Modelling Exchange Rate Volatility by Macroeconomic Fundamentals in Pakistan

Munazza Jabeen® and Saud Ahmad Khan

Int. Institute of Islamic Economics and National University of Sciences and Tech.

ABSTRACT

What drives volatility in foreign exchange market in Pakistan? This paper undertakes an analysis of modelling exchange rate volatility in Pakistan by potential macroeconomic fundamentals well-known in the economic literature. For this monthly data on Pak Rupee exchange rates in the terms of major currencies (US Dollar, British Pound, Canadian Dollar and Japanese Yen) and macroeconomics fundamentals is taken from April, 1982 to November, 2011. The results show that the PKR-USD exchange rate volatility is influenced by real output volatility, foreign exchange reserves volatility, inflation volatility and productivity volatility. The PKR-GBP exchange rate volatility is influenced by foreign exchange reserves volatility and terms of trade volatility. The PKR-CAD exchange rate volatility is influenced by terms of trade volatility. The findings of this paper reveal that exchange rate volatility in Pakistan results from real shocks than nominal shocks.

Key words: *Exchange Rate Volatility, GARCH*
JEL Classifications: F31, C22

1. INTRODUCTION

Modelling exchange rate volatility continues to attract attention from both academic and policy researchers due to its significance for the economy. In spite of considerable amount of empirical work undertaken, the modelling volatility in exchange rates remains a challenge. Using information in macroeconomic fundamentals to model volatility in foreign exchange markets is not completely new to the literature (see e.g. Calderón, 2004; Grydaki and Fountas, 2009; Cheung and Lai, 2009; Chipili, 2012) but there is no general conclusion on modelling exchange rates volatility by macroeconomic fundamentals due to the divergent theoretical exchange rate determination models are found in economic literature. There are some studies that have emphasized the importance of nominal shocks with transitory effects on exchange rates volatility (Morana, 2009), while others has documented real shocks with large permanent effects as the dominant source of exchange rate volatility (Bayoumi and Eichengreen, 1998; Devereux and Lane, 2003). Moreover, there are some studies that have shown no connection between macroeconomic fundamentals and exchange rates (Flood and Rose, 1995).

Exchange rate volatility in developing countries like Pakistan is very pervasive. In Pakistan, an extensive increase in the exchange rate volatility is seen in the recent years. It has significant effects on decisions made by many economic agents who participate in foreign exchange markets like traders, investors, managers and firms. It also has significant effects on decisions made by policy makers in formulating suitable policies. Therefore, understanding

® Munazza Jabeen, International Institute of Islamic Economics, International Islamic University Islamabad, Pakistan, (email: munazza.jabeen17@gmail.com or munazza.mseco246@iiu.edu.pk).
Saud Ahmad Khan, National University of Sciences and Technology (saudak2k3@yahoo.com).

volatility movements in exchange rates is of crucial importance and understanding the macroeconomic causes of exchange rate volatility helps to uncover linkages between exchange rate movements and underlying shocks. Moreover, a better understanding of the driving forces of exchange rate volatility is important for policy makers and monetary authorities.

Our paper undertakes an analysis of modelling exchange rate volatility in Pakistan by potential macroeconomic fundamentals well-known in the economic literature. It investigates which macroeconomic fundamentals drive volatility in foreign exchange market in Pakistan through GARCH models and how well do the potential macroeconomic fundamentals explain nominal exchange rate volatility over time? In order to study the volatility dynamics, monthly data on Pak Rupee exchange rates in the terms of major currencies (US Dollar, British Pound, Canadian Dollar and Japanese Yen) and macroeconomics fundamentals are taken from April 1982 to November 2011 for a total of 356 monthly observations.

The structure of paper is as follows: Section 2 presents the literature review. Section 3 presents exchange rate volatility model. Section 4 reports empirical analysis. Section 5 provides conclusion and policy recommendations.

2. A REVIEW OF EMPIRICAL STUDIES ON EXCHANGE RATE VOLATILITY

Most of the empirical work has used either a specific or a combination of fundamentals-based models in modelling exchange rate volatility. For instance, Bartolini and Bodnar (1996) and Morana (2009) have employed the monetary model of exchange rates; Benita and Lauterbach (2007) has taken the central bank intervention in the foreign exchange market; Calderón (2004) has focused on new open economy macroeconomics; Bayoumi and Eichengreen (1998) and Devereux and Lane (2003) have based the analysis on optimum currency areas (OCA) factors while Hausmann et al. (2006) has incorporated factors from different exchange rate models. Therefore, there is no consensus regarding determinants of volatility of exchange rates due to the existence in economic literature of divergent theoretical models of exchange rate determination.

De Grauwe et al. (1985) have found that positive relation between variability of exchange rates and variability of monetary shocks. Dornbusch (1976), Mussa (1986) and Edwards (1987) have emphasized nominal shocks with transitory effects on exchange rates fluctuations. Stockman (1983) has emphasized real shocks with permanent effects on exchange rate fluctuations. Flood and Rose (1995) have found macroeconomic fundamentals explain a small proportion of volatility in exchange rates. Benita and Lauterbach (2007), in a panel study have found positive correlation between volatility of exchange rates, the central bank intervention and real interest rates. In a specific country, Israel, they have found negative correlation between them. Hviding et al. (2004) has found higher international reserves reduce exchange rate volatility. Grydaki and Fountas (2009) have found that variability in the money supply, inflation and output explains variability in exchange rates. Morana (2009) have found that that exchange rate volatility is affected by the monetary shocks particularly output and inflation volatility.

The “New Open Economy Macroeconomics” Obstfeld and Rogoff (1995) have argued that non-monetary factors are important in explaining volatility in exchange rates. Calderón (2004) has analyzed non-monetary factors such as productivity shocks, terms of trade; openness and government spending are also explaining volatility in exchange rates. Greater variability in real productivity shocks results in higher exchange rate variability. Greater trade openness reduces exchange rate volatility.

Some studies have shown OCA factors as potential sources of volatility in exchange rates. Bayoumi and Eichengreen (1998) have evaluated OCA theory and have found OCA factors substantially explain exchange rate volatility. They have concluded nominal exchange rate volatility decreases with trade and increases with the size of the countries. Obstfeld and Rogoff (2000) and Hau (2002) have found trade flows and openness reduces exchange rate volatility. Devereux and Lane (2003) have extended OCA theory by adding financial factors as determinants of exchange rate volatility and have found higher trade and financial linkages reduces volatility of exchange rates. Bangaké (2008) has found that volatility in exchange rates is influenced by OCA factors for selected African countries. They have concluded trade flows and openness have negative effects on exchange rate volatility which is supported by Devereux and Lane (2003) and Hau (2002). Cheung and Lai (2009) have found exchange rate volatility tends to increase with financial openness and decrease with financial depth and trade openness. They have also concluded that financial factors influence exchange rate volatility in shorter horizons while trade related factors influence exchange rate volatility in longer horizons.

A number of studies have employed GARCH models in modelling underlying sources of exchange rate volatility. Hua and Gau (2006) have employed the periodic GARCH model in analyzing intraday Taiwan dollar/US dollar exchange rates by controlling for the impact of news, central bank intervention and inventory control in the conditional variance equation. All these factors impact positively on conditional volatility. Bauwens et al. (2006) has model the Norwegian krone volatility by investigating the role of information arrival on the market using the EGARCH. Exchange rate volatility is specified as a function of information variables, Euro/US dollar exchange rate, oil price volatility, stock market index, and the interest rate as explanatory variables. Stančík (2007) has estimated the Threshold ARCH (TGARCH) model in analyzing exchange rates volatility by controlling for news factors, openness and exchange rate regime with variable effect across countries. Similarly, Fidrmuc and Horváth (2008) have focused on new EU countries and applied GARCH and TGARCH models. Chipili (2012) has examined the sources of volatility of Zambian kwacha exchange rates using the GARCH models and has found both monetary and real factors effect exchange rate volatility. They have concluded that real factors have smaller effect on exchange rate volatility than monetary factors. The factors such as foreign reserves changes, money supply growth, openness, domestic real interest rates changes and output growth increase exchange rate volatility while real foreign interest rates changes and inflation rate changes decrease exchange rate volatility. Ahmed (2012) has used GARCH models and found money supply, general price level (CPI), and current account as main determinants of exchange rates volatility in Sudan.

3. EXCHANGE RATE VOLATILITY MODEL

In order to study what drives exchange rate volatility in Pakistan and which macroeconomic fundamentals accounts for volatility, GARCH models based on potential macroeconomic fundamentals are estimated. The empirical model of exchange rate volatility is given by:

Mean equation: (3.1)

$$r_t = c + \sum_{p=1}^{l} \delta_p r_{t-p} + \sum_{q=1}^{m} \varphi_q \varepsilon_{t-p} + \phi_1 RRY_t + \phi_2 FXRES_t + \phi_3 INFD_t + \phi_4 TOT_t + \phi_5 PR_t + \phi_6 TR_t + \varepsilon_t$$

Variance equations:

GARCH (1,1) (3.2)

$$h_t = \omega_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 h_{t-1} + \theta_1 VRRY_t + \theta_2 VFXRES_t + \theta_3 VINFD_t + \theta_4 VTOT_t + \theta_5 VPR_t + \theta_6 VTR_t$$

GJR-GARCH(1,1) (3.3)

$$h_t = \omega_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 h_{t-1} + \gamma_1 \varepsilon_{t-1}^2 S_{t-1} + \theta_1 VRRY_t + \theta_2 VFXRES_t + \theta_3 VINFD_t + \theta_4 VTOT_t + \theta_5 VPR_t + \theta_6 VTR_t$$

where r_t is the exchange rate returns, RRY_t is relative real income, $FXRES_t$ is in foreign reserves and $INFD_t$ is inflation rate differential, TOT_t is terms of trade, PR_t is productivity and TR_t is trade restrictions. All the variables are transformed into log difference form. $VRRY_t$ is the volatility of relative real income, $VFXRES_t$ is the volatility of foreign exchange reserves, $VINFD_t$ is the volatility of inflation rate differential, $VTOT_t$ is the volatility of terms of trade, VPR_t is the volatility of productivity and VTR_t is the volatility of trade restrictions.

4. EMPIRICAL ANALYSIS

In our empirical analysis, the monthly data from April 1982 to November 2011 for a total of 356 monthly observations are used. The data is obtained from International Financial Statistics (IFS), Annual State Bank Reports. Bilateral Pak Rupee nominal exchange rates in the term of major currencies (US dollar, British pound sterling, Canadian dollar and Japanese yen) are taken. The monthly average data of these exchange rates are used and expressed in Pak Rupees for one unit of foreign currency. The monthly return series are constructed as logarithmic first difference of monthly Pak Rupee exchange rates of successive months [$r_t = ln(E_t / E_{t-1})$]. The monthly data on real income measured by industrial production index (2005 = 100), foreign exchange reserves, inflation measured as percentage changes in consumer price index (2005 = 100), foreign terms of trade measured by foreign price level of exports to imports ratio, trade restrictions measured by the reciprocal of trade openness which is sum of exports and imports to nominal GDP ratio, productivity measured as manufacturing production index to real GDP ratio are used. The conditional volatilities of these macroeconomic variables are measured through GARCH models.

In the estimation of GARCH models, various ARMA(p,q) model specifications for mean equation are used with the conditional variance equation simultaneously. The covariance matrix of the estimates (outer-product of gradients) is computed with the Maximum Likelihood Estimation (MLE) method. Further, normal distribution is used for conditional distribution of the error term. The model selection criterion for the GARCH models is based on diagnostic tests. These include AIC (Akaike Information Criteria) and SIC (Schwartz Information Criteria), Log-likelihood values, LM ARCH test, Box-Pierce Q and Q^2 statistics, Forecast evaluation measures and Nyblom test for parameter stability. In the case of model selection under the normal distribution the model with the minimum AIC, SIC, or maximum log likelihood values and Chi-square statistics which passes the Q-test, the LM ARCH test, Nyblom Test and minimum forecast errors is selected.

The plots of the monthly logarithmic changes in macroeconomic fundamentals are given in Figure 4.1 which shows fluctuations in exchange rates and macroeconomic fundamentals.

Figure 4.1 Monthly Logarithmic Changes in Exchange Rates and Macroeconomic Fundamentals

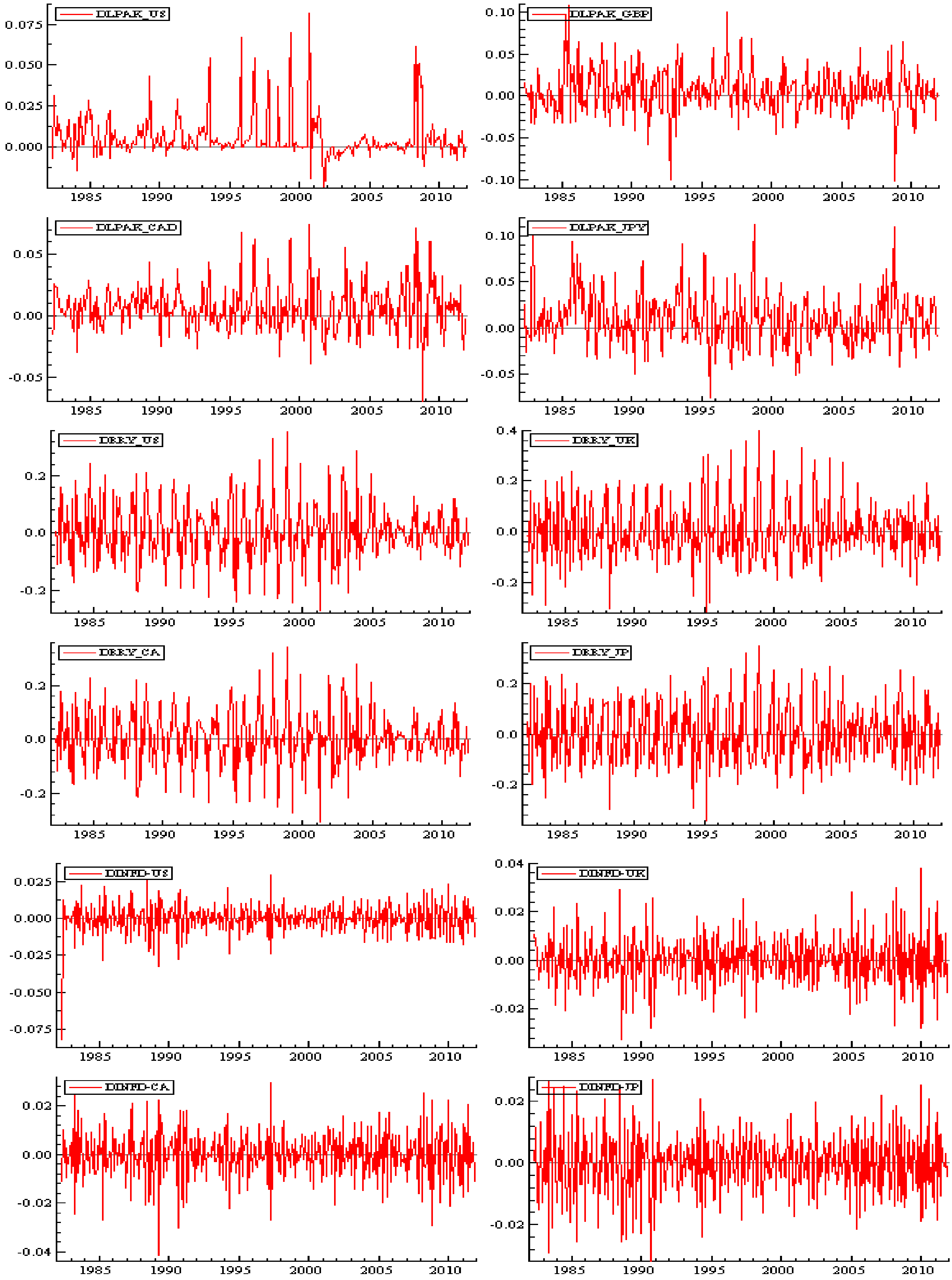
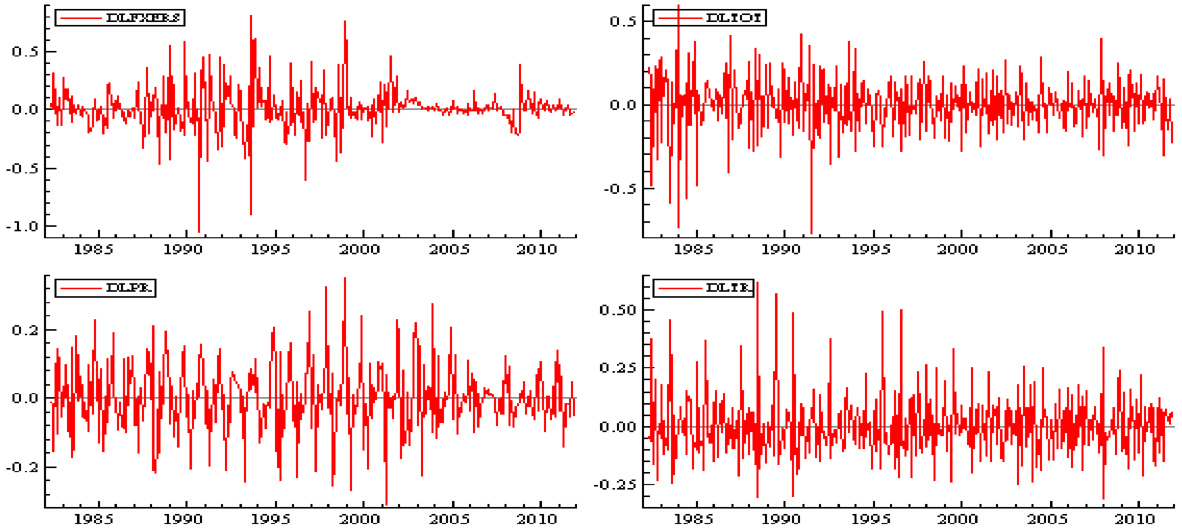


Figure 4.1 Monthly Logarithmic Changes in Exchange Rates and Macroeconomic Fundamentals (cont.)



Since the conditional volatility is not directly observable, squared returns of exchange rates and squared logarithmic difference of macroeconomic fundamentals are used instead as a proxy of the realized volatility. In Figure 4.2, plots show variations in realized volatility of exchange rates and macroeconomic fundamentals.

Figure 4.2 The Monthly Volatility of Exchange Rates and Macroeconomic Fundamentals

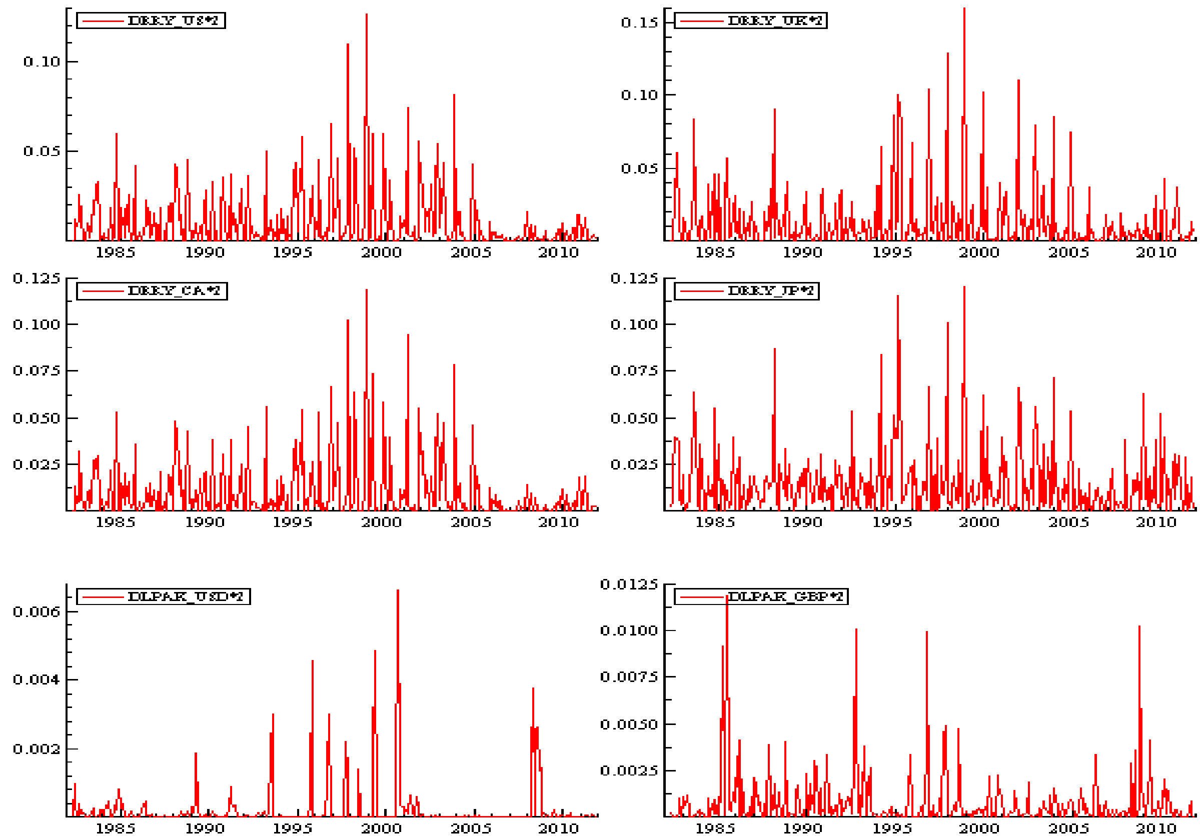
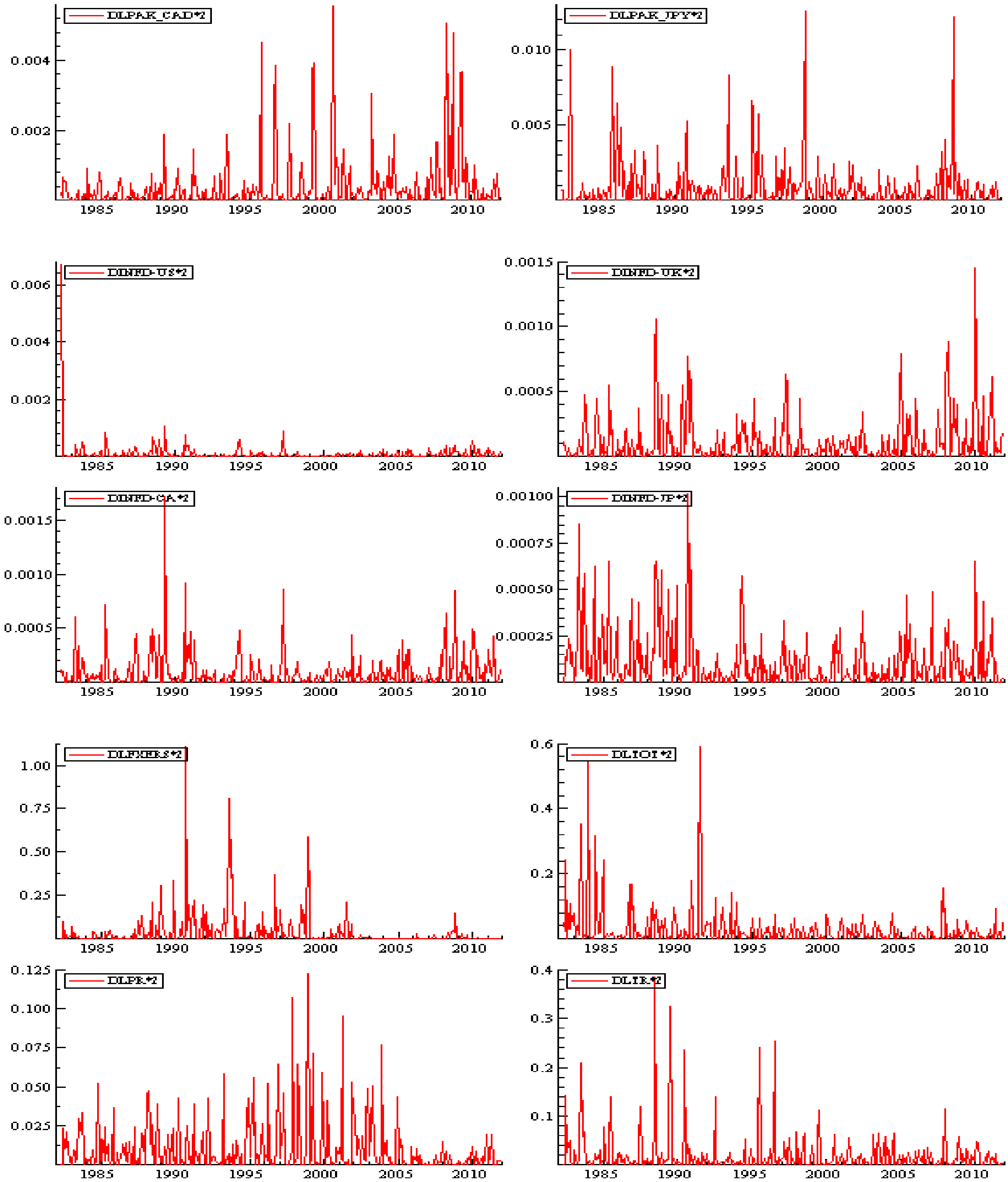


Figure 4.2 The Monthly Volatility of Exchange Rates and Macroeconomic Fundamentals (cont.)



The Table 4.1 reports summary statistics for the monthly exchange rate returns series and macroeconomic variables. The mean of monthly exchange returns are slightly positive as the exchange rates increase slightly overtime. The value of skewness is positive statistically significant in PKR-USD, PKR-GBP, PKR-CAD and PKR-JPY exchange rate returns which implies that depreciation are more probable in these exchange rates. The excess kurtosis is statistically significant and positive for each of Pak Rupee exchange rates returns which indicate the monthly exchange rate returns are heavy tailed and have leptokurtic distribution. The Jarque-Bera statistic is used to indicate the characteristics of distribution of exchange rate return series. The Jarque-Bera test statistics are positive and statistically significant for each of Pak Rupee exchange rates returns showing non-normality in each of Pak Rupee exchange rates returns distributions.

	Mean	**Std.Dev.**	**Skewness**	**Excess Kurtosis**	**J-B**	**LB Q(10)**	**LB $Q(10)^2$**	**LM ARCH 1-10**
PKR-USD	0.005659	0.012784	2.6048	8.9661	1590.6**	69.6999 [0.00000]**	33.1112 [0.000260]**	2.8736 [0.0019]**
PKR-GBP	0.0053317	0.026628	0.15780	1.9774	59.313**	35.4966 [0.000102]**	19.7577 [0.031630]*	2.6678 [0.0221]*
PKR-CAD	0.0061434	0.01879	0.53498	1.8007	64.898**	42.2191 [0.000006]**	36.8883 [0.000059]**	3.1354 [0.0008]**
PKR-JPY	0.0089009	0.028201	0.53067	0.94036	29.742**	50.3937 [0.000000]**	18.9032 [0.006883]**	2.0672 [0.0266]*
FXERS	0.0084734	0.19438	-0.093215	5.4127	433.86**	8.46245 [0.583761]	99.4315 [0.000000]**	6.9024 [0.0000]**
RRY-US	0.0024609	0.10103	0.21614	0.52657	6.8654**	122.510 [0.000000]**	30.1658 [0.000804]**	3.2347 [0.0005]**
RRY-UK	0.003527	0.11203	0.42177	0.83072	20.733**	45.4351 [0.000001]**	164.536 [0.000000]**	1.2286 [0.0213]*
RRY-CA	0.0020464	0.099982	0.067154	0.72156	7.9682**	57.6615 [0.000000]**	11.2894 [0.000000]**	1.1190 [0.0419]*
RRY-JP	0.0034399	0.12126	0.13088	0.68432	6.7039**	126.594 [0.000000]**	31.6426 [0.000459]**	3.2055 [0.0006]**
INFD-US	-0.00019402	0.010494	-1.3995	9.7145	1511.8**	80.2489 [0.000000]**	67.2512 [0.000000]**	6.0656 [0.0000]**
INFD-UK	5.198e-005	0.010737	0.10018	0.53328	4.8004**	108.970 [0.000000]**	69.1032 [0.000000]**	8.4942 [0.0000]**
INFD-CA	1.369e-005	0.010202	-0.32102	0.73387	14.064**	104.983 [0.000000]**	46.8242 [0.000001]**	3.9364 [0.0000]**
INFD-JP	3.9751e-005	0.010592	-0.17740	5.7817	483.91**	91.6881 [0.000000]**	36.4768 [0.000069]**	3.7380 [0.0001]**
TOT	7.8484e-005	0.16873	-0.57371	2.5516	115.78**	106.086 [0.000000]**	18.4110 [0.048414]*	1.8768 [0.0474]*
PR	0.00056145	0.099953	0.063826	0.77355	9.0921**	140.496 [0.000000]**	70.7464 [0.000000]**	6.3918 [0.0000]**
TR	5.383e-005	0.13829	1.1239	2.6636	179.68**	128.466 [0.000000]**	30.5992 [0.000683]**	3.1465 [0.0007]**

Table 4.1 Summary Statistics and Diagnostic Checks of Monthly Pak Rupee Exchange Returns and Macroeconomic Variables
Notes: *p* – values are in parentheses, ** indicates significant at 1% and * significant at 5%

In order to test conditional heteroskedasticity, Lagrange Multiplier test and the Ljung-Box test are employed on exchange rate return series (PKR-USD, PKR-GBP, PKR-CAD, PKR-JPY) and macroeconomic variables. The Ljung-Box–Pierce Q-statistics and Q2-statistics at lag 10 are significant, showing there is serial correlation in residuals and square residuals. The LM test shows strong evidence that the square residuals exhibit an ARCH effect. These results support for the estimation of a conditional heteroscedasticity model for Pak Rupee exchange rate returns.

In order to test the stationarity of time series Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test is employed. KPSS statistics test the null hypothesis that series is stationary. The KPSS test is used with constant term and with constant and trend terms. The results in Table 4.2 show non-stationarity of all the variables in level form and stationarity of all the variables in first difference form.

	KPSS test statistic					
	Level			First Difference		
Variables	**With Constant**	**With Constant and Trend**	**Results**	**With Constant**	**With Constant and Trend**	**Results**
PKR-USD	16.7154 (1)	2.38705 (1)	Non- Stationary	0.202707 (1)	0.0922526 (1)	Stationary
PKR-GBP	16.6579 (1)	1.76262 (1)	Non- Stationary	0.088708 (1)	0.0529174 (1)	Stationary
PAK_CAD	16.618 (1)	0.554864 (1)	Non- Stationary	0.0549032 (1)	0.0359339 (1)	Stationary
PAK_JPY	15.73 (1)	3.24744 (1)	Non- Stationary	0.289753 (1)	0.0773787 (1)	Stationary
FXERS	12.2103 (1)	2.10017 (1)	Non- Stationary	0.0570066 (1)	0.0309141 (1)	Stationary
RRY-US	10.1915 (1)	1.25872 (1)	Non- Stationary	0.0109182 (1)	0.0097189 (1)	Stationary
RRY-UK	13.7029 (1)	1.58354 (1)	Non- Stationary	0.011519 (1)	0.00688007 (1)	Stationary
RRY-JP	14.1062 (1)	0.939006 (1)	Non- Stationary	0.00663364 (1)	0.00576231 (1)	Stationary
RRY-CA	10.9562 (1)	0.72615 (1)	Non- Stationary	0.00788414 (1)	0.00779097 (1)	Stationary
INFD-US	0.883188 (1)	0.314914 (1)	Non- Stationary	0.0601229 (1)	0.0283392 (1)	Stationary
INFD-UK	1.10031 (1)	0.251238 (1)	Non- Stationary	0.0123917 (1)	0.00523015 (1)	Stationary
INFD-JP	1.02054 (1)	0.246272 (1)	Non- Stationary	0.00587113 (1)	0.00339713 (1)	Stationary
INFD-CA	0.805195 (4)	0.128358 (2)	Non- Stationary	0.00256549 (1)	0.00245922 (1)	Stationary
TR	2.57887 (1)	0.585381 (1)	Non- Stationary	0.0056173 (1)	0.00508163 (1)	Stationary
TOT	3.08026 (1)	2.52369 (1)	Non- Stationary	0.0357993 (1)	0.00497849 (1)	Stationary
PR	5.19819 (1)	0.757749 (1)	Non- Stationary	0.00654536 (1)	0.00646422 (1)	Stationary
Critical Values (KPSS)						
	1%	5%	10%			
No Trend	0.739	0.463	0.347			
With Trend	0.216	0.146	0.119			

Table 4.2 KPSS Unit Root Test
*Notes***:** lag lengths are in parentheses

The evidences of non-stationarity, non-normal distribution and significant volatility clustering of exchange rate returns series and macroeconomic variables imply the use of non-linear models to model volatility. Hence, GARCH models are estimated. The Table 4.3 presents the estimated GARCH models for the macroeconomic variables.

The Tables 4.4 and 4.5 present estimated GARCH(1,1) and GJR-GARCH(1,1) results for PKR-USD, PKR-GBP, PKR-CAD and PKR-JPY exchange rates returns series.

Model	GARCH(1,1) FXERS	GARCH(1,1) RRY-US	GARCH(1,1) RRY-UK	GARCH(1,1) RRY-CA	GARCH(1,1) RRY-JP	GJR-GARCH(1,1) TOT
Mean Equation						
c (constant)	0.015766 (0.0034)	0.003384 (0.0007)**	0.004459 (0.0000)**	0.002539 (0.0100)*	0.003888 (0.0000)**	0.000961 (0.8597)
δ_1 (AR(1))	0.680582 (0.0003)**					0.416516 (0.0000)**
φ_1 (MA(1))	0.781850 (0.0000)**	-0.124474 (0.0294)*	-0.204631 (0.0002)**	-0.157686 (0.0053)**	-0.246650 (0.0000)**	
φ_2 (MA(2))		-0.120274 (0.0277)*	-0.283776 (0.0000)**	-0.115855 (0.0349)*	-0.337342 (0.0000)**	
φ_1 (MA(3))		-0.262670 (0.0000)**	-0.333716 (0.0000)**	-0.195500 (0.0003)**	-0.297353 (0.0000)**	
φ_2 (MA(4))		-0.278970 (0.0000)**		-0.314979 (0.0000)**		
Variance Equation						
ω (constant)	0.000213 (0.0740)	0.000062 (0.5425)	0.000216 (0.4533)	0.000051 0.6525)	0.003382 (0.3628)	0.000379 (0.1653)
α_1ARCH-Co	0.027841 (0.0000)*	0.075015 (0.0201)*	0.034366 (0.0822)	0.061784 (0.0253)*	0.015767 (0.1345)	0.077773 (0.0124)*
β_1 GARCH-Co	0.734188 (0.0000)*	0.918750 (0.0000)**	0.944381 (0.0000)**	0.932448 (0.0000)**	0.748833 (0.0000)**	0.934888 (0.0000)**
γ GJR-Co						-0.063048 (0.1117)
AIC	-1.045435	-1.927001	-1.691533	-1.944620	-1.429582	-0.974363
SIC	-0.979991	-1.839742	-1.615181	-1.857361	-1.353231	-0.908919
Log likelihood	191.565	350.043	307.247	353.170	260.751	178.949
Skewness	0.020731	0.24735	0.20528	0.31649	0.10473	-0.017863
Excess Kurtosis	1.9954	0.0089301	0.095200	0.24431	-0.35177	0.60199
Jarque-Bera	58.921	3.6211	2.6274	6.8095	2.4793	5.3792
LM-ARCH 1-5	0.33566 [0.7151]	1.2329 [0.2927]	0.24443 [0.7833]	1.1969 [0.3034]	1.3567 [0.2589]	2.5687 [0.0781]
LM-ARCH 1-10	0.15308 [0.9790]	1.1136 [0.3528]	1.1421 [0.3377]	1.1519 [0.3327]	0.84169 [0.5208]	1.1970 [0.3102]
LB- Q(10)	12.8656 [0.1165567]	10.5686 [0.2273584]	12.0715 [0.1480431]	19.7298 [0.3482380	10.4205 [0.3175247]	13.3700 [0.0997375]
LB- $Q(10)^2$	5.64691 [0.6867152]	16.8789 [0.2313946]	9.35267 [0.3134239]	17.7883 [0.1228708]	6.54698 [0.5862019]	14.4446 [0.0708884]

Table 4.3 GARCH Models

Notes: p – values are in parentheses, ** indicates significant at 1% and * significant at 5%.

Model	GARCH(1,1) INFD-US	GARCH(1,1) INFD-UK	GARCH(1,1) INFD-CA	GARCH(1,1) INFD-JP	GJR-GARCH(1,1) PR	GARCH(1,1) TR
Mean Equation						
c (constant)	0.000021 (0.6809)	0.000028 (0.6225)	0.000015 (0.6561)	0.000020 (0.4863)	0.006699 (0.2160)	0.001217 (0.3296)
δ_1 (AR(1))					0.103175 $(0.00000)^{**}$	
φ_1 (MA(1))	-0.868038 $(0.0000)^{**}$	-0.872533 $(0.0000)^{**}$	-0.925290 $(0.0000)^{**}$	-0.933893 $(0.00000)^{**}$		-0.801001 $(0.00000^{**}$
Variance Equation						
ω (constant)	0.075019 $(0.0317)^{*}$	0.154627 (0.1663)	0.055771 (0.3061)	0.024576 (0.2376)	0.000444 $(0.0429)^{*}$	0.009249 $(0.0000)^{**}$
α_1ARCH-Co	0.122076 $(0.0047)^{**}$	0.082318 (0.1025)	0.071513 (0.1085)	0.057962 (0.0643)	0.234273 $(0.0027)^{**}$	0.325925 $(0.0004)^{**}$
β_1 GARCH-Co	0.749578 $(0.0000)^{**}$	0.690133 $(0.0006)^{**}$	0.837076 $(0.0000)^{**}$	0.901271 $(0.0000)^{**}$	0.877705 $(0.0000)^{**}$	0.799988 $(0.0000)^{**}$
γ GJR-Co					-0.285261 $(0.0015)^{**}$	
AIC	-6.656914	-6.731450	-6.864614	-6.842168	-1.825826	-1.511505
SIC	-6.602377	-6.676913	-6.810077	-6.787631	-1.760382	-1.456968
Log likelihood	1186.602	1199.832	1223.469	1219.485	330.084	273.292
Skewness	-0.83943	0.30832	0.21548	0.24686	0.30321	0.069783
Excess Kurtosis	6.5706	1.1160	0.34275	0.46186	0.65606	0.30728
Jarque-Bera	680.29	24.046	4.4851	6.7610	11.806	1.6848
LM-ARCH 1-5	1.0816 [0.3402]	1.7285 [0.1791]	0.24933 [0.7795]	0.93262 [0.3945]	0.90658 [0.4049]	0.14509 [0.8650]
LM-ARCH 1-10	0.52608 [0.7565]	1.2390 [0.2903]	0.54560 [0.7417]	0.49661 [0.7788]	0.80437 [0.5471]	0.87381 [0.4988]
LB- Q(10)	0.948582 [0.8136908]	6.10739 [0.1912708]	17.5904 [0.1402344]	14.4153 [0.1442684]	20.4167 [0.3699083]	13.4160 [0.1446666]
LB- $Q(10)^2$	1.06076 [0.9978346]	15.4090 [0.0516646]	7.18641 [0.5166610]	9.62584 [0.2922750]	17.8511 [0.1223711]	8.35890 [0.3992197]

Table 4.3 GARCH Models (cont.)
Notes: p – values are in parentheses, ** indicates significant at 1% and * significant at 5%.

The estimated parameters of GARCH(1,1) & GJR- GARCH(1,1) for Pak Rupee exchange rates series show α_1 is significant in all exchange rates except PKR-JPY exchange rates and β_1 is significant in all exchange rates. The estimated parameter γ_1 which captures the asymmetric effects is insignificant and negative in PKR-USD, PKR-GBP, and PKR-JPY exchange rates implying no leverage and asymmetric effects. While it is asymmetric effect is significant in PKR-CAD exchange rates implying leverage and asymmetric effects. The diagnostic tests point out that Jarque-Bera statistics still shows that the standardized residuals are not normally distributed. Moreover, the LM-ARCH test shows no ARCH effects The Q statistic for the standardized residuals indicates no sign of serial autocorrelation in exchange rates. The Q^2 statistic for squared standardized residuals indicates no sign of serial autocorrelation in exchange rates.

Parameter Mean Equation	Monthly Pak Rupee Exchange Returns PKR-USD	PKR-GBP	PKR-CAD	PKR– JPY
c (constant)	0.003389 (0.0002)**	0.004116 (0.0009)**	0.005603 (0.0000)**	0.008106 (0.0002)**
φ_1(RRY)	0.016073 (0.5983)	0.021645 (0.2178)	0.049389 (0.5469)	0.007037 (0.6910)
φ_2(FXR)	-0.000452 (0.8266)	-0.006491 (0.2259)	-0.001435 (0.7553)	-0.003862 (0.5955)
φ_3(INFD)	-0.000381 (0.9919)	0.090569 (0.4838)	0.114936 (0.1220)	0.036129 (0.7872)
φ_4(TOT)	-0.000528 (0.8356)	0.005288 (0.5207)	0.001894 (0.7208)	0.006156 (0.4695)
φ_5(PR)	-0.017985 (0.5817)	-0.021577 (0.2938)	-0.057819 (0.4818)	-0.007359 (0.7583)
φ_6(TR)	-0.001077 (0.7869)	-0.003801 (0.6504)	-0.003901 (0.5862)	-0.006038 (0.5781)
δ_1 (AR(1))	0.363010 (0.0000)**	0.115188 (0.0417)*	0.284799 (0.0000)**	0.265419 (0.0000)**
δ_2 (AR(2))	-0.085289 (0.2136)	-0.031088 (0.5770)		
δ_3 (AR(3))	0.063636 (0.4170)			
Variance Equation				
ω_0 (constant)	0.058975 (0.5920)	0.000000 (1.0000)	0.199323 (0.5652)	0.000000 (1.0000)
θ_1 (V RRY)	-0.001816 (0.0129)*	-0.009721 (0.2008)	-0.004748 (0.5254)	0.002119 (0.9999)
θ_2 (VFXR)	-0.000069 (0.0009)**	-0.000464 (0.0000)**	-0.000054 (0.4919)	0.000134 (0.6619)
θ_3 (VINFD)	-0.013885 (0.3118)	0.606936 (0.3507)	0.187909 (0.6686)	-0.936332 (0.3817)
θ_4 (VTOT)	-0.000246 (0.2957)	0.005197 (0.0196)*	-0.001078 (0.1191)	-0.000580 (0.7373)
θ_5 (VPR)	0.004071 (0.0001)**	0.003216 (0.4202)	0.006256 (0.3279)	-0.001538 (0.6891)
θ_6 (VTR)	0.000451 (0.4573)	0.004586 (0.3366)	0.001397 (0.5323)	0.012226 (0.0853)
α_1 ARCH-Co	0.154518 (0.0000)**	0.079240 (0.0262)**	0.106956 (0.0302)*	0.059559 (0.1658)
β_1 GARCH-Co	0.510789 (0.0000)**	0.712544 (0.0000)**	0.746448 (0.0000)**	0.780694 (0.0000)**
$\alpha + \beta$	0.66531	0.79178	0.85340	0.84025
AIC	-6.263757	-4.463201	-5.218733	-4.318596
SIC	-6.056517	-4.266869	-5.033307	-4.122263
Log likelihood	1130.817	810.218	943.325	784.551
Skewness	2.6019	0.034231	0.40624	0.45904
Excess Kurtosis	11.222	1.0035	0.93874	0.29552
Jarque-Bera	2263.4	14.964	22.799	13.759
LM-ARCH 1-5	0.51751 [0.7630]	1.0432 [0.3920]	1.0404 [0.3937]	0.52210 [0.7595]
LM-ARCH 1-10	0.40107 [0.9458]	0.75262 [0.6745]	0.94805 [0.4891]	1.0950 [0.3652]
LB- Q(10)	13.1788 [0.1699209]	14.7538 [0.2846565]	11.7255 [0.2292294]	11.1642 [0.2646246]
LB- $Q(10)^2$	4.70693 [0.7883911]	8.21350 [0.4128974]	10.3318 [0.2425033]	8.72537 [0.3659905]

Table 4.4 GARCH (1,1) Model:
Notes: p – values are in parentheses, ** indicates significant at 1% and * significant at 5%

Parameter	**Monthly Pak Rupee Exchange Returns**			
Mean Equation	**PKR-USD**	**PKR-GBP**	**PKR-CAD**	**PKR– JPY**
c (constant)	0.007619 (0.0000)**	0.004384 (0.0050)**	0.005759 (0.0000)**	0.009365 (0.0000)**
φ_1(RRY)	0.001802 (0.9555)	0.035000 (0.0423)*	0.040278 (0.6584)	-0.003083 (0.8657)
φ_2(FXR)	-0.003000 (0.2390)	-0.001239 (0.8303)	-0.000658 (0.8992)	-0.002129 (0.7729)
φ_3(INFD)	0.003271 (0.9469)	0.112876 (0.4090)	0.120087 (0.1164)	0.042534 (0.7549)
φ_4(TOT)	0.004024 (0.2195)	0.007526 (0.3129)	0.003228 (0.5354)	0.005862 (0.4914)
φ_5(PR)	-0.006683 (0.8375)	-0.031371 (0.1132)	-0.046515 (0.6120)	0.008737 (0.7157)
δ_1 (AR(1))	0.197564 (0.0004)**	0.240478 (0.0002)**	0.275213 (0.0000)**	0.286530 (0.0000)**
δ_2 (AR(2))	-0.001082 (0.9879)	-0.073290 (0.2077)	-0.120365 (0.0361)*	-0.042414 (0.5109)
δ_3 (AR(3))	0.066442 (0.4263)			
δ_4 (AR(4))	0.042951 (0.5824)			
Variance Equation				
ω_0(constant)	0.072544 (0.2024)	0.000000 (1.0000)	0.888198 (0.8311)	0.000000 (1.0000)
θ_1 (V RRY)	-0.003136 (0.0142)*	-0.027365 (0.0537)	-0.012069 (0.3851)	0.012171 (0.9997)
θ_2 (VFXR)	-0.000088 (0.0000)**	-0.000699 (0.0058)*	-0.000126 (0.5104)	0.000211 (0.6299)
θ_3 (VINFD)	-0.029172 (0.0000)*	0.867810 (0.1069)	0.834039 (0.0817)	0.882090 (0.6036)
θ_4 VTOT)	0.000002 (0.9945)	0.006847 (0.0725)	-0.003289 (0.0086)*	-0.003126 (0.2981)
θ_5 (VPR)	0.005379 (0.0021)*	0.012563 (0.1606)	0.012894 (0.2462)	0.003456 (0.6052)
α_1 ARCH-Co	0.094067 (0.0000)**	0.241069 (0.0057)*	0.344930 (0.0268)*	0.134747 (0.1314)
β_1 GARCH-Co	0.737731 (0.0000)**	0.527061 (0.0001)**	0.345901 (0.0408)*	0.658435 (0.0019)**
γ_1 GJR-Co	-0.137213 (0.1202)	-0.144093 (0.1236)	-0.336383 (0.0385)*	-0.146119 (0.1373)
AIC	-6.156531	-4.511978	-5.237670	-4.325654
SIC	-5.949291	-4.326553	-5.063152	-4.140228
Log likelihood	1111.784	817.876	945.686	784.804
Skewness	2.3300	0.093064	0.45162	0.48355
Excess Kurtosis	7.7518	0.48793	1.2308	0.44829
Jarque-Bera	1210.0	4.0339	34.475	16.807
LM-ARCH 1-5	2.0107 [0.0766]	0.48622 [0.7865]	0.46953 [0.7989]	0.62914 [0.6776]
LM-ARCH 1-10	1.1860 [0.2992]	0.45526 [0.9176]	0.76609 [0.6616]	0.95644 [0.4815]
LB- Q(10)	34.0621 [0.0935465]	12.0358 [0.1496124]	12.4399 [0.1896288]	8.35791 [0.3993118]
LB- $Q(10)^2$	13.8010 [0.0871016]	4.96249 [0.7615781]	7.69417 [0.4639004]	7.04584 [0.5316956]

Table 4.5 GJR-GARCH (1,1)
Notes: *p* – values are in parentheses, ** indicates significant at 1% and * significant at 5%

The results in mean equations of estimated GARCH models show monthly exchange rate returns are affected by their own 1 month lag. The changes in other variables are insignificant in explaining the short run movements in exchange rates at returns. The results in variance equations of estimated GARCH models show relative real income volatility has negative and significant effect on PKR-USD exchange rate volatility. The negative effect is consistent with the findings of Chipili (2012) that real output volatility reduces exchange rate volatility. It has positive and insignificant effect on volatility in PKR- JPY exchange rates. The insignificance of real output volatility is in line with Morana (2009) and Grydaki and Fountas (2009) and positive effect is in line with Friedman (1953) where output volatility amplifies exchange rate volatility. The foreign reserves volatility has negative and significant effect on volatility in PKR-USD and PKR-GBP exchange rates. The negative effect is consistent with the findings of Shah et al. (2009) and Goyal and Arora (2012) that foreign exchange reserves volatility decreases exchange rate volatility. The inflation rate differential volatility has no statistical significant effect on volatility in exchange rates while it has significant effect on PKR-USD exchange rate volatility in GJR-GARCH model. The positive effect is confirmed by Morana (2009) and Cheung and Lai (2009) and insignificance is in line with Chipili (2012). The terms of trade volatility has positive and significant effect on PKR-GBP exchange rate volatility in GARCH(1,1) model. Calderon (2004) has found similar results that terms of trade volatility increases exchange rate volatility. The terms of trade volatility has negative and significant effect on PKR-CAD exchange rate volatility in GJR-GARCH(1,1) model which is consistent with Chipili (2012) findings that terms of trade volatility reduces exchange rate volatility The productivity volatility has positive and significant effects on PKR-USD exchange rate volatility. The trade restrictions volatility has positive and insignificant effect on exchange rate volatility.

4.1 Stability Test

In order to check the stability of GARCH models, Nyblom test for individual and joint parameter stability is used. The Table 4.6 and 4.7 present the Nyblom test for parameter stability of GARCH (1,1) and GJR- GARCH(1,1) models which suggest that there is no any statistically significant parameter instability in parameters.

4.2 Model Selection and Good- of- Fit Test

The traditional model selection criteria such as the Akaike information criterion (AIC), the Schwartz Information Criteria (SIC) and Log likelihood are used for selecting exchange rate model. The Table 4.8 presents the AIC, SIC and log likelihood values. According to these criteria GARCH (1,1) is nominated as the best model in all exchange rates as it has minimum AIC and SIC values and maximum log likelihood values in all exchange rates as compared to GJR-GARCH(1,1) model.

The Adjusted Pearson Chi-square Goodness-of-fit test is also used for the selection of best model. It compares the empirical distribution of the innovations with the theoretical one. The Table 4.8 reports the results of the χ^2 test for the distribution used in the GARCH models. The test results show that the null hypothesis is not rejected at 1% in both models which implies that the empirical distribution of the innovations and the theoretical one are identical for 40 cells in all exchange rates.

Parameters	PAK-USD	PAK-GBP	PAK-CAD	PAK-JPY
Cst (M)	0.47584	0.08444	0.02923	0.20842
RRY(M)	0.02053	0.03180	0.08623	0.07054
FXR (M)	0.04383	0.34704	0.01661	0.08374
INFD (M)	0.05013	0.05398	0.06175	0.11662
TOT (M)	0.07792	0.09279	0.17499	0.16722
PR (M)	0.04581	0.16700	0.09275	0.50465
TR (M)	0.02321	0.44278	0.05162	0.40583
AR(1)	0.11028	0.44326	0.12955	0.05300
AR(2)	0.26458	0.59680		
AR(3)	0.07476			
Cst(V)	0.28769	0.23547	0.20504	0.10555
VRRY (V)	0.60848	0.50283	0.12506	0.17156
VFXR (V)	0.16392	0.07826	0.04372	0.03286
VINFD (V)	0.06313	0.05531	0.06044	0.05799
VTOT (V)	0.29157	0.45368	0.09440	0.03714
VPR (V)	0.57800	0.54774	0.12329	0.09834
VTR (V)	0.29282	0.32047	0.29065	0.09556
ARCH(Alpha1)	0.32372	0.44038	0.30336	0.03693
GARCH(Beta1)	0.21619	0.50370	0.19360	0.11657
Joint Lc	4.37259	3.94228	3.58652	3.42105

Table 4.6 GARCH (1,1) **-** Nyblom Test for Parameter Stability
Notes: For individual statistics 1% and 5% critical values = 0.75 and 0.47. For joint statistics 1% and 5 % critical values = 5.13 and 4.52

Parameters	PAK-USD	PAK-GBP	PAK-CAD	PAK-JPY
Cst(M)	0.56066	0.03142	0.03022	0.31811
RRY(M)	0.32737	0.03358	0.09467	0.10255
FXR (M)	0.07442	0.04103	0.03503	0.08161
INFD (M)	0.06366	0.12992	0.06658	0.12514
TOT (M)	0.02233	0.09125	0.07143	0.15907
PR (M)	0.49481	0.12026	0.11338	0.18749
AR(1)	0.08277	0.07192	0.13442	0.08790
AR(2)	0.52428	0.16316		0.54792
AR(3)	0.08231			
AR(4)	0.28345			
Cst(V)	0.36713	0.07998	0.19114	0.13078
VRRY (V)	0.27962	0.07775	0.12987	0.13079
VFXR (V)	0.25780	0.00874	0.09529	0.04545
VINFD (V)	0.40552	0.08870	0.30957	0.06857
VTOT (V)	0.60219	0.08207	0.08769	0.03294
VPR (V)	0.26666	0.05766	0.13628	0.13661
ARCH(Alpha1)	0.69484	0.13421	0.28397	0.08979
GARCH(Beta1)	0.42969	0.08446	0.45395	0.13822
GJR(Gamma1)	0.05861	0.12846	0.17533	0.09942
Joint Lc	4.88737	2.51159	1.90455	4.34341

Table 4.7 GJR- GARCH (1,1)**-** Nyblom Test for Parameter Stability
Notes: For individual statistics 1% and 5% critical values = 0.75 and 0.47.For joint statistics 1% and 5 % critical values = 5.13 and 4.52

4.3 In-sample Forecasting Evaluation

In order to see which model best describe the data, in-sample forecasting performance is generated. The Table 4.9 presents the in- sample exchange rate volatility forecasts errors for the Mean Square Error (MSE), Mean Absolute Error (MAE) and Root Mean Square Error (RMSE) criteria. The MSE and RMSE criteria show GARCH (1,1) model in all exchange rates performs best in in- sample forecasting.

Models Specifications GARCH(1,1)	AIC	SIC	Log Likelihood	Chi-Square Statistics
PKR-USD	-6.180688	-6.054615	1036.994	39.5663
PKR-GBP	-4.474330	-4.354731	756.739	37.6386
PKR-CAD	-5.245487	-5.085029	887.548	36.6747
PKR-JPY	-4.334571	-4.209958	735.848	36.6747
GJR-GARCH(1,1)				
PKR-USD	-6.143054	-5.959674	1035.747	28.9639
PKR-GBP	-4.460386	-4.351476	755.424	25.8313
PKR-CAD	-5.244267	-5.049426	884.751	41.4940
PKR-JPY	-4.320349	-4.182814	731.178	37.1566

Table 4.8 Model Selection Criteria and Goodness-of-Fit Test

Specifications GARCH(1,1)	Mean Squared Error (MSE)	Mean Absolute Error (MAE)	Root Mean Squared Error (RMSE)
PKR-USD	4.11e-009	6.346e-005	6.411e-005
PKR-GBP	9.441e-007	0.0008732	0.0009716
PKR-CAD	1.332e-007	0.0003143	0.0003649
PKR-JPY	3.855e-007	0.0006039	0.0006208
GJR-GARCH(1,1)			
PKR-USD	3.98e-009	6.268e-005	6.309e-005
PKR-GBP	9.891e-007	0.0008802	0.0009945
PKR-CAD	1.332e-007	0.0003098	0.000365
PKR-JPY	4.258e-007	0.0003941	0.0006525

Table 4.9 Evaluation of the In-sample Volatility Forecasts

5. CONCLUSION AND POLICY RECOMMENDATIONS

This paper empirically investigates the volatility of Pak Rupee exchange rates GARCH models using macroeconomic fundamentals. The results show that Pak Rupee exchange rates are characterized by different dynamics of conditional volatility and conditional volatility in Pak Rupee exchange rates are affected by different factors indicating variations across exchange rates in terms of the factors driving conditional volatility. The PKR-USD exchange rate volatility is influenced by real output volatility, foreign exchange reserves volatility, inflation volatility and productivity volatility. The PKR-GBP exchange rate volatility is influenced by foreign exchange reserves volatility and terms of trade volatility. The PKR-CAD exchange rate volatility is influenced by terms of trade volatility.

The findings of this study reveal the important macroeconomic fundamentals that are potential sources of exchange rate volatility in Pakistan. The instability in these macroeconomic fundamentals causes variability in the exchange rates in Pakistan. In addition, exchange rate volatility in Pakistan results from real shocks than nominal shocks. The role for exchange rate stabilization is identified. Therefore policy and decision makers need to pay attention to exchange rate stability. For the achievement of exchange rate stability, it is vital to realize these macroeconomic fundamentals affecting the exchange rates volatility. In other words, by controlling these macroeconomic fundamentals, they are able to stabilize fluctuations in exchange rates. They should provide good strategic policies for the exchange rate market and develop mechanisms to manage with various shocks. The government policies should be design in a way that would able to moderate fluctuations in exchange rates. Wanaset (2001) has pointed out an experience of stability in exchange rates in Singapore which confirmed that government policies encouraged exchange rate stability through the strong institutional setup which includes credible price stability, fiscal discipline, considerable openness and transparency and well-developed capital markets.

Therefore, policy and decision makers in Pakistan should design and develop set of policies and instruments for the exchange rate stabilization and strengthening of whole financial system. An efficient financial system leads to efficient intermediation of financial flows. This in turn reduces fluctuations in the exchange rates and enlarges the economy's resistance to shocks. Further, policy and decision makers should pursue close monitoring of the financial system and develop warning systems for emergence of risks and vulnerabilities. Moreover, for healthy economics foundations, there is a need to strengthen macroeconomic policies which encourage macroeconomic balance and lower exposure to speculative movements in currencies.

REFERENCES

Ahmed, M. (2012). Estimation of Exchange Rate Volatility via GARCH Model Case Study Sudan (1978 – 2009). *International Journal of Economics and Finance*, 4 (11), 183-192.

Bangaké, C. (2008). Exchange Rate Volatility and Optimum Currency Area: Evidence from Africa. *Economics Bulletin*, 6 (12), 1-10.

Bartolini, L. and G. M. Bodnar (1996). Are Exchange Rates Excessively Volatile? And What Does "Excessively Volatile" Mean, anyway? *Federal Reserve Bank of New York Research Paper No.*9601, January.

Bauwens, L., D. Rime and G. Sucarrat (2006). Exchange Rate Volatility and the Mixture of Distribution Hypothesis. *Empirical Economics*, 30, 889-911.

Bayoumi, T. and B. Eichengreen (1998). 'Exchange Rate Volatility and Intervention: Implications of the Theory of Optimum Currency Areas. *Journal of International Economics*, 45, 191-209.

Benita, G. and B. Lauterbach (2007). Policy Factors and Exchange-Rate Volatility: Panel Data versus a Specific Country Analysis. *International Research Journal of Finance and Economics*, 7, 7-23.

Calderón, C. (2004). Trade Openness and Real Exchange Rate Volatility: Panel Data Evidence. *Central Bank of Chile working paper*, 294.

Cheung, W. and S. Lai (2009). A multiple-horizon search for the role of trade and financial factor in bilateral real exchange rate volatility. *Journal of Economics and Management*, 5 (2), 187-218.

Chipili, J. (2012). Modelling Exchange Rate Volatility in Zambia. *The African Finance Journal*, 14 (2), 85-107.

De Grauwe, P., M. J. J. Janssens and H. Leliaert (1985). Real-Exchange Rate Variability from 1920 to 1926 and 1973 to 1982. *Princenton Studies in International Finance*, No.56.

Devereux, M. and P. Lane (2003). Understanding Bilateral Exchange Rate Volatility. *Journal of International Economics*, 60, 109-132.

Dornbusch, R. (1976). Expectations and Exchange Rate Dynamics. *Journal of Political Economy*, 6, 1161-1176.

Edwards, S. (1987). Real Exchange Rate Variability: An Empirical Analysis of the Developing Countries Case. *International Economic Journal*, 1, 91-106.

Fidrmuc, J. and R. Horvath (2007). Volatility of Exchange Rates in Selected New EU Members: Evidence from Daily Data. *CESifo Working Paper* No.2107.

Flood, P. and A. Rose (1995). Fixing Exchange Rates: A Virtual Quest for Fundamentals. *Journal of Monetary Economics*, 36, 3-37.

Friedman, M. (1953). *The Case For Flexible Exchange Rates. Essays in Positive Economics.* Chicago: University of Chicago Press, 157-203

Grydaki, M. and S. Fountas (2009). Exchange Rate Volatility and Output Volatility: A Theoretical Approach. *Review of International Economics*, 17 (3), 552-569.

Goyal, A. and S. Arora (2012). The Indian Exchange Rate and Central Bank action: An EGARCH Analysis. *Journal of Asian Economics*, 23 (1) ,60-72.

Hau, H. (2002). Real Exchange Rate Volatility and Economic Openness: Theory and Evidence, *Journal of Money, Credit and Banking*, 34 (3), 611-630

Hausmann, R., U. Panizza and R. Rigobon (2006). The Long-Run Volatility Puzzle of the Real Exchange Rate. *Journal of International Money and Finance*, 25, 93-124.

Hua, M. and Y. Gau (2006). Determinants of Periodic Volatility of Intraday Exchange Rates in the Taipei FX Market. *Pacific-Basin Finance Journal*, 14, 193-208.

Hviding, K., M. Nowak and L. Ricci (2004). Can Higher Reserves Help Reduce Exchange Rate Volatility? *International Monetary Fund Working Paper* No.189.

Morana, C. (2009). On the Macroeconomic Causes of Exchange Rate Volatility. *International Journal of Forecasting*, 25, 328-50.

Mussa, M. (1986). Nominal Exchange Rate Regimes and the Behavior of Real Exchange Rates: Evidence and Implications. *Carnegie-Rochester Conference Series on Public Policy*, 26.

Obstfeld, M. and K. Rogoff (1995). Exchange Rate Dynamics Redux. *Journal of Political Economy*, 103, 624-660.

Obstfeld, M. and K. Rogoff (2000). New Directions in Open Macroeconomics. *Journal of International Economics*, 50, 117-153.

Shah, M. K. A., Z. Hyder and M. K. Pervaiz (2009). Central Bank Intervention and Exchange Rate Volatility in Pakistan: An Analysis Using GARCH-X Model. *Journal of Applied Financial Economics,* 19 (18), 1497-1508.

Stančík, J. (2007). Determinants of Exchange Rate Volatility: The Case of the New EU Members. *The Czech Journal of Economics and Finance,* 57 (9 -10), 414-432.

Stockman, A. (1983). Real Exchange Rates under Alternative Nominal Exchange-Rate Systems. *Journal of International Money and Finance,* 2, 147-166.