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Testing the Monetary Models of Exchange Rate Determination: some New Evidence From Modern Float

Muhamamad Zakaria
School of Economics, Quaid-i-Azam University, Islamabad, Pakistan
Eatzaz Ahmad
School of Economics, Quaid-i-Azam University, Islamabad, Pakistan
Corresponding author: mzakaria80@hotmail.com

Abstract

The paper empirically takes an extensive evaluation of the long-term relationship between monetary variables and nominal exchange rates in Pakistan. For this purpose, three monetary models determining the values of the Pak-rupee vis-àvis the currencies of 17 major trading partners of Pakistan are estimated using quarterly time-series data for the floating exchange rateperiod (1983Q1 to 2007Q4). Empirical results reveal that the flexible price monetary model best explains the behavior of Pak-rupee nominal exchange rates as compared to the sticky price and the real interest differential monetary models. Further, by taking into account stat ionarity and endogeneity problems, the Generalized Method of Moments (GMM) estimates provideconsiderable support for the flexible price monetary model on the basis of country-by-country analysis. Therefore, we conclude that monetary variables confirm results for the determination of nominal exchange rates and validate monetary models as long-run equilibrium conditions.

Keywords: Exchange Rates, Money Supply, Income, Interest Rate, Inflation

1. Introduction

The evolution of the international monetary system into the regime of flexible exchange rates has stimulated a renewed interest in the economics of exchange rates. One main characteristic of the current flexible exchange rate system, which is against the expectations of its proponents (Friedman, 1953; Johnson, 1970), is high variability in real exchange rates. It is now well established that the real exchange rate is volatile because the corresponding nominal rate is volatile (Mark, 1990; Obstfeld *et al*., 1995; Mendoza, 2000). According to many researchers, the fact is that prices in goods market change sluggishly; therefore, any variability in nominal exchange rates is transmitted into real exchange rates (Dornbusch, 1976; Mussa, 1986). An important explanation of high variability in nominal exchange rates is that the on-going flexible exchange rate system is accompanied by greater international financial (asset) market integrations. As a result, nominal exchange rates are mainly driven by (short-term) highly speculative capital flows, thereby resulting in greater volatility in nominal exchange rates (Flood and Rose, 1999; Ghosh, 1998; Moosa, 2002). For instance, due to high capital mobility, investors adjust their portfolios instantaneously in response to changes in rates of return and expectations about future changes in exchange rates, thereby causing exchange rates to become highly volatile.

An implication of this global asset market integration is that nominal exchange rates, being one element which determines the expected yield of assets denominated in different currencies, is now viewed as the relative price of two national assets (monies),[1] rather than the relative price of foreign versus domestic goods stressed in traditional versions of Purchasing Power Parity (PPP) (Black, 1973; Mussa, 1976).[2] Therefore, nominal exchange rates are determined primarily by the relative supplies of and demands for stocks of different national monies (Dornbusch, 1976). This makes exchange rates a monetary phenomena.[3] As a result, various models of monetary approaches to exchange rate determinations are developed. It is not surprising that exchange rates turn out to be as volatile as the prices of bonds, equities, gold, and other assets, in contrast to the more stable national price levels. The supply of and the demand for various national monies depend on expectations, incomes, and rate of returns as well as other considerations that are relevant for portfolio choice, therefore,

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[1] For more details on asset-view of exchange rates, reader is referred to Dornbusch and Krugman (1976).

[2] In fact, in PPP exchange rate is also the relative price of two monies, since prices serve only to proxy the underlying monetary conditions because prices and monies are linked via quantity theory of money.

[3] From the perspective of the monetary approach, elasticities approach to exchange rate determination is fundamentally irrelevant as it views exchange rate as the relative price of national outputs, rather than as the relative price of national monies. Further, the later approach assumes that the exchange rate is determined by the conditions for equilibrium in the markets for *flows* of funds, rather than by the conditions for equilibrium in the markets for *stocks* of assets. For more details see Mussa (1976).

the monetary (asset) approach to exchange rate determination is expected to explain considerable variations in nominal exchange rates in the presence of high asset market assimilation, which has occurred in current flexible exchange rate systems. Expectations respond immediately and sharply to actual or rumored news about the fundamentals, therefore, they are subject to large unexpected variations. As a result, spot exchange rates will also undergo wide fluctuations.[4] Although monetary approach takes exchange rate as monetary phenomena, it does not take it as exclusively monetary phenomena. Therefore, this approach also takes into account real factors (like real outputs) in determining exchange rates which operate through monetary channels.[5] The inference of this approach is that an analysis of exchange rates should not be conducted in the partial framework of the foreign trade sector; rather, it should be integrated into the general framework of macroeconomics.

The central aim of this study is to develop a testable monetary model in order to analyze the behavior of the exchange rate of Pakistan against the currencies of its major trading partners using quarterly data for the flexible exchange rate period (1983Q1 to 2007Q4). In panel data estimation there is a possibility of obtaining spurious results by concluding that all countries in a panel satisfy long-run monetary models when, in fact, some individual countries are not well characterized by the monetary models. Therefore, we will conduct country-by-country analysis to find a clear picture of the models. Further, special attention is paid to stationarity and endogeneity issues. The objective is to explore the monetary model out of three alternative monetary models – Flexible Price Monetary Model, Sticky Price Monetary Model and Real Interest Differential Monetary Model – that best explains the behavior of Pak-rupee exchange rates against its major trading partners.

The rest of this paper is organized as follows. In Section 2 a brief literature review of the leading versions of monetary models of exchange rate determination is presented. Section 3 reviews the monetary policy and the exchange rate regime of Pakistan. Econometric models are developed in Section 4. Section 5 provides the empirical results along with their interpretations. Concluding remarks are given in the final section of the paper.

2. Literature Review

Monetary models – in its three versions namely flexible price, sticky price and real interest differential models – were developed and refined just after the collapse of

[4] Since one important element entering expectations of future exchange rates is forecast of the future course of macroeconomic and in particular monetary policy, increasing the predictability of future monetary policy becomes prerequisite if exchange rate variability is to be reduced.

[5] As pointed out by Mundell, countries which enjoy rapid growth of real income will also experience rapid growth in demand for money, which in turn will appreciate the exchange rates.

the Bretton Woods system in the early 1970s.[6] In an influential paper, Frenkel (1976) finds strong supportive evidence for the flexible price monetary model in order to explain German hyperinflation of the 1920s. Frankel (1979) has supported the real interest differential monetary model. The 1980s decade, however, witnessed considerable volatility in foreign exchange markets. Consequently, the flexible price model (and its real interest differential version) ceased to provide a good explanation of variations in exchange rate data. The estimated equations provided poor fits and exhibited incorrectly signed regression coefficients. Frankel (1982) called it a mystery (of multiplying marks) and gave a tentative explanation that current account fluctuations during the period might have created wealth effects, which could not be adequately captured by simple monetary models.

A similar pattern holds for the sticky price model that also proved weak when data were extended beyond the late 1970s. An important implication of the sticky price model is the proportional variation between real exchange rate and real interest differential. This phenomenon originates from the so-called overshooting hypothesis, slowly adjusting prices and uncovered interest parity condition. The lack of empirical evidence for a stable long-run relationship among nominal exchange rates and monetary variables renders the monetary models seemingly plausible theoretical model with little practical evidence.

Similarly, forecasting performance of the monetary models was shown to be no better, and sometimes worse than the predictions obtained, assuming that the exchange rate follows a random walk (Meese and Rogoff, 1983). In fact, these studies tested the monetary models only for the short-term, whereas, the proponents of monetary models present them as a long-term equilibrium condition. According to Bilson (1979) monetary models have underperformed for the short-run mainly due to three reasons. Firstly, uncovered interest parity and purchasing power parity conditions do not hold in the short-run (Smith and Wickens, 1986). Secondly, monetary models fail during the floating period as relative price shocks and money supply fluctuations remain incapable of explaining the volatile behavior of exchange rates. Finally, the assumption of exogenous interest rates does not exist in the real world. The upshot is that monetary models have performed poorly due to failure of their assumptions.

According to some researchers, this breakdown is due to econometric misspecifications. MacDonald and Taylor (1993) find support for monetary models by

[6] In fact, there are various forms of monetary models – Frenkel (1976) and Bilson's (1978) flexible price monetary models, Dornbusch's (1976) sticky price monetary model, Frankel's (1979) real interest differential monetary model, Hooper and Morton's (1982) equilibrium real exchange rate monetary model and Griton and Roper's (1977) exchange market pressure monetary model. The present study is confined only to the first three monetary models because they are more comprehensive in nature and because of their wider applicability to economic data.

applying multivariate cointegration analysis technique. Groen (2000), Mark and Sul (2001), and Rapach and Wohar (2004), using data for post Bretton Wood era, exert that monetary models hold for the floating rate era if panel techniques are applied rather than undertaking the simple country-by-country analysis. Further, monetary models are based on (long-run) PPP condition, which is found to hold in panel estimations in the recent floating era (see e.g. Frankel and Rose, 1996; MacDonald, 1996; and Taylor and Sarno, 1998). Applying more appropriate estimation techniques also validates PPP condition and the monetary models even in time-series data also (Garces-Diaz, 2004). Another reason, for finding fragile results for the monetary models is that many previous studies ignore, inter alia, the nonstationary nature of the relevant time-series as most of the time-series have been found to be nonstationary.

Current empirical literature on exchange rates in developing countries provide mixed results about the validation of monetary models (Odedokun, 1996, 1997; Chinn, 1999; Cuaresma *et al.,* 2005; Egert and Leonard, 2008). work on exchange rate in Pakistan is mainly focused on real exchange rate or real effective exchange rate (see e.g. Burney and Akhtar, 1992; Chishti and Hasan, 1993; Afridi, 1995; Siddiqui *et al.,*). The empirical work on nominal exchange rate is confined only to PPP (Ahmad and Ali, 1999; Bhatti, 1996). Similarly, Bhatti (1997) focused on *ex ante* PPP and examined the role of expectations in the determination of Pak-rupee exchange rates against British pound, Japanese yen and the US dollar and concluded that real exchange rate is random walk and nominal exchange rate is determined by relative prices as well as expected real exchange rate. Alam *et al*. (2001) using panel cointegration technique explore the long-run relationship between real exchange rate and real interest differential in 10 Asian countries including Pakistan and find that uncovered interest parity holds continuously. Unfortunately, most of these studies are weak in terms of theoretical rigor, data and coverage of trading partners.

An important contribution to the nominal exchange rate determination of Pak-rupee is Bhatti (2001). Bhatti tests the empirical validity of the Mundell-Fleming model of exchange rate determination for Pak-rupee against the currencies of six industrialized countries –British pound, French franc, German mark, Japanese yen, Swiss franc and the US dollar – over the period 1982Q1 to 2000Q4. The study validates the Mundell–Fleming model in all cases except Pak-rupee exchange rates against the French franc and the US dollar; and concludes that the Pak-rupee is determined against the six industrial countries by differences in prices, income and interest rates. However, the results obtained are trivial and lack interpretation, therefore, the policy implications drawn may not hold.

More recently, Kemal and Haider (2004) test the validity of the monetary model for Pakistan against the Euro Area, Japan, the United Kingdom and the United States using monthly data ranging from July 2000 to August 2004. The evidence indicates that the monetary model significantly explains the movements in real exchange rates, especially in the case of Pak-Euro and Pak-Yen rates, while the monetary model for the three countries, except for Pak-Euro, does not significantly explain movements in nominal exchange rates. It is concluded that exchange rate do not respond to the frequent changes in prices, which shows that PPP does not hold in the short-term. However, a careful review of this study reveals that it is not based on sound economic theory.

Thus, there is a greater need to focus more on nominal exchange rate determination in Pakistan. In this regard, the present study is an attempt to fill this gap by providing a detailed analysis of nominal exchange rate determination in Pakistan using monetary variables.

3. Monetary Policy and Exchange Rate Regime

Pakistan is a developing country having multiple objectives of monetary policy. The State Bank of Pakistan (SBP) has the mandate of maintaining price stability, promoting output growth and exchange rate stability. Initially, monetary policy was used to correct external balances in the economy. The government followed tight monetary policy in order to prevent inflationary tendencies in the economy. However, during the floating exchange rate period, there has been no clear prioritization of the objectives with shifting preferences between price stability and exchange rate stability. Monetary policy has been kept expansionary whenever inflation was under control and/or government was unable to provide fiscal stimulus. But as inflation reached a sufficiently high level, the SBP tried to contain it (like the contractionary actions taken in 2005 and are still in force). Pakistan has brefining the monetary policy framework in order to focus on inflation modeling and control, which has implications for the exchange rate regime. Thus, the issue of a competitive exchange rate versus domestic price stability bears special emphasis in formulation of monetary policy. SBP needs to design its monetary policy taking account of the impact of money supply on exchange rate as well as on international capital flows.

At the time of independence Pakistan adopted an on-going policy of fixed exchange rates, particularly known as the Bretton Woods system. Pakistan fixed the parity of its currency against the US dollar at rupees 3.32 in 1948, revised it to 4.78 in 1955, to 11.03 in 1972, and finally to 9.90 in 1973 and this continued until 1982.[7] In 1982 Pakistan decided to delink the rupee from the US dollar. Since then the rupee continued to depreciation from 12.98 rupees per US dollar in 1983 to 59.83 rupees per US dollar in 2005. In fact, Pakistan has made adjustments to its exchange rate regime over the last two decades, including currency depreciation, mainly with the objective

[7] All these figures are taken from *International Financial Statistics*.

to maintain inflation at reasonable levels, to restore external, and to cope with external shocks. With the belief that instability in nominal exchange rate is closely linked to money supply (via price inflation), fluctuations in Pak-rupee nominal exchange rate should therefore be expected in the presence of large monetary shocks.

4. Anaytical Framework

Much of the recent work on floating exchange rates goes under the name of monetary approach to exchange rate determination. According to this approach, since exchange rate is the price of one country's money in terms of another, analysis of the supply of and demand for monies across countries provides a natural basis for the determination of exchange rate.[8] However, the model does not preclude the role of real factors (such as output) in exchange rate determination. Three specific models of monetary approach with somewhat conflicting conclusions are known as Basic Flexible Price Model, Sticky Price Model, and the Real Interest Differential Model.

To construct building blocks of the monetary models, we consider the following variables for home country and similar ones with an asterisk for the foreign country. All variables, except the nominal and real interest rates and the expected inflation rate are expressed in natural logarithms.

m_t = Stock of nominal money balances
p_t = Price level
y_t = Real income level
π_t = Expected inflation rate
i_t = Nominal interest rate
r_t = Real interest rate
e_i^e = Nominal exchange rate
Δe_i^e = Expected change in nominal exchange rate

In addition, the superscripts *d, s, e* indicate demand, supply and market expectations respectively. The monetary models are built on 8 basic equations. The first four equations, given below, represent money demand function, money market equilibrium condition, Fischer equation for interest rate and rational expectations for price level in the home country. The similar four equations for foreign country are not shown here. The final four equations indicate the relationships between home and foreign countries' variables based on price and interest rate parity conditions.

[8] Under PPP exchange rate is the relative price of goods in two countries, while under monetary theory exchange rate is the relative price of two monies (Levich, 1983). Thus, while PPP based theories consider current account balance of payments, monetary theory focuses on the capital account.

$$m_t^d - p_t = k + \delta y_t - \lambda i_t \quad (1)$$
$$m_t^d = m_t^s = m_t \quad (2)$$
$$i_t = r_t + p_{t+1}^e - p_t (= r_t + \Delta p_{t+1}^e = r_t + \pi_t) \quad (3)$$
$$p_{t+1}^e = E[p_{t+1} \mid I(t)] \quad (4)$$
$$p_t = e_t + p_t^* \quad (5)$$
$$\Delta e_{t+1}^e = i_t - i_t^* \quad (6)$$
$$\Delta e_{t+1}^e = \Delta p_{t+1}^e - \Delta p_{t+1}^{e*} = \pi_t - \pi_t^* \quad (7)$$
$$r_t = r_t^* \quad (8)$$

The monetary model is a combination of both monetary approach to exchange rate and efficient market model. Monetary nature of the model arises from the first two equations that specify a stable demand for money and instantaneous money market equilibrium conditions. The efficient market characteristics enter through the last four equations, since these conditions jointly eliminate any consistent opportunities for rents. We now explain each of the three monetary models one by one.

4.1 Basic Flexible Price Monetary Model

The Basic Flexible Price Monetary (FP) Model, also known as Chicago Theory, was developed by Frenkel (1976) and Bilson (1978). As the term flexible price indicates, this model builds upon the assumption that PPP holds continuously (both in the short and long-runs) in a sense that changes in the demand for and supply of money result in an instantaneous adjustment in price level, which then leads to an immediate exchange rate adjustment to maintain the PPP.

Assuming similar liquidity preferences at home and abroad, we use home and foreign money demand functions (equation 1 plus the similar equation for foreign country) and the PPP equation (5), solve the resulting expression for e_t and add an error term to yield Bilson's (1978) model.

$$e_t = \delta_1 + \delta_2(m_t - m_t^*) + \delta_3(y_t - y_t^*) + \delta_4(i_t - i_t^*) + \mu_t \quad (9)$$

Here $\delta_1 = -(k - k^*) = 0$ and $\delta_2 = 1$ are the assumed restrictions, while $\delta_1 = -\delta < 0$ and $\delta_4 = \lambda > 0$ are the theoretical signs.

The model illustrates that a given increase in domestic money supply inflates domestic prices, which by virtue of PPP depreciates domestic currency proportionately. A higher level of domestic real income (or real output) reduces the domestic price level, which under PPP results in appreciation of domestic currency. Finally, an increase in domestic nominal interest rate reduces the demand for domestic currency, causing domestic price level to rise and, hence, domestic currency to depreciate.

Since capital markets are assumed to be fully integrated, the interest rate differential, $i_t - i_t^*$, is viewed as representing the relative expected inflation rate differential, $\pi_t - \pi_t^*$, (Fischer hypothesis). So equation (9) can be written alternatively to obtain Frenkel's (1976) model.

$$e_t = \delta_1 + \delta_2(m_t - m_t^*) + \delta_3(y_t - y_t^*) + \delta_4(\pi_t - \pi_t^*) + \mu_t \tag{10}$$

Here again $\delta_4 > 0$, indicating and high expected domestic inflation rate leads to depreciation of domestic currency. For empirical purpose we will follow the more popular of the two models, that is, Frenkel's (1976) version (equations 10) in order to make comparison with previous literature.

4.2 Sticky Price Monetary Model

Sticky Price Monetary (SP) Model of Dornbusch (1976), also known as Keynesian Theory, assumes that in short run prices are sticky, hence changes in the nominal interest rate reflect changes in the tightness of monetary policy. It is assumed that the exchange rate tends to converge to its long run equilibrium level, $\bar{e}_t$, according to the adjustment mechanism $\Delta\, e^e_{i+1} = -\theta(e_t - \bar{e}_t)$, where $\theta > 0$ is the speed of adjustment. Combining this equation with uncovered interest parity condition (6) yields $e_t = \bar{e}_t - (1/\theta)(i_t - i_t^*)$. In the long run PPP holds, therefore equation (9) becomes valid at the long run equilibrium position. Thus, substituting for $\bar{e}_t$ from equation (9) yields

$$e_t = -(\bar{k} - \bar{k}^*) + (\bar{m}_t - \bar{m}_t^*) - \delta(\bar{y}_t - \bar{y}_t^*) - \alpha(\bar{i}_t - \bar{i}_t^*) + \mu_t \tag{11}$$

where $\alpha = (1/\theta) - \lambda$ and bars indicate long run equilibrium values. If we assume that current values of the explanatory variables are equal to the long-run equilibrium values, then equation (11) can be written in empirical form as

$$e_t = \rho_1 + \rho_2(m_t - m_t^*) + \rho_3(y_t - y_t^*) + \rho_4(i_t - i_t^*) + \mu_t \tag{12}$$

where $\rho_1 = -(k - k^*) = 0$, $\rho_2 = 1$, $\rho_3 = -\delta < 0$ and $\rho_4 = -\alpha < 0$.

In this model interest rate differential reflects relative liquidity positions. A rise in domestic interest rate indicates a relative shortage of liquidity in the domestic money market, which gives rise to capital inflow and result in appreciation of the domestic currency.

4.3 Real Interest Rate Differential Monetary Model

The Real Interest Rate Differential Monetary (RID) Model of Frankel (1979) relies on the main assumptions that the expected rate of depreciation is a function of the gap between current spot exchange rate and the equilibrium rate, and the expected long-run inflation differential between domestic and foreign countries, that is, $\Delta e^e_{t+1} = -\theta(e_t - \bar{e}_t) + (\pi_t - \pi^*_t)$. This equation indicates that in the short-run exchange rate is expected to return to its equilibrium value at a rate proportional to the gap between current and the equilibrium exchange rate; and in the long run when $e_t = \bar{e}_t$, it is expected to change at the long-run rate $\pi_t - \pi^*_t$. It is straightforward to show that with this extension, the empirical equation for exchange rate determination becomes

$$e_t = \psi_1 + \psi_2(m_t - m^*_t) + \psi_3(y_t - y^*_t) + \psi_4(i_t - i^*_t) + \psi_5(\pi_t - \pi^*_t) + \mu_t \qquad (13)$$

where $\psi_1 = -(k - k^*) = 0$, $\psi_2 = 1$, $\psi_3 = -\delta < 0$, $\psi_4 = -1/\theta < 0$ and $\psi_5 = 1/\theta + \lambda > 0$.

This model holds that exchange rate is negatively related to nominal interest rate differential (as in the fixed price monetary model), and positively related to expected long-run inflation differential (as in the floating price monetary model). This model is a general description of exchange rate determination in the sense that it accounts for (a) the direct effect of monetary expansion, (b) the indirect effect of expected inflation and (c) the liquidity induced effect of interest rates, capital movements, and, therefore, the exchange rate.

Table 1 describes the signs of the regression coefficients in three models.

Table 1: Theoretically Expected Signs of Regression Coefficients

Variables	Flexible Price Model	Sticky Price Model	Real Interest Differential Model
$m_t - m^*_t$	(+)	(+)	(+)
$y_t - y^*_t$	(-)	(-)	(-)
$i_t - i^*_t$	(0)	(-)	(-)
$\pi_t - \pi^*_t$	(+)	(0)	(+)

5. Data, Estimation and Results

We have accumulated quarterly data for seventeen major trading partners of Pakistan for the floating exchange rate period 1983 to 2007. Exchange rates have been defined as units of domestic currency per unit of foreign currency. For money supply, M_1 definition is utilized.[9] Since data on income are available only on an annual basis, we have proxied income level by industrial production index.[10] Interest rate has

9 However, for Sweden and the United Kingdom M_2 definition of money supply was applied due to non-availability of data for M_1.

10 Industrial production index may distort the results since for many developing countries like Pakistan a considerable proportion of GDP originates mainly from the agriculture sector. However, the results are expected not to differ significantly if interpolated quarterly GDP data is used.

been measured by money market rates.[11] Expected inflation rate has been proxied by log change in consumer price index. Data have been collected from various issues of *International Financial Statistics* (International Financial Corporation) and *Economic Survey* (Government of Pakistan).

While estimating the model, there are two econometric issues that need to be tackled. The first issue is to confirm whether or not the estimated equation represents a long-run stable relationship. This issue can be handled easily with the standard tools of co-integrating analysis available in literature. The second issue has to do with the endogeneity problem. Specifically the relative money and inflation between the two trading partners appearing on the right hand side of the equations are affected by changes in nominal exchange rates via its effect on the prices of imported goods denominated in home currency units. This imported inflation can fuel inflation in general price levels, especially when the imported goods include raw material and other intermediate goods. Furthermore, the productivity variable, as measured by the industrial production index, can also be affected by changes in exchange rates through the potential real effects of exchange rate variations. In order to tackle the endogeneity problem, the *Generalized Method of Moments* (GMM) estimation technique is adopted with lagged values of the variables involved and used as instruments.

Note that our interest lies in testing the validity of monetary models for each trading partner of Pakistan. Therefore, the model is to be estimated for each trading partner, one by one. This analysis, as opposed to the analysis based on panel data estimation, provides useful information regarding Pakistan's trade potential based on money and productivity differential with each country. Thus, the estimation follows three-step procedure as outlined below.

1. At the first step stationarity properties of all the variables are analyzed on the basis of standard Augmented Dickey-Fuller (ADF) unit-root test. If all variables are found to be integrated of order one, it will indicate that the estimated nominal exchange rate equation could possibly form a long-run relationship of nominal exchange rate with relative price levels and relative productivity levels at home and abroad.
2. At the second step co-integrating equation is estimated. Since endogeneity problem is likely to arise in our right hand side variables, we apply GMM estimation technique of Arellano and Bond (1991) and Arellano (1993) using lagged values of independent variables used as instruments.
3. The third step is to apply the ADF tests on the regression residuals in order to confirm whether or not the estimated equations in step 2 form long-run relationships.

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[11] Some studies have used the government bond yield to measure interest rates. We have also used this data but the results do not differ.

As for the first step, the ADF tests confirm that all the variables are integrated of order one, except the inflation rate, which is found to be integrated of order zero.[12] It indicates that the estimate of nominal exchange rate equation can form a long-run relationship of nominal exchange rate. It is obvious that real interest rate differential monetary model encompasses both the flexible price and the sticky price monetary models or the flexible and the fixed price models are nested into the real interest rate differential model. A choice between flexible or fixed price model and the real interest rate differential model can simply be made by testing the null hypothesis $\psi_4 = 0$ or $\psi_5 = 0$ respectively.

5.1 Testing the Nested Models

We have applied Wald test to diagnose whether the flexible price monetary model and the sticky price model are valid against the real interest rate differential model. The results are presented in Table 2. The Table reveals that for ten countries (Belgium, Canada, France, Germany, Italy, Japan, Korea, Kuwait, Malaysia and the United States) both the real interest rate differential model and the sticky price model are rejected in favor of flexible price model both on the basis of F and Chi-square statistics. For three countries (Australia, Netherlands, and Sweden) both the flexible price and the real interest rate differential models are rejected in favor of sticky price model. While for three countries (Singapore, Switzerland and Thailand) real interest rate differential model is accepted against both flexible and fixed price models. On the other hand, for one country (the United Kingdom) neither of the models is true. Thus, the data supports flexible price monetary model against sticky price and real interest rate differential monetary models for most of the bilateral nominal exchange rates. Therefore, we may conclude that flexible price model is the best model as it can explain over and above what the other two models could explain for most of the cases.

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[12] The results of ADF tests are not presented to conserve space.

Table 2: Results of Wald Test

	WALD TEST							
	Flexible Price Model vs. Real Interest Differential Model, H_0: $\psi_4 = 0$				Sticky Price Model vs. Real Interest Differential Model, H_0: $\psi_5 = 0$			
Countries	F-Stats	Prob.	χ^2	Prob.	F-Stats	Prob.	χ^2	Prob.
Australia	5.9871	0.0169	5.9871	0.0144	0.0139	0.9066	0.0139	0.9063
Belgium	0.0742	0.7862	0.0742	0.7854	6.7987	0.0111	6.7987	0.0091
Canada	0.0296	0.8639	0.0296	0.8634	6.6541	0.0119	6.6541	0.0099
France	0.6205	0.4334	0.6205	0.4309	3.1626	0.0796	3.1626	0.0753
Germany	0.3683	0.5458	0.3683	0.5439	20.5779	0.0000	20.5779	0.0000
Italy	0.1460	0.7034	0.1460	0.7023	13.2709	0.0005	13.2709	0.0003
Japan	1.3735	0.2449	1.3735	0.2412	6.1676	0.0152	6.1676	0.0130
Korea	0.0619	0.8041	0.0619	0.8034	16.9847	0.0001	16.9847	0.0000
Kuwait	1.4223	0.2370	1.4223	0.2330	18.0827	0.0001	18.0827	0.0000
Malaysia	0.6058	0.4388	0.6058	0.4364	14.7975	0.0002	14.7975	0.0001
Netherlands	4.5801	0.0356	4.5801	0.0323	0.0992	0.7537	0.0992	0.7528
Singapore	67.5115	0.0000	67.5115	0.0000	67.5115	0.0000	67.5115	0.0000
Sweden	4.5418	0.0367	4.5418	0.0331	0.1777	0.6747	0.1777	0.6733
Switzerland	8.9863	0.0037	8.9863	0.0027	5.2727	0.0245	5.2727	0.0217
Thailand	61.1339	0.0000	61.1339	0.0000	61.1339	0.0000	61.1339	0.0000
United Kingdom	0.0235	0.8785	0.0235	0.8781	0.0260	0.8724	0.0260	0.8719
United States	1.6008	0.2098	1.6008	0.2058	7.2550	0.0087	7.2550	0.0071

5.2 Model Estimations and Interpretation of Results

Monetary models are estimated with each of the 17 trading partners of Pakistan in order to check co-integration among the variables. Table 3 provides the estimated results of monetary models of exchange rate determination.

The table reveals that in all regression equations most of the parameter estimates have theoretically expected signs and most of them are statistically significant. For each country high values of R-square (R^2) adjusted R-square (R^2) that the models fit the data well. Autoregressive (AR) process has been applied to remove autocorrelation in the models. In almost all the estimated regression equations Durbin-Watson (DW) statistics are approximately close to the desired value of two, indicating the absence of autocorrelation problem. However, for Canada, Malaysia, Netherlands and the United Kingdom, we cannot ignore the possibility of presence of autocorrelation.

The relative money supply variable $(m_t - m_t^*)$ has the theoretically predicted positive sign in almost all regression equations and in most of the cases it is statistically significant. This result indicates that the relative expansionary monetary policy of Pakistan has depreciated its currency against the currencies of its major trading partners during the flexible exchange rate period. The justification is that the increased domestic money supply has inflated domestic price levels in relative terms, which in turn has adversely affected international competitiveness of domestic goods and hence deteriorated the trade balance. This led the Pak-rupee exchange rate to depreciate. But perhaps reverse has happened in case of Korea, Malaysia and Switzerland where monetary policy seemed to be restrictive, which, in turn, has appreciated the Pak-rupee against the currencies of these countries via improved trade balance. However, this negative effect on exchange rates is found to be significant only in the regression equations of Korea and Switzerland. In most of the regression equations the magnitude of the estimated coefficients of the relative money supply variable is close to or greater then unity, which indicates the significant of monetary policy for the determination of exchange rate behavior in Pakistan. One possible reason for not obtaining unitary elasticities is that there are financial innovations for the period under consideration that has shifted the demand for money. This has resulted in unstable demand for money, which violates the implicit assumption of stable money demand function of the monetary models.

The relative income level variable $(y_t - y_t^*)$ bears significant negative sign in most of the regression equations as was theoretically expected. This result indicates that increased production of Pakistan in relative terms has appreciated its currency against the currencies of its major trading partners via improved trade balance as increased domestic production has lowered domestic price levels which in turn improved the international competitiveness of domestic goods. It indicates the significance of the non-transitory real factors such as real economic growth and productivity growth for exchange rate changes. In regression equations of France, Italy, Kuwait and Sweden relative income variable show a positive effect on exchange rates, which indicates that Pakistan's domestic production has decreased in relative terms against the production of these countries during the period of analysis, thereby depreciation of Pak-rupee has occurred against the currencies of these countries through trade balance deterioration. However, this positive effect of relative income variable on exchange rate is significant only in regression equations of Italy and Kuwait.

Out of six regression equations, interest rate differential variable $(i_t - i_t^*)$ shows significant positive coefficient in the regression equations of four countries i.e. Australia, Singapore, Switzerland and Thailand. One reason might be that domestic interest rate has decreased in relative terms against the interest rates of these countries, which in turn led capital to outflow and hence depreciated Pak-rupee exchange rate against the currencies of these countries through balance of payments deficits. For the regression equations of the remaining two countries (Netherlands and Sweden) this variable appeared with significant negative coefficients. The justification may be that relative increase in domestic inertest rate has resulted in capital inflow, which in turn has appreciated Pak-rupee exchange rate against the currencies of these countries through improved balance of payments.

Table 3: Empirical Findings of Monetary Models of Exchange Rate Determination with Major Trading Partners of Pakistan (1983Q1-2007Q4)

	Constant	$m_t - m_t^*$	$y_t - y_t^*$	$i_t - i_t^*$	$\pi_t - \pi_t^*$	AR(1)	AR(2)	R^2	$\overline{R}^2$	DW	ADF Test
Australia	3.5480	0.0446	-0.0126	0.0099		0.9831		0.9809	0.9799	1.9243	-8.4828†
	(4.6321)*	(0.2116)	(-0.3103)	(2.1271)*		(74.859)*					
Belgium	2.1378	1.5376	-0.4064		-4.2890	0.5660		0.9633	0.9613	1.8785	-8.2968†
	(17.5992)*	(21.3165)*	(-2.7473)*		(-2.4664)*	(8.9315)*					
Canada	1.6432	1.3435	-0.0855		3.7984	0.8305		0.9559	0.9535	2.3141	-8.6767†
	(8.9787)*	(8.2834)*	(-0.8144)		(2.5604)*	(17.7435)*					
France	2.8457	0.8956	0.1017		6.0627	0.4052	0.1680	0.9670	0.9648	1.8470	-8.8134†
	(37.9256)*	(22.1089)*	(0.8678)		(3.1527)*	(4.3683)*	(1.7172)**				
Germany	3.8510	2.3728	-0.2892		19.0220		-0.8046	0.8464	0.8381	1.9860	-7.9666†
	(36.4744)*	(21.3930)*	(-0.8046)		(8.5063)*		(-5.5593)*				
Italy	2.9051	0.9472	0.0289		2.4963	0.5898		0.9474	0.9445	1.8865	-8.3257†
	(4.6191)*	(10.9915)*	(2.5394)*		(2.8009)*	(9.2406)*					
Japan	11.9118	2.1860	-0.5451		-3.3053	0.7510		0.9505	0.9479	2.1964	-9.8144†
	(10.7322)*	(12.5290)*	(-2.4305)*		(-2.1328)*	(11.7898)*					
Korea	-6.5923	-0.7766	-1.0007		-10.4423	0.2405		0.8013	0.7907	1.8586	-8.3852†
	(-6.8610)*	(-3.2601)*	(-15.2506)*		(-4.1461)*	(2.6889)*					
Kuwait	0.2666	0.8014	0.1910		-13.5902	0.4246	-0.3662	0.7567	0.7402	2.2295	-10.4221†
	(1.0024)	(17.7654)*	(3.5223)*		(-5.0336)*	(4.1222)*	(-4.4377)*				
Malaysia	2.8725	-0.2161	-0.7759		-10.5981	0.7049		0.6565	0.6380	2.4856	-7.1778†
	(2.8048)*	(-0.4908)	(-4.4993)*		(-3.6335)*	(4.9950)*					
Netherlands	1.2320	1.8547	-0.3962	-0.0156		0.8683		0.9690	0.9674	2.3912	-9.9730†
	(7.0239)*	(9.7015)*	(-5.3757)*	(-1.8967)**		(14.642)*					
Singapore	-0.4651	1.0095	-0.7780	0.0658	0.6280			0.9246	0.9204	1.8169	-7.9436†
	(-0.8245)	(5.6141)*	(-4.8629)*	(8.2165)*	(0.1844)						
Sweden	1.9936	0.9846	0.0465	-0.0238		0.8198		0.9484	0.9454	1.9994	-8.4446†
	(18.129)*	(5.6916)*	(0.4950)	(-2.6059)*		(17.331)*					
Switzerland	7.0257	-0.5630	-0.0899	0.0159	0.1588	0.9864		0.9704	0.9684	1.9333	-8.6641†
	(1.9761)**	(-2.1786)*	(-1.8120)**	(1.8592)**	(0.2302)	(75.384)*					
Thailand	-1.6760	0.1443	-1.0136	0.0321	-7.1937			0.7821	0.7706	1.7897	-8.0151†
	(-13.002)*	(1.1683)	(-11.418)*	(7.8188)*	(-2.8223)*						
United Kingdom	4.7471	0.5944	-0.1249			0.9686		0.9824	0.9817	2.3771	-9.6021†
	(24.338)*	(2.1035)*	(-3.4463)*			(75.660)*					
United States	4.5813	1.1614	-0.0321		3.2787	0.7038		0.9805	0.9795	2.2260	-10.3911†
	(72.9610)*	(19.8586)*	(-0.4318)		(2.6415)*	(8.3446)*					

Note: Values in parentheses show t-statistics. The statistics significant at 5% and 10% levels of significance are indicated by * and ** respectively. Critical values of ADF test at 5% and 10% level of significance are -1.9450 and -1.6140 respectively. † indicates that the series is stationary at 5% significance level.

Finally, the inflation differential variable ($\pi_t - \pi_t^*$) provides somewhat mixed results. In the estimation equations of seven countries (Canada, France, Germany, Italy, Singapore, Switzerland and the United States) this variable shows a positive effect on exchange rates as the theory predicts. It indicates that inflation in Pakistan has increased in relative terms, which in turn has depreciated Pak-rupee against the currencies of these trading partners via balance of payment deficits. This variable is statistically significant in five out of these seven countries (Canada, France, Germany, Italy and the United States). Conversely, for the remaining six countries (Belgium, Japan, Korea, Kuwait, Malaysia and Thailand) inflation differential variable appeared with statistically negative sign. These results show that inflation rate in Pakistan has decreased in relative terms against these countries, which in turn has appreciated Pak-rupee exchange rate against the currencies of these countries through improved balance of payments.

To confirm whether or not the estimated equations in step 2 form long-run relationships, we have applied residual-based ADF test. In essence if the estimated residuals are found to be stationary in levels then long-run cointegration relationships establish otherwise not.[13] Our results of long-run cointegration relationship are supported by the stationarity of the residuals (residuals of the whole model including the AR terms) since all stochastic terms are found to be stationary in levels at conventional 5 per cent significance level as the last column of the table shows.[14]

6. Conclusion

This paper analyzes the determination of bilateral nominal exchange rates of the Pak-rupee against its 17 major trading partners using standard econometric techniques based on quarterly time-series data for the period 1983 to 2007. First, the data supports the flexible price monetary model against the sticky price and the real interest differential monetary models for most of the bilateral Pak-rupee exchange rates. Second, the results show that nominal exchange rates depend upon both monetary and real variables related to Pakistan and its trading partners. Specifically, fluctuations in nominal exchange rates can be explained by governments' monetary policies, relative output level, and relative interest rate and inflation differentials at home and abroad. This implies that if the monetary authorities in Pakistan wish to strengthen the Pak-rupee against the currencies of its major trading partners they

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13 Verifying a cointegration relationship between variables is equivalent to testing whether the autoregressive coefficient ρ in the following autoregressive equation is equal to unity

$\mu_t + \rho\mu_{t-1} + \eta_t$

where $H_0: \rho = 1$, $H_1: \rho < 1$. Since the test statistics diverge to negative infinity under the alternative hypothesis, large negative values imply that the null is rejected.

14 Results are not reported here to conserve space; however, it is available upon request.

should adopt policies aimed at contracting the money supply and inflation rates relative to countries under consideration. Thus, a consistently followed tight monetary policy is the key (also see Siddiqui *et al.,*). Unless consistency is maintained, the gains would be temporary and the monetary shocks will continue to produce inflation, and in turn, the depreciation of the rupee.

It is argued that monetary policy contributes to exchange rate fluctuations; it may be conducted according to a generally known and enforced rule. The benefit of a rule would be that the forecasting problem of each economic agent would be simplified, since the path of monetary policy would be subject to less arbitrary variation. Changes in the expectations of future policy would be less frequent and the exchange rate would be less volatile. Since movements in exchange rates are also driven by high inflation rates, it is argued the practice of using exchange rates as independent instruments is not sustainable in the presence of high inflation. The adoption of a restricted monetary policy seems desirable not only for fighting inflation, but also producing exchange rate stability and sustained trade balances. Moreover, authorities can rely on the monetary policy in altering real output and balance of payments position (Bhatti, 2001). Alternative measures to achieve various objectives can produce conflicting results, therefore, a strict discipline and coordination is essential for the effectiveness of polices.

The estimated coefficients of the model in our country-by-country analysis support the view that the monetary theory of exchange rate determination still holds if more appropriate estimation techniques are applied, which takes into account the non-stationarity and endogeneity issues. Thus, this paper supports the findings of Rapach and Wohar (2002) to a considerable extent in that the monetary approach, with some qualification is validated as a long-term relationship, even if country-by-country analysis in undertaken rather than panel estimation. Our findings show that the support for the long-term monetary model of exchange rate determination is not as trifling as it once appeared. However, our results do not overstate the support for the monetary models. In fact, monetary models do not provide results for Pak-rupee exchange rate determination satisfactorily against few countries and even worst in some cases. These research findings suggest that support for the monetary models provided by the country-by-country analysis is to some extent spurious. Although there exists a long-term relationship in monetary models, this relationship may not be as simple as the model suggests. The long-term monetary models are responsible for such weak results mainly because of its assumptions, as it is derived from stable commodity, money and financial market conditions that are unlikely to hold in Pakistan relative to the rest of the world. Another reason is that the monetary models are subject to omitted variable bias problems. This implies that further refinements and modifications in the monetary models are called for.

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