A SIMULTANEOUS-EQUATION MODEL OF SHORT-RUN DETERMINANTS OF THE PKR/USD EXCHANGE RATE

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ABSTRACT

This paper examines the determinants of the exchange rate between the Pakistani rupee (PKR) and the U.S. dollar (USD) based on a simultaneous-equation model consisting of demand for and supply of the U.S. dollar. Empirical results show that the PKR/USD exchange rate is positively associated with the real U.S. policy rate, real GDP in Pakistan, real U.S. stock prices and the expected PKR/USD exchange rate and is negatively affected by the real Pakistani discount rate, U.S. real GDP, and real stock prices in Pakistan. Hence, policy rates, real GDP or income, stock prices and expected exchange rates play important roles in exchange rate determination in the short run.

Keywords: Exchange rates, Rupee, USD, Interest rates, Output, Stock prices, EGARCH.
JEL Classification: F31, F41.

Contribution/ Originality

This paper applies a simultaneous-equation model to examine the PKR/USD exchange rate in the short run. Interest rates, real GDP, stock prices and the expected exchange rate in Pakistan and the U.S. play important roles in determining the PKR/USD exchange rate in the short run.

1. INTRODUCTION

Partly due to the recent global financial crisis and partly due to market forces, the Pakistani rupee had depreciated as much as 77.41% against the U.S. dollar from 61.22 rupees per U.S. dollar in 2008.M1 to 108.61 rupees per U.S. dollar in 2013.M11. Although the rupee appreciated 9.57% from 108.61 rupees per U.S. dollar in 2008.M1 to 98.22 rupees per U.S. dollar in 2014.M3, the rupee still depreciated 62.62% during 2008.M1 – 2014.M3.

A weaker rupee is expected to cost Pakistanis more to purchase imported goods and services, lead to a higher domestic inflation, reduce international capital inflows, and increase the value of

the sovereign debt measured in the rupee. A volatile PKR/USD exchange rate may affect international trade and dampen economic growth. A tight monetary policy to raise the interest rate may defend the value of the rupee but is expected to hurt consumption and investment expenditures due to higher lending rates. Hence, it is significant to study the PKR/USD exchange rate in order to gain more insights into the subject.

2. LITERATURE SURVEY

There have been several recent studies examining the determinants of exchange rates for Pakistan or related countries. Zakaria *et al.* (2007) examine the PKR exchange rate versus 12 major trading partners. They indicate that exchange rates are influenced by relative inflation rates, monetary policies, terms of trade, trading policies and capital mobility. Monetary variables play important roles in exchange rate determination. Based on three monetary models and exchange rates versus 17 major trading partners, Zakaria and Ahmad (2009) find that the rupee exchange rate in the long run can better be explained by the flexible-price monetary model than the sticky-price and the real interest rate differential monetary models.

Khan and Qayyum (2007) find strong evidence of purchasing power parity for the PKR/USD exchange rate and that the nominal exchange rate makes adjustments and eliminates deviations from long-run purchasing power parity. They also show that there is a high degree of integration between the foreign exchange and goods markets. In another article, Khan and Qayyum (2011) employ different monetary models to study the rupee exchange rate. They reveal that empirical results are in line with the interest rate differential version of monetary models in the long run (Frankel, 1979). The PKR/USD exchange rate has a positive relationship with relative money supply and relative inflation rates and a negative relationship with relative real GDP and the interest rate differential. In the short run, exchange rate disequilibrium is corrected by relative money supply, the inflation differential, and the change in exchange rates.

Saeed *et al.* (2012) show that the PKR/USD exchange rate is positively affected by the relative money supply, the relative government debt and political instability and is negatively affected by foreign exchange reserves.

Applying demand and supply analysis, Hubbard and O'Brien (2012) indicated that the exchange rate (units of a foreign currency per U.S. dollar) in the short run is determined by the interest rates and real GDP in the foreign country and the U.S. and expectations about the value of the U.S. dollar or the foreign currency. A higher U.S. interest rate tends to cause the U.S. dollar to appreciate whereas a higher foreign interest rate tends to cause the U.S. dollar to depreciate. A higher real GDP in the U.S. tends to cause the U.S. dollar to depreciate whereas a higher real GDP in the foreign country tends to cause the U.S. dollar to appreciate. Expectations that the U.S. dollar will become stronger tends to cause the U.S. dollar to appreciate whereas expectations that the foreign currency would become stronger tends to cause the U.S. dollar to depreciate.

Hsing (2014) employed demand and supply analysis to study short-run determinants of the Croatian kuna/U.S. dollar (HRK/USD) exchange rate. He found that the HRK/USD exchange rate

had a positive relationship with the real interest rate in the U.S., real GDP in Croatia, the real stock price in the U.S. and the expected HRK/USD exchange rate and a negative relationship with U.S. real GDP and the real stock price in Croatia. The coefficient of the real interest rate in Croatia was negative but insignificant at the 10% level. The R^2 value of 0.9053 and the mean absolute percent error of 4.37% suggest that the model for short-run determinants of the exchange rate for Croatia works reasonably well.

Rehman (2014) studies the relationship between the Pakistani rupee exchange rate and seven macroeconomic variables including total reserves less gold, the inflation rate, imports, exports, industrial production and the stock price index. The causality test shows that the exchange rate may have unidirectional or bi-directional relationship with some of these variables.

Abbasi and Safdar (2014) show that a modified monetary model works better than the simple monetary model. They emphasis the importance of dollarization and indicate that the more dollar deposits as a percent of total deposits in the Pakistani banking system, the weaker the Pakistani rupee.

These previous studies have made significant contributions to the literature. To the author's best knowledge, few of these studies have applied demand and supply analysis in determining exchange rates in the short run. Monetary models of exchange rates are based on the validity of purchasing power parity in the long run. In addition to interest rates or stock prices, exchange rates may be affected by other variables. This paper attempts to examine the PKR/USD exchange rate based on a simultaneous-equation model. The demand for and the supply of the U.S. dollar versus the Pakistani rupee are considered simultaneously in determining the equilibrium PKR/USD exchange rate.

3. THE MODEL

Extending Hubbard and O'Brien (2012), Hsing (2014) and other studies and incorporating monetary policy shocks,[1] we can express the demand for and supply of the U.S. dollar in the foreign exchange market versus the Pakistani rupee as:

$$USD^d = D(\varepsilon, Y^{PK}, R^{US}, E^{US}, \varepsilon^e) \qquad (1)$$
$$\quad - \quad + \quad + \quad + \quad +$$

$$USD^s = S(\varepsilon, Y^{US}, R^{PK}, E^{PK}) \qquad (2)$$
$$\quad + \quad + \quad + \quad +$$

where
USD^d = demand for the U.S. dollar,
USD^s = supply of the U.S. dollar,

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[1] An attempt was made to include productivity shocks. However, the data for the Pakistani productivity are incomplete. Hence, the productivity shock variable is not included in the model.

ε   = the PKR/USD (Pakistani rupee/U.S. dollar) exchange rate,

Y^{PK} = real GDP or income in Pakistan,

R^{US} = the real policy rate in the U.S.,

E^{US} = the equity or stock price in the U.S.,

$ε^e$ = the expected PKR/USD exchange rate,

Y^{US} = real GDP or income in the U.S.,

R^{PK} = the real discount rate in Pakistan,

E^{PK} = the equity or stock price in Pakistan.

We expect that the demand for the U.S. dollar has a negative relationship with the PKR/USD exchange rate and a positive relationship with real GDP or income in Pakistan, the real policy rate in the U.S., the real stock price in the U.S., and the expected PKR/USD exchange rate. The supply of the U.S. dollar is expected to be positively associated with the PKR/USD exchange rate, real GDP or income in the U.S., the real discount rate in Pakistan, and the real stock price in Pakistan. As real GDP or income in Pakistan rises, Pakistanis tend to import more goods and services from the U.S. and increase the demand for the U.S. dollar. When real GDP or income in the U.S. rises, Americans tend to import more goods and services from Pakistan and increase the supply of U.S. dollar in exchange for the Pakistani rupee. A higher real policy rate or stock price in the U.S. tends to attract Pakistanis to invest in these financial assets and to increase the demand for the U.S. dollar. On the other hand, a higher real discount rate or stock price in Pakistan tends to attract American investors to buy these financial assets and increase the supply of the U.S. dollar in exchange for the Pakistani rupee (Frankel, 1979).

Solving for the equilibrium values of the two endogenous variables simultaneously, we can express the equilibrium exchange rate as a function of all the exogenous variables:

$$\bar{\varepsilon} = f(R^{US}, R^{PK}, Y^{US}, Y^{PK}, E^{US}, E^{PK}, \varepsilon^e) \tag{3}$$

Comparative static analysis shows that a change in any one of the exogenous variables is expected to have an impact on the equilibrium PKR/USD exchange rate:

$$\partial \bar{\varepsilon} / \partial R^{US} = -D_{R^{US}} / |J| > 0 \tag{4}$$

$$\partial \bar{\varepsilon} / \partial R^{ID} = -S_{R^{ID}} / |J| < 0 \tag{5}$$

$$\partial \bar{\varepsilon} / \partial Y^{US} = -S_{Y^{US}} / |J| < 0 \tag{6}$$

$$\partial \bar{\varepsilon} / \partial Y^{ID} = -D_{Y^{ID}} / |J| > 0 \tag{7}$$

$$\partial \bar{\varepsilon} / \partial E^{US} = -D_{E^{US}} / |J| > 0 \tag{8}$$

$$\partial \bar{\varepsilon} / \partial E^{ID} = -S_{E^{ID}} / |J| < 0 \tag{9}$$

$$\partial \overline{\varepsilon} / \partial \varepsilon^e = -D_{\varepsilon^e} / |J| > 0 \qquad\qquad (10)$$

where $|J| = (D_{\varepsilon} - S_{\varepsilon})$ is the Jacobian for the endogenous variables and has a negative value.

Note that in the monetary models based on the equilibrium condition in the money market, the sign of the interest rate differential between Pakistan and the U.S. may be positive or negative, depending upon whether the Bilson (1978) model or the Dornbusch (1976) and Frankel (1979) models would apply.

4. EMPIRICAL RESULTS

The data were collected from the *International Financial Statistics*, which is published by the International Monetary Fund. The PKR/USD exchange rate measures units of the Pakistani rupee per U.S. dollar. Hence, an increase means an appreciation of the U.S. dollar or a depreciation of the Pakistani rupee. R^{PK} is measured by the discount rate minus the inflation rate in Pakistan. Likewise, R^{US} is measured by the Federal Reserve Bank's policy rate minus the inflation rate in the U.S. Real GDP in the U.S. or Pakistan is an index number with 2005 as the base year. The expected exchange rate is represented by the average PKR/USD exchange rate of past three years. The real stock price in the U.S. is represented by the real share price in the U.S., and the real stock value in Pakistan is measured by the real share price in Pakistan. Because of lack of quarterly data for real GDP, the sample consists of annual data ranging from 1982 to 2013 and has a total of 32 observations. The data for the U.S. policy rate before 1982 are not available.

To determine whether these time series variables are cointegrated, the ADF test on the regression residuals is applied. The value of the test statistic is estimated to be -5.2698, which is greater than the critical value of -3.6702 in absolute values at the 1% level. Thus, these time series variables have a long-term stable relationship.

Table 1 reports estimated coefficients and other related statistics. The EGARCH method is applied in order to generate a positive conditional variance and no restriction on the parameters. As shown, 99.11% of the variation in the equilibrium PKR/USD exchange rate can be explained by the seven right-hand side variables. All the coefficients are significant at the 1% or 5% level. The equilibrium PKR/USD exchange rate is positively associated with the real U.S. policy rate, real GDP in Pakistan, U.S. stock prices and the expected exchange rate and negatively affected by the real Pakistani discount rate, U.S. real GDP and stock prices in Pakistan.

Several comments can be made. If the real U.S. policy rate rises 1 percentage point, the PKR/USD exchange rate would increase by 0.4486. Conversely, if the real discount rate in Pakistan increases 1 percentage point, the PKR/USD exchange rate would decline by 0.4999. It suggests that international capital flows between the U.S. and Pakistan respond to interest rate movements. According to the Wald test, the null hypothesis that the two coefficients have the same value cannot be rejected at the 1% level.

If U.S. real GDP index rises 1, the PKR/USD exchange rate would decline by 0.6057. As real GDP in the U.S. rises, Americans are likely to buy more from Pakistan. The supply of the U.S. dollar increases, causing the PKR/USD exchange rate to decline. On the other hand, if real GDP index in Pakistan rises 1 unit, the PKR/USD exchange rate would increase by 0.7577. Stock market conditions

Table-1. Estimated Regression of the PKR/USD Exchange Rate

Real U.S. policy rate	0.4486	2.0722
Real Pakistani discount rate	-0.4999	-5.1283
U.S. real GDP	-0.6057	-5.1042
Pakistani real GDP	0.7577	10.0209
Real U.S. stock prices	0.1197	3.3887
Real Pakistani stock prices	-0.1533	-15.1720
Expected PKR/USD exchange rate	0.5680	9.2166
Constant	14.9773	4.5832
R^2	0.9911	
Mean absolute percent error	5.5869%	
Sample period	1982-2013	
Number of observations	32	
Methodology	EGARCH	

Notes: Except that the coefficient of the real U.S. policy rate is significant at the 5% level, other coefficients are significant at the 1% level. PKR stands for the Pakistani rupee.

also affect exchange rates. As the real stock price index in the U.S. rises 1 unit, the PKR/USD exchange rate would increase by 0.1197 whereas a one unit increase in the real stock price index in Pakistan would reduce the PKR/USD exchange rate by 0.1533.

Several other versions are tested to determine whether the results may vary. If the average PKR/USD exchange rate is replaced by the simple lagged PKR/USD exchange rate, its coefficient is positive and significant at the 1% level. However, the positive coefficient of the real U.S. policy rate is insignificant at the 10% level, and the R^2 value of 0.9940 is similar to the R^2 value of 0.9911 as reported in Table 1. Other results are similar. It may suggest that the specification of the expected exchange rate would affect empirical outcomes. When the difference form between the U.S. and Pakistani variables is used, the value of R^2 is 0.9925, the coefficient of the interest rate differential is positive but insignificant at the 10% level, and other coefficients have the expected signs and are significant at the 1% level.

5. SUMMARY AND CONCLUSIONS

This paper has examined the determinants of the PKR/USD exchange rate in the short run based on a simultaneous-equation model consisting of the demand for and supply of the U.S. dollar. A reduced-form equation is estimated by the EGARCH method. The paper finds that a higher real U.S. policy rate, a lower Pakistani real discount rate, a lower real GDP in the U.S., a higher real GDP in Pakistan, a higher real U.S. stock price, a lower Pakistani real stock price, or a higher expected PKR/USD exchange rate would cause the PKR/USD exchange rate to appreciate.

There are several policy implications. It seems that demand and supply analysis of the PKR/USD exchange rate in the short run works reasonably well because it can explain approximately 99% of exchange rate movements and because the forecast error as measured by the mean absolute percent error is 5.5869%. Policy rates, real GDP, expected exchange rates and stock prices in the U.S. and Pakistan play important roles in exchange rate movements in the short run. Recently, more rapid increase in Pakistani stock prices, higher inflation rates in Pakistan which reduce the real discount rate, and slower growth in real GDP in Pakistan may change the PKR/USD exchange rate in different directions.

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