity for the East Asian economies lie between 1.00-3.00. Kletzer (2000) estimated the relative income elasticity, which is less than -0.50 for India. Khan (2008) obtains the elasticity of exchange rate with respect to relative real income equal to 1.48 for Pakistan.

The semi-elasticity of exchange rate with respect to interest rate is negative and significant; indicating that a rise in the domestic interest rate relative to foreign interest rate induces exchange rate appreciation

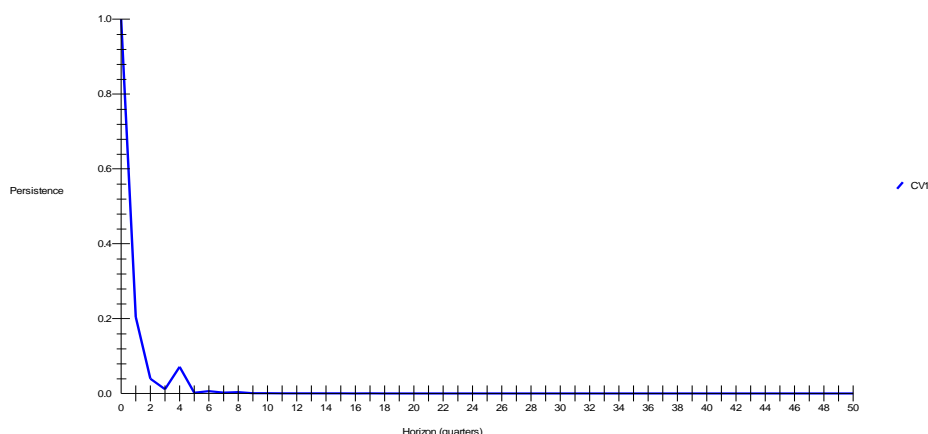
via capital inflows. However, the size of the coefficient is relatively small. This result verifies the earlier findings obtained by Bhatti (2001) for the case of Pak-rupee vis-à-vis US dollar. The coefficient of the inflation differential is positive and significant implies that an increase in domestic inflation relative to foreign inflation induces exchange rate depreciation via the deviation from the purchasing power parity.

The adjustment coefficients indicate that how fast the exchange rate and the monetary fundamentals are adjusted towards long-run equilibrium. The results suggest that the nominal exchange rate, relative money supply and inflation differential has significant feedback coefficients and restores the long-run equilibrium. However, feedback coefficient of exchange rate possesses expected negative sign only. The feedback coefficient associated to exchange rate ( $\Delta s$ ) suggests that around 5 percent of the deviations are eliminated by changes in exchange rate per quarter. This implies that the response of exchange rate is much weaker, while real income differential and interest rate differential play no role in the adjustment process in the short-run.

### Persistence Profiles

The persistence profiles for the monetary exchange rate model are computed from the maximum likelihood estimates of the restricted VEC model. Figure 2 present these profiles.

**Figure 2: Estimates of the Persistence Profiles for the Monetary Exchange Rate Model**



The value of persistence profile is unity on impact, but should tends to zero as time horizon ( $T$ )  $\rightarrow \infty$ . The persistence profile can be viewed as a function of  $T$  which provides information on the speed with which the effects of system-wide shocks on the cointegration relations disappears. The persistence profiles of the monetary exchange rate model shown in Figure 2, tends to zero as time horizon grows. These profiles provide an important insight into the dynamic response of the system to disequilibria (Yazgan, 2003). The persistence profile presented in Figure 2 indicates that due to system-wide shock initially nominal exchange rate depreciates sharply. After second quarter the depreciation of exchange rate is relatively slow. It appreciates from third-fourth quarters. Again it depreciates and completely dies out after ninth quarter. The possible explanation of this inverted J-shaped persistence profile would be due to the price stickiness, asymmetric information, less developed domestic markets and productivity differential across countries. Another reason for this slow speed of adjustment may be the J-effect characterizing the adjustment path of the current account in the presence of monetary shocks (Rogoff, 1996). Since the system-wide shocks is rapidly eroded that provides indirect evidence of monetary factor as a main source of exchange rate volatility which is consistent with monetary model of exchange rate determination.

## 5. Conclusions and policy implications

This paper examines the role of monetary fundamentals in the determination of Pak-rupee vis-à-vis US-dollar exchange rate over the period 1982Q2-2008Q2 using multivariate cointegration technique. The results are broadly consistent with the predictions of the Frankel's interest rate differential variants of the monetary exchange rate model. The adjustment coefficient is equal to -0.05 suggests that about 5% of the deviations are corrected to bring back the exchange rate at its long-run equilibrium level. Furthermore, short-run exchange rate dynamics are analyzed using persistence profiles approach of Lee and Pesaran (1993) and Pesaran and Shin (1996). The results indicate that the effect of system-wide shocks on nominal exchange rate is not permanent. Due to system-wide shock initially exchange rate depreciates sharply and after second quarter it appreciates. It again depreciates after fourth quarter and completely dies out after ninth quarter. This pattern of adjustment may be due to the non-linearities in the exchange rate

adjustment process, asymmetric information, less developed domestic markets and productivity differential across countries. Moreover, our results provide indirect evidence of non-linearities in exchange rate adjustment and monetary factor as main source of exchange rate volatility.

The most important policy implication derived from these results is that the monetary fundamentals would be so important in determining the exchange rate in Pakistan. Hence, the monetary authorities may use monetary fundamentals as stabilization tools for the prediction of Pak-rupee exchange rate. Furthermore, non-linearities in exchange rate are important in the short-run adjustment process. Therefore, non-linearities in exchange rate should be considered at the time of policy formulation.

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