Volatility Spillover, Asymmetric Behavior and role of Terrorism in Financial Markets: Empirical Evidence from Pakistan

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Abstract

Equity market and currency market generally play vital role in any country especially developing economies like Pakistan. A review of literature suggests that there may or may not have volatility spillover between stock markets and currency market. This study examines the volatility spillover and asymmetric behavior in financial markets in Pakistan. Further it also examines the standing of terrorism related activities towards the currency and equity markets. Empirical analysis is based on the daily data starting from January 1, 2000 to December 31, 2013. This study further divides the sample into three subsamples. The efficiency of financial markets in term of calendar anomalies is also tested. To capture the volatility dynamics in the financial time series, the idea of ARCH model by R. F. Engle (1982) and its extension is used. Study concluded that there exist the phenomena of volatility spillover in financial markets of Pakistan. If volatility in KSE-100 index increases then it also causes increase in volatility of exchange rate. But on the other hand if there is volatility in the exchange rate then it has calm effects on the volatility in the stock markets. But in last subsample it has an exciting effect on the volatility of equity markets. On the other hand, terrorism also played a role towards the financial markets in Pakistan. In equity market, Terrorism has significant effect in each subsample period on the volatility in KSE-100 index. But it has only exciting effect in the second sample period. Terrorism has an exciting effect on the volatility in exchange rate. The EGARCH (1, 1) model for foreign exchange rate and equity markets confirmed the presence of asymmetry. Both the markets were found inefficient in the context of day-of-the-week effect. Therefore the foreign investor, fund manager and policy maker should be aware such volatility spillover and role of terrorism in financial markets.

Key words: Exchange Rate, Stock Market, Terrorism, Volatility Clustering, Calendar anomalies
JEL Classification: C22, F31

Introduction

Equity markets of emerging economies have been of vital importance to global investment communities especially in Pakistan. The emerging economies have unpredictable behavior mainly due to uncertainty in the economy and pathetic policies. These are considered to

be more volatile as compared to well develop countries stock markets. From an investor point of view, both the return of stock markets and volatility or variability in those return have equal importance. There are numbers of macroeconomics variables which can explain the volatility of stock markets. It may include liquidity risk (Min 2002), asymmetry in information (Attanasio 1990) and volatility in exchange rate (Karoui 2006).

Due to advancement and innovation in technology, whole world become a global village. Due to liberation in policies of countries, it is comparatively easy for foreign investor and fund manager to invest their funds in different economies. This is mainly to get the benefit of portfolio diversification (Li, Sarkar and Wang 2003) and to achieve the desire level of risk for their investment. The whole game plays to minimize or manage the risk not to eliminate the risk (Wriston 2004). On the basis of liberalization, good or bad news, political instability and integration and most important one that is the terrorism, fund moves from one economy to other. This flow of fund among different stock markets of the world ultimately uncovers the importance of foreign exchange rate (Karoui 2006). When there is any shock or any bad event occurred in a country then the foreign investor may withdraw their investment from the stock market of the country and convert it into other currency (Karoui 2006). This phenomenon ultimately affects the foreign exchange rate.

Volatility in exchange rate may have serious consequence for the stock market of a country (Adjasi, Harvey and Agyapong 2008). A review of literature suggests that volatility in exchange rate may or may not have impact on the stock markets. Financial economist tries to understand the association or linkage between the foreign exchange rate and stock market after the Asian currency crises (Mishra 2004). Globalization further strengthens the concept of cross listing of companies. Foreign investor always tries to maximize the values of his portfolio in term of desire currency whereas the firm tries to maximize its worth in local currency. The appreciation in the floating exchange rate ultimately effect negatively to the domestic market (Yucl and Kurt 2003). Due to reduction in the input cost this effect is reversed for the export dominated country. So there is a strong linkage between the foreign exchange rate and stock market of a country. A number of studied had already investigate this like Vardar, Aksoy and Can (2008) and (Karoui 2006) etc. The shocks in one market may transfer to other market rapidly especially in developing economies. If we think rationally then the role of terrorism in any country cannot be ignored in any circumstance. The country like Pakistan faces range of terrorism related activites in different shapes like suicides attacks, bomb blast, strikes, drones attack etc. ultimately this should reflect in the financial markets as per the efficient market hypothesis (EMH) by Fama (1970).

This study examines the volatility spillover and asymmetric behavior in financial markets in Pakistan. Further it also examines the importance of terrorism related activities towards the currency and equity markets. This study further divides the sample into three subsamples to comments upon the efficiency of financial markets in term of calendar anomalies. This study uses ARCH family model to capture the effect of exchange rate on the volatility of stock markets and vice versa which is consistent with the work done by Kanas (2000), Vardar, Aksoy and Can (2008) and Adjasi, Harvey and Agyapong (2008). To capture the effect of exchange rate on the volatility of stock market, study added the explanatory variable on the variance equation of ARCH model by Engle (1982) and GARCH model by T. Bollerslev (1986). The basic assumption of ARCH/GARCH model is that these are symmetric and not capable to capture the asymmetric effect. In most of the financial time series there exist some period which has higher volatility as compare to other period and vice versa and hence there exists the phenomena of

volatility clustering. To capture this asymmetry in term of positive and negative shocks, study also use an exponential GARCH model which was first introduced by Nelson (1991).

The remaining paper is structured as follow. The next section contains the theoretical foundation as well as literature review. After this, there is data description and methodological section. Finally there is an empirical finding and it is followed by conclusion and policy implication.

Literature Review

The exchange rate always remained critical issue to stock market of the country. It is equally important for both of the import and export dominant country. A substantial research have been conducted in developed and least developed countries to know the impact of macroeconomics variables on equity prices by using multiple econometric tools. Most of the researcher studied the long run co movement of exchange rate along with other macroeconomic variable and stock markets (Wong et al. 2004, Kazi 2008 and Guidi and Gupta 2010). Along with this, many other also analyzed the volatility aspect of macroeconomic variable and equity prices (Adjasi, Harvey and Agyapong 2008). This particular study focused the foreign exchange rate volatility and equity market volatility. The already work done by various researchers have been described as follow.

Adjasi, Harvey and Agyapong (2008) examined the impact of forex exchange volatility on equity market in Ghana. They also determined the effect of macroeconomics variables like; money supply in the market, T Bill rate, inflation and trade deficit on the equity market for the period of 10 year starting from 1995 to 2005. To check the stationary of the data a unit root test (Augmented Dickey Fuller) ADF was used and to capture the volatility an exponential GARCH (1, 1) model was used. The empirical study showed that forex rate volatility and equity market returns were inversely proportionate with each other and further explored that the existence in the volatility shocks in forex rate had significant effect on the equity market of Ghana. It was further empirically revealed that depreciation in the local currency leads to boost up the equity market prices in the long run and in short run it reduced the stock prices. They recommended that to gain the investors' confidence to invest in stock market, there should be stability and consistency in the stock market of country. They suggested that to achieve the desire targets, a country must formulated a strong exchange rate policies that reduced the volatility in exchange rate.

Some researcher used the sector index returns to examine the impact of exchange rate volatility on stock return likes Vardar, Aksoy and Can (2008). They investigated the effect of interest rate and foreign exchange rate volatility on the volatility of sector prices indices in Istanbul Stock Exchange for period of 8 year starting from 2001 to 2008. GARCH model by Engle (1982) was used to examine the volatility of interest rate and exchange rate and its impact on volatility behaviors of sector prices index. Augmented Dickey Fuller ADF (Dickey and Fuller 1979) model was used to examine the stationarity of the data. The research showed that exchange rate and interest rate volatility had significant positive impact on stock prices of Istanbul stock exchange. It is suggested that the investor must over sight their investment portfolio and re-design according to exchange rate variation. Few other studies also analyzed the impact of same variable on the stock market and end up with the same findings like Frank and Young (1972), Granger et al. (2000) and Apte (2001).

Kanas (2000) analyzed that whether exchange rate changes was influenced by stock return's volatility for three developed countries. The countries under study were united states of America, United Kingdom (UK) and Japan. The study used the 26 month data starting from January, 1986 to February, 1988. To examine the impact of volatility, EGARCH model was used. It was concluded that equity market volatility has a significant positive impact on the exchange rate volatility of all three developed countries for the entire study period and further empirically showed that the financial markets of all these countries were assimilated and co-integrated with each other. Morley and Pentecost (2000) and Ibrahim (2000) also found the same results as those of Kanas (2000).

The issue of volatility of exchange rate was further analyzed in the group of different emerging countries. Karoui (2006) investigated the relationship between the volatilities of the return of stock market indexes and FX rates of 18 emerging countries' currencies with respect to Dollar, Pound and Yen by using the different periods of stock indexes. To tests the volatility of exchange rate and stock return a GARCH model was used. The study investigated that there were significant relation between exchange rate volatility and stock return of mostly emerging countries and also observed that the US Dollar based currencies have relatively greater impact on stock returns. He further suggested that to avoid the exchange rate risk exposure the investor should be concentrate on country exchange rate policies rather than sector indices.

Morales and Donnell (2006) empirically assessed the volatility relation between equity returns and exchange rates in the five East Asian countries markets. It consists of the Hong Kong, South Korea, Singapore, Taiwan and Thail. Their study period was 9 year and seven months, started from January, 1997 to July, 2006. The FX rates parameter of respected countries' currencies to USD rates were used to analyze the volatility. For the stationarity of the data, an Augmented Dickey-Fuller (ADF) test was applied, and Lagrange Multiplier (LMF) test was used to confirm the validity of ADF. An EGARCH model (Nelson 1991) was used to analyze the volatility in equity returns of five Asian countries. They used descriptive statistic to confirm the statistic characteristic of foreign exchange rates and equity market rates between the countries. They divide the study period into two parts: during in the Asian financial crises and after the financial market crises. The empirical result showed that there exists significant volatility in most of the countries exchange rate and stock markets. But there was no volatility spillover between equity and currency market of Taiwan and Korea, and as well as no volatility spillover between the currency market and equity in Thiland and Singapore. It was argued that this volatility was due to market financial crises. They summarized their work that since the Asian financial crises, there exist significant scope for portfolio managers and investor to redesign their investment portfolio stock and currencies in these markets.

From the existing literature review, it is concluded that if there exist volatility in the financial time series then it is better to use such types of model which are capable to capture the volatility. This particular study uses the ARCH family model to capture the volatility spillover and asymmetric behaviors in financial markets. As there exist volatility clustering in most of the financial time series, to handle this phenomena we also uses the EGARCH model.

Data and Methodology

This particular study employs the daily stock prices of Pakistani equity markets and daily foreign exchange rates. The period of the study is 13 year and starts from January 1, 2000 to December 31, 2013 which corresponds to 5114 daily observations. As Karachi Stock Exchange

(KSE) is one of the major stock market in Pakistan and KSE-100 index which is value weighted index can be used as a benchmark. To capture the effect of foreign exchange rate volatility, this study uses daily RS/ USD, which is the direct quotation of USD in Pakistan. The data related to equity markets is collected from the yahoo finance and exchange rate is collected from OANDA. This study further divides the sample into three subsamples to comments upon the efficiency of financial markets in term of calendar anomalies. The first subsamples starts form January 1, 2000 to December 31, 2004, the second subsample starts form January 1, 2005 to December 31, 2009 and third subsample starts form January 1 2010 to December 31, 2013. Study uses bomb blast in Pakistan as proxy of terrorism related activities in Pakistan. To check the calendar anomalies in both of the markets i.e. equity and currency study uses the dummy variable and it captures the day-of-week effect in different subsamples.

Daily series of continuous compounded returns of the KSE-100 index is obtained by using the following equations.

$$R_t = ln\left(\frac{Z_t}{Z_{t-1}}\right)$$

Where,

R_t Denote the continuous compounded return of day‘t’

Z_t And Z_{t-1} denote the closing values of KSE-100 index of day‘t’ and‘t-1’ respectively

The change in the RS/ US $ exchange rate is calculated with the help of following equation.

$$\text{Change in foriegn exchange rate} = ln\left(\frac{A_t}{A_{t-1}}\right)$$

Where A_t and A_{t-1} represent the RS/ US $ exchange rate of the day‘t’ and‘t-1’ respectively.

Study first runs the ordinary least square (OLS) with the following equations.

$$Y_t = \propto + \beta_1 Y_{t-1} + \beta_2 X_t + \beta_3 T_t + \sum_{j=1}^{5} \gamma_j D_j + \varepsilon_t$$

The above equation is estimated for two times, one for the equity markets and other for the currency markets. Here T_t denotes the dummy variable for terrorism activities in Pakistan. And D_j denote the dummy variables to capture the day-of-week effect in both the markets. This equation is then tested for homoscedasticity with the help of White test and autocorrelation with the help of Breusch-Godfrey Serial Correlation LM Test.

An ARCH model

If we look at the basic assumptions of simple Ordinary Least Square (OLS) then among others, the assumption of homoskedasticity i.e. the variance of the error term is constant over time regardless of the value of independent variable is important. On the other hand, if there is heteroskedasticity in the data i.e. the variance of the error term is not constant then it requires some model to capture the volatility in the data. This idea to capture the volatility dynamics in the financial time series was introduced by Robert F. Engle (1982).

Engle (1982) proposed an ARCH model which simultaneously models the mean and variance of the series.

$$Y_t = \propto + \beta X_t + \varepsilon_t$$

$$\varepsilon_t \sim \text{iid } N(0, \sigma^2)$$

$$\sigma_t^2 = \gamma_0 + \gamma_1 \varepsilon_{t-1}^2$$

In ARCH (q) model, the variance equation can be written as:

$$\sigma_t^2 = \gamma_0 + \gamma_1 \varepsilon_{t-1}^2 + \gamma_2 \varepsilon_{t-2}^2 + \cdots + \gamma_q \varepsilon_{t-q}^2$$

In summation form:

$$\sigma_t^2 = \gamma_0 + \sum_{i=1}^{q} \gamma_i \varepsilon_{t-i}^2$$

Also

$$\gamma_i \geq 0 \ \forall \ i = 0,1,2,3, \ldots, q$$

Where X_t shows the explanatory variables, σ_t^2 shows the volatility and ε_t be the error term which is ideally, independently distributed.

The GARCH model

Tim Bollerslev (1986) comes with the idea of Generalized ARCH model. According to that variance depends on both the past values of the shocks and past values of itself.

The GARCH (p, q) has the following equations:

$$Y_t = \propto + \beta X_t + \varepsilon_t$$

$$\varepsilon_t \sim iid\ N(0, \sigma^2)$$

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2 + \sum_{i=1}^{p} \beta_i \sigma_{t-i}^2$$

If we put the value of p equal to zero ($p = 0$) in the above equation, then GARCH (p, q) will reduces to ARCH (q) model.

In GARCH (1, 1) the variance equation with a set of explanatory variables can be written as:

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2 + \sum_{i=1}^{p} \beta_i \sigma_{t-i}^2 + \sum_{k=1}^{r} \mu_k X_k$$

It is clear that left hand side of the variance equation is σ_t^2 which measures the volatility (risk). From the above equation, if the coefficient α, β and μ are negative and significant then it decreases the volatility of the dependant variable and vice versa.

The exponential GARCH (EGARCH) model

ARCH and GARCH model are symmetric. It deals with the absolute values of shocks and ignores the signs. So these models are not capture the volatility clustering which is most common phenomena in the financial time series. To capture this, we also use the exponential GARCH (EGARCH) model proposed by Nelson (1991). The variance equation for this model (Nelson 1991) describe as follow:

$$log(\sigma_t^2) = \gamma + \sum_{i=1}^{q} \rho_i \left|\frac{\varepsilon_{t-i}}{\sigma_{t-i}}\right| + \sum_{i=1}^{q} \xi_i \frac{\varepsilon_{t-i}}{\sigma_{t-i}} + \sum_{j=1}^{p} \omega_j \sigma_{t-j}^2 + \sum_{m=1}^{n} B_m X_m$$

In the above equation, on the left side there is log of the variance which ensures that the estimates are nonnegative. The value of the parameter ξ_i has importance for analyzing the model. The model is symmetric if its value equal to zero. If the value of ξ_i is not equal to zero then the impact is asymmetric. If the value of ξ_i is less than zero then we can say that bad news causes more volatility as those of good news.

Results

The following figure shows the daily continuous compounded return of KSE-100 index for the entire study period. Figure 1 shows that in the return of KSE-100 there are some periods which has higher volatility as compare to other periods. In other words, there exists periods which are more risky as compare to other periods which has comparatively low risk. This phenomenon is termed as volatility clustering.

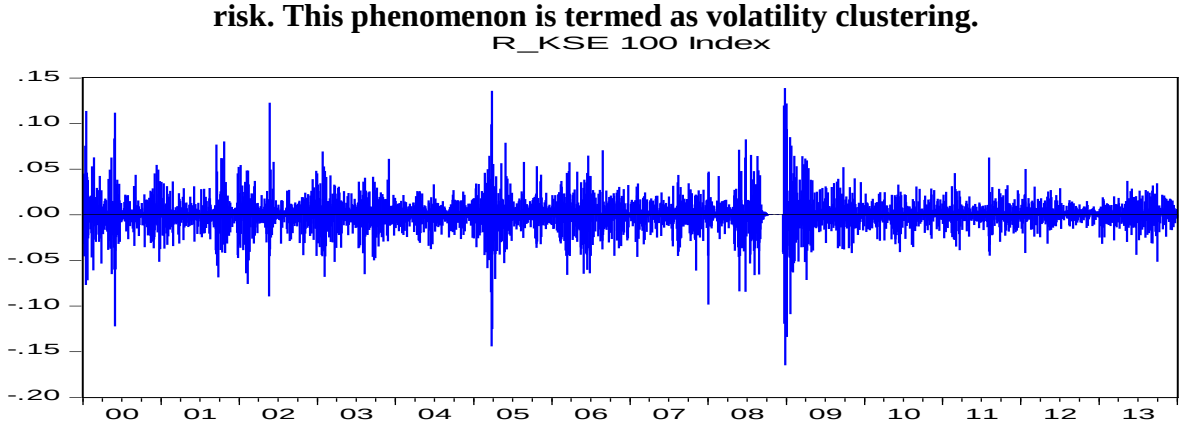

Figure 1: Plot of the return of KSE-100 index

The following figure shows the change in the exchange rate RS/ US$. It is clear that there are certain periods which have higher volatility as compare to other periods. In other words, there exists periods which are more risky than others. Similarly like the figure1, the phenomena of volatility clustering are quite visible.

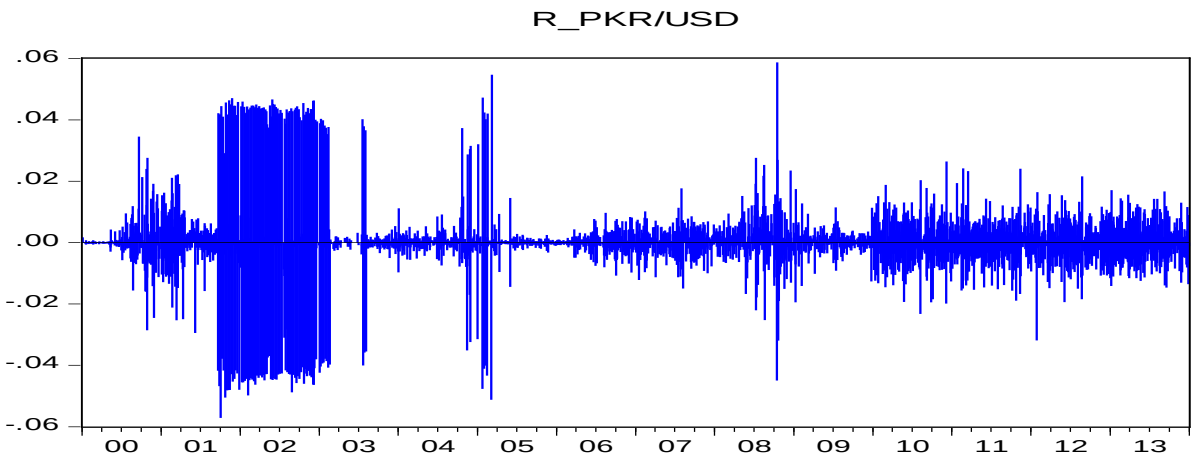

Figure 2: Plot of the change in the exchange rate

From the graph it is clear visibly that there exists heteroskedasticity in the data and therefore this study may follow the models which are capable to capture this volatility clustering. Table 1 and 1(a) shows the descriptive statistics of the KSE-100 index and foreign exchange rate. It is clear that the average daily return of KSE-100 is 0.06% along with a standard deviation of 1.81%. Similarly the average change in the exchange rate of RS/US $ is 0.01% with a standard deviation of 0.93%. The result of Skewness shows that both of the series are negatively skewed. The results of Jarque-Bera suggests the rejection of null hypothesis and suggests the non-normality of data. Similarly the results for three subsamples are also reported for both of the markets.

Table 1: Descriptive Statistics of Equity Markets

	R_KSE	S1_R_KSE	S2_R_KSE	S3_R_KSE
Mean	0.0006	0.0008	0.0000	0.0007
Median	0.0010	0.0010	0.0005	0.0012
Maximum	0.1388	0.1229	0.1388	0.0624
Minimum	-0.1650	-0.1220	-0.1650	-0.0517
Std. Dev.	0.0181	0.0195	0.0215	0.0110
Skewness	-0.1974	0.1169	-0.3902	-0.1914
Kurtosis	13.0562	8.3690	12.9134	5.6790
Jarque-Bera (Pro)	21581 (0.00)	1758(0.00)	6019(0.00)	445(0.00)

Table 2 reports the results of OLS for the equity markets in Pakistan along with explanatory variables. It is quite evident that future can be predicted on the basis of one past period. Further Exchange rate also has significant effect on the return of KSE-100 index in Pakistan. But this regression model further tested on the basis of OLS assumption like homoscedasticity with the

help of White test and autocorrelation with the help of Breusch-Godfrey Serial Correlation LM Test. Both the results showed that there exist heteroscedasticity as well as autocorrelation in the error term of the model. So the results of the OLS may not be reliable.

Table 2(a): Descriptive Statistics

	R_PKR/USD	S1_R_PKR/USD	S2_R_PKR/USD	S3_R_KSE
Mean	0.0001	0.0000	0.0002	0.0007
Median	0.0000	0.0000	0.0000	0.0012
Maximum	0.0587	0.0470	0.0587	0.0624
Minimum	-0.0571	-0.0571	-0.0512	-0.0517
Std. Dev.	0.0093	0.0149	0.0059	0.0110
Skewness	-0.0599	-0.0738	0.5010	-0.1914
Kurtosis	17.3599	7.9636	38.5800	5.6790
Jarque-Bera (Pro)	43942 (0.00)	1501 (0.00)	77124 (0.00)	445.(0.00)

Table 2: A Regression Model for the KSE-100 index

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.0007	0.0007	0.9816	0.3263
R_KSE(-1)	-0.2112	0.0137	-15.4343	0.0000
T_R_PKR/USD	-0.0634	0.0272	-2.3299	0.0199
T_Terrorism	-0.0004	0.0005	-0.7160	0.4740
T_Monday	0.0013	0.0009	1.4315	0.1524
T_Tuesday	0.0007	0.0009	0.7163	0.4738
T_Wednesday	0.0013	0.0009	1.4053	0.1600
T_Thursday	0.0007	0.0009	0.7899	0.4296
T_Friday	0.0003	0.0009	0.3723	0.7097
R-squared	0.0517	Schwarz criterion		-5.2259
Adj. R-squared	0.0500	Hannan-Quinn criter.		-5.2342
F-statistic (Prob)	30 ***	Durbin-Watson stat		2.1077
Breusch-Godfrey Serial Correlation LM Test:				
F-statistic	182.1398	Prob. F(2,5101)		0
Obs*R-squared	340.799	Prob. Chi-Square(2)		0
Heteroskedasticity Test: White				
F-statistic	96.39256	Prob. F(9,5103)		0
Obs*R-squared	742.9314	Prob. Chi-Square(9)		0

Table 3 reports the results of OLS for the currency market in Pakistan along with explanatory variables. It is quite evident that future can be predicted on the basis of one past period. Further equity market also has significant effect on the currency market in Pakistan. But this regression model further tested on the basis of OLS assumption like homoscedasticity with the help of White test and autocorrelation with the help of Breusch-Godfrey Serial Correlation

LM Test. Both the results showed that there exist heteroscedasticity as well as autocorrelation in the error term of the model. So the results of the OLS may not be reliable.

Table 3: A Regression Model for the Currency Market (PKR/USD)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.0020	0.0003	7.7309	0.0000
T_R_PKR/USD(-1)	-0.1581	0.0138	-11.4582	0.0000
R_KSE	-0.0171	0.0070	-2.4526	0.0142
T_Terrorism	0.0004	0.0003	1.5189	0.1288
T_Monday	-0.0025	0.0004	-6.0949	0.0000
T_Tuesday	-0.0059	0.0004	-14.4104	0.0000
T_Wednesday	-0.0017	0.0004	-4.1223	0.0000
T_Thursday	-0.0017	0.0004	-4.2636	0.0000
T_Friday	-0.0024	0.0004	-5.9770	0.0000
R-squared	0.0621	Durbin-Watson stat		2.0225
Adjusted R-squared	0.0607	Akaike info criterion		-6.5806
F-statistic(Pro)	42 ***	Schwarz criterion		-6.5691
Breusch-Godfrey Serial Correlation LM Test				
F-statistic	102.7365	Prob. F(2,5102)		0
Obs*R-squared	197.9441	Prob. Chi-Square(2)		0
Heteroskedasticity Test: White				
F-statistic	29.70704	Prob. F(8,5104)		0
Obs*R-squared	227.4832	Prob. Chi-Square(8)		0

Therefor on the basis of Figure 1 and Figure 2 as well as the results of white test and Breusch-Godfrey Serial Correlation LM Test leads towards the application of ARCH family models. GARCH (p, q) models allow the researchers to add the explanatory variable in the specification of the variance or simply the variance equation. To capture the effect of change in exchange rate on the volatility of KSE-100 index, study add the explanatory variable in the specification of the variance equation of the GARCH model. Table 4 shows the result of the GARCH (1, 1) model with explanatory variable (change in foreign exchange rate, Terrorism and Day dummies) in the specification of variance equation. The result of table 4 shows that the explanatory variable of foreign exchange rate and terrorism are highly statistically significant (significance level is 5%). Hence the volatility of foreign exchange rate has significant impact on the volatility of KSE-100 index. Moreover, it has a clam effect on the volatility of stock return. The same effect can be observer in the case of terrorism. Further there exists significant day-of-week effect for Monday, Tuesday and Friday for whole sample period.

The Exponential GARCH model

To check the normality of data the Quantile-Quantile plots are used (Cleveland1994, Chambers et al. 1983). The QQ plot shows that the returns are not symmetrical (See Appendix). To capture the asymmetry in term of positive and negative shocks, this study also uses the EGARCH model. Table 5 shows the result of exponential general autoregressive conditional heteroskedasticity (EGARCH specification which was firstly proposed by Nelson 1991). From

the results EGARCH (1, 1), the estimate ξ is statistically significant and negative. From this we can say that for the return of KSE-100 index there exist asymmetry and especially bad news has more effect than good news on the volatility of stock.

Table 4: A GARCH (1, 1) model for the KSE-100 index with Explanatory Variable

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.0002	0.0001	1.4675	0.1422
R_KSE(-1)	-0.2161	0.0154	-14.0512	0.0000
Variance Equation				
α_0	0.000026	0.000003	9.847084	0.0000
α_1	0.254433	0.012055	21.106330	0.0000
β_1	0.619557	0.009082	68.217630	0.0000
T_R_PKR/USD(-1)	-0.000692	0.000109	-6.361798	0.0000
T_Terrorism	-0.000020	0.000002	-10.114230	0.0000
T_Monday	0.000300	0.000020	14.934540	0.0000
T_Tuesday	-0.000152	0.000014	-11.206830	0.0000
T_Wednesday	0.000005	0.000006	0.790110	0.4295
T_Thursday	-0.000003	0.000005	-0.516401	0.6056
T_Friday	-0.000013	0.000004	-3.699933	0.0002
R-squared	0.0430	Akaike info criterion		-5.8047
Adjusted R-squared	0.0429	Schwarz criterion		-5.7894
Log likelihood	14851.8300	Durbin-Watson stat		2.0942

Table 5: An EGARCH (1, 1) model for KSE-100 index with Explanatory Variable

Variable	**Coefficient**	**Std. Error**	**z-Statistic**	**Prob.**
C	-0.0004	0.0001	-6.5829	0.0000
R_KSE(-1)	-0.3290	0.0129	-25.5819	0.0000
Variance Equation				
γ	-2.0170	0.0664	-30.3758	0.0000
ρ	0.4459	0.0147	30.3035	0.0000
ξ	-0.0321	0.0096	-3.3513	0.0008
ω	0.9279	0.0040	229.8183	0.0000
T_R_PKR/USD(-1)	-11.0662	1.8399	-6.0146	0.0000
T_Terrorism	-0.0333	0.0101	-3.2965	0.0010
T_Monday	3.7120	0.1131	32.8311	0.0000
T_Tuesday	0.2264	0.0751	3.0140	0.0026
T_Wednesday	0.9681	0.0688	14.0675	0.0000
T_Thursday	0.8787	0.0674	13.0375	0.0000
T_Friday	1.7339	0.1114	15.5660	0.0000
R-squared	0.0252	Akaike info criterion		-5.9140
Adjusted R-squared	0.0250	Schwarz criterion		-5.8973
Log likelihood	15132.0300	Durbin-Watson stat		1.9259

Study divides the whole data period into three subsamples and tries to explore the role of terrorism and calendar effect in each subsample. Mean equation shows that future return in each subsample can be forecasted with historical data. Further there exists GARCH effect in each subsample. Result shows that change in exchange rate has statistically significant effect on the volatility of equity markets in each period. It has calm effect in first two sample periods while in last periods it has exciting effect on the volatility of equity markets. Terrorism has significant effect on the volatility in equity markets. But it has only exciting effect in the second sample period. Further there exists significant day-of-week effect for Tuesday and Wednesday in each subsamples shows that markets are not perfectly efficient.

Table 6: A GARCH (1, 1) model for the KSE-100 index (Sub-Samples)

	S1_R_KSE	**S2_R_KSE**	**S3_R_KSE**
Variable	Coefficient (Prob)	Coefficient (Prob)	Coefficient (Prob)
C	-0.0001	0.001 ***	0.000122
Y(-1)	-0.3459 ***	-0.1229 ***	-0.216835 ***
Variance Equation			
α_0	0.000	0.0003***	0.000
α_1	0.17709***	0.3054***	0.18533***
β_1	0.72865***	0.6038***	0.56738***
S_i_R_PKR/USD	-0.0005***	-0.0009*	0.00081**
S_i_Terrorism	-0.00001***	0.0000***	-0.00001**
S_i_Monday	0.00048***	-0.0001	0.00018***
S_i_Tuesday	-0.00029***	-0.0004***	-0.00003*
S_i_Wednesday	0.00005***	-0.0003***	0.00002**
S_i_Thursday	-0.00001	-0.0003***	0.00002**
S_i_Friday	0.0000	-0.0003***	0.00002**
R-squared	0.03143	0.0360	0.01120
Adjusted R-squared	0.03089	0.0355	0.01052
Log likelihood	5203.57600	4854.4920	4713.63600
Durbin-Watson stat	1.93134	2.2385	1.97015

***P<0.01, **P<0.05, *P<0.1

The QQ plot shows that the returns in each subsample are not symmetrical (See Appendix). To capture the asymmetry in term of positive and negative shocks, this study also uses the EGARCH model in each subsample. Table 7 shows that the estimate ξ is statistically significant and negative only for second sample period. From this we can say that for second sample period, in return of KSE-100 index there exist asymmetry and especially bad news has more effect than good news on the volatility of stock.

To capture the effect of change in KSE-100 index on the volatility of exchange rate, study adds the explanatory variable in the specification of the variance equation of the GARCH model. Table 8 shows the result of the GARCH (1, 1) model with explanatory variable (change in KSE-100 index, Terrorism and Day dummies) in the specification of variance equation. The result of table 8 shows that the explanatory variable KSE-100 index and terrorism are highly statistically significant (significance level is 5%). Hence the volatility in KSE-100 index has significant impact on the volatility of equity markets. Moreover, it has an exciting effect on the on the volatility in exchange rate. The same effect can be observer

in the case of terrorism. Further there exists significant day-of-week effect for whole sample period.

Table 7: An EGARCH (1, 1) model for KSE-100 index (Sub-Samples)

	S1_R_KSE	**S2_R_KSE**	**S3_R_KSE**
Variable	**Coefficient**	**Coefficient**	**Coefficient**
C	0.0002	-0.0006***	0.0005*
Y(-1)	-0.3350***	-0.3347***	-0.2993***
Variance Equation			
γ	-1.9556***	-2.1173***	-2.0299***
ρ	0.4195***	0.5552***	0.2814***
ξ	0.0057	-0.0582***	0.0125
ω	0.9358***	0.9310***	0.9149***
S_i_ R_PKR/USD	4.6841**	-8.3618	1.1657
S_i_Terrorism	-0.0960**	-0.0082	-0.0478
S_i_Monday	3.7202***	3.9269***	3.3851***
S_i_Tuesday	0.2134	0.2431*	0.4086**
S_i_Wednesday	1.0713***	1.0158***	0.9594***
S_i_Thursday	1.0097***	0.9097***	0.7565***
S_i_Friday	1.6828***	1.8266***	1.9320***

***P<0.01, **P<0.05, *P<0.1

Table 8: A GARCH (1, 1) model for Currency Market (PKR/USD)

Variable	**Coefficient**	**Std. Error**	**z-Statistic**	**Prob.**
C	-4.18E-05	5.42E-05	-0.7709	0.4408
Y(-1)	-0.2951	0.0190	-15.5398	0.0000
Variance Equation				
α_0	6.67E-06	8.40E-08	79.4206	0.0000
α_1	0.1928	0.0051	37.9382	0.0000
β_1	0.8032	0.0020	395.1593	0.0000
R_KSE	3.71E-06	2.08E-06	1.7823	0.0747
T_Terrorism	2.72E-07	4.83E-08	5.6330	0.0000
T_Monday	-4.32E-06	1.95E-07	-22.1392	0.0000
T_Tuesday	-1.30E-05	3.43E-07	-37.7408	0.0000
T_Wednesday	-7.44E-06	1.83E-07	-40.5887	0.0000
T_Thursday	1.63E-06	2.79E-07	5.8253	0.0000
T_Friday	-1.34E-05	2.49E-07	-53.6985	0.0000
R-squared	-0.0018	**Log likelihood**		19557
Adjusted R-squared	-0.0020	**Akaike info criterion**		-7.6454
Durbin-Watson stat	1.7746	**Schwarz criterion**		-7.6300

The Exponential GARCH model

To capture the asymmetry in term of appreciation and depreciation, this study also uses the EGARCH model. Table 9 shows the result of exponential general autoregressive conditional heteroskedasticity. From the results of EGARCH (1, 1), the estimate ξ is statistically significant and negative. From this we can say that for the exchange rate there exist asymmetry and especially depreciation in the Pakistani currency (RS) has more effect than of appreciation on the volatility of foreign exchange rate.

Table 9: An EGARCH (1, 1) model for Currency Market with Explanatory Variable

Variable	**Coefficient**	**Std. Error**	**z-Statistic**	**Prob.**
C	0.0002	0.0000	7.9797	0.0000
Y (-1)	-0.2391	0.0157	-15.1977	0.0000
Variance Equation				
γ	-0.0461	0.0218	-2.1175	0.0342
ρ	0.2254	0.0039	57.8684	0.0000
ξ	-0.0439	0.0047	-9.3609	0.0000
ω	0.9862	0.0007	1469.5740	0.0000
T_R_KSE	0.2068	0.1927	1.0730	0.2833
T_Terrorism	-0.0232	0.0025	-9.1705	0.0000
T_Monday	-0.7202	0.0431	-16.7091	0.0000
T_Tuesday	0.4452	0.0387	11.4999	0.0000
T_Wednesday	-0.6176	0.0492	-12.5569	0.0000
T_Thursday	-0.0973	0.0339	-2.8667	0.0041
T_Friday	-0.5468	0.0436	-12.5328	0.0000
R-squared	0.0124	Durbin-Watson stat		1.8676
Adjusted R-squared	0.0122	Akaike info criterion		-7.7598
Log likelihood	19850.9400	Schwarz criterion		-7.7432

Study divides the whole data period into three subsamples and tries to explore the role of terrorism and calendar effect in each subsample. Mean equation shows that future of exchange rate in each subsample can be forecasted with historical data. Further there exists GARCH effect in each subsample. Result shows that change in KSE-100 index has statistically significant effect on the volatility of exchange rate in two sub periods. It has calm effect in first two sample periods. Terrorism has significant effect on the volatility in exchange rate in two sample periods. Further there exists significant day-of-week effect for Monday, Thursday and Friday in each subsamples shows that markets are not perfectly efficient.

Table 10: A GARCH (1, 1) model for Currency Market (PKR/USD) (Sub-Samples)

	S1_R_PKR/USD	**S2_R_PKR/USD**	**S3_R_PKR/USD**
Variable	Coefficient	Coefficient	Coefficient
C	7.27E-05	8.77E-05	0.0003
Y(-1)	-0.1105*	-0.2206***	-0.3221***
Variance Equation			

α_0	0.0002***	1.11E-05***	1.60E-05***
α_1	0.1494***	0.1905***	0.0467**
β_1	0.5812***	0.7018***	0.6556***
S_i_R_KSE	-0.0005*	-4.58E-05***	-4.92E-05
S_i_Terrorism	-6.67E-05***	3.09E-06***	-1.66E-06
S_i_Monday	-0.0001***	-9.20E-06***	2.01E-05***
S_i_Tuesday	-4.40E-05	-1.71E-05***	-2.76E-05***
S_i_Wednesday	-0.0001***	-1.29E-05***	-1.93E-06
S_i_Thursday	-0.0001***	-1.20E-05***	-1.50E-05***
S_i_Friday	-0.0001***	-1.05E-05***	-1.10E-05***
R-squared	0.012	0.0382	0.1012
Adjusted R-squared	0.0115	0.0377	0.1006
Durbin-Watson stat	2.0205	1.9821	2.1593
Schwarz criterion	-5.9231	-8.1682	-7.5032

***P<0.01, **P<0.05, *P<0.1

The QQ plot shows that the returns in each subsample are not symmetrical (See Appendix). To capture the asymmetry in term of positive and negative shocks, this study also uses the EGARCH model in each subsample. Table 9 shows that the estimate ξ is statistically significant and negative only for all three sample period. From this we can say that for the exchange rate there exist asymmetry and especially depreciation in the Pakistani currency (RS) has more effect than of appreciation on the volatility of foreign exchange rate in all the subsample.

Table 9: An EGARCH (1, 1) model for Currency Market (PKR/USD) (Sub-Samples)

	S1_R_PKR/USD	**S2_R_PKR/USD**	**S3_R_PKR/USD**
	Coefficient	Coefficient	Coefficient
C	-7.37E-05***	5.67E-05*	0.0001
Y(-1)	-0.0839***	-0.1949***	-0.3174***
Variance Equation			
γ	-0.5339***	-0.8922***	-1.9157**
ρ	0.4041***	0.1232***	0.1309***
ξ	-0.1864***	-0.0195***	-0.0813***
ω	0.9853***	0.9980***	0.7977***
S_i_ R_KSE	-1.4613***	0.1834	-1.8562
S_i_Terrorism	0.2505***	0.0432***	-0.0503
S_i_Monday	-2.5011***	0.9185***	0.2545*
S_i_Tuesday	3.2158***	2.5385***	-0.8247***
S_i_Wednesday	-0.0724	0.5348***	-0.1228
S_i_Thursday	0.8822***	0.5119***	-0.6314***
S_i_Friday	-0.5471***	0.8763***	-0.4348***
R-squared	0.0112	0.0385	0.1013
Adjusted R-squared	0.0107	0.0379	0.1006
Log likelihood	7101.318	8106.878	5527.819

Durbin-Watson stat	2.0682	2.03	2.1662
Schwarz criterion	-7.7245	-8.8308	-7.5075

***P<0.01, **P<0.05, *P<0.1

Conclusion

This study examines the volatility spillover and asymmetric behavior in financial markets in Pakistan. Further it also examines the importance of terrorism related activities towards the currency and equity markets. This particular study employs the daily stock prices of Pakistani equity markets and daily foreign exchange rates. The period of the study is 13 year and starts from January 1, 2000 to December 31, 2013 which corresponds to 5114 daily observations. This study further divides the sample into three subsamples to comments upon the efficiency of financial markets in term of calendar anomalies. The first subsamples starts form January 1, 2000 to December 31, 2004, the second subsample starts form January 1, 2005 to December 31, 2009 and third subsample starts form January 1 2010 to December 31, 2013. To check the calendar anomalies in both of the markets i.e. equity and currency study uses the dummy variable and it captures the day-of-week effect in different subsamples.

Results of White test and Breusch-Godfrey Serial Correlation LM Test showed that there exist heteroscedasticity as well as autocorrelation in the error term of the model. So the results of the OLS may not be appropriate and study applied the ARCH family model. Result of the GARCH (1, 1) model with explanatory variable (change in foreign exchange rate, Terrorism and Day dummies) in the specification of variance equation showed that foreign exchange rate and terrorism have significant calm impact on the volatility of KSE-100 index. Further there exists significant day-of-week effect for Monday, Tuesday and Friday for whole sample period. Change in exchange rate has statistically significant effect on the volatility of equity markets in each subsample period. It has calm effect in first two sample periods while in last periods it has exciting effect on the volatility of equity markets. Terrorism has significant effect in each subsample period on the volatility in equity markets. But it has only exciting effect in the second sample period. Further there exists significant day-of-week effect for Tuesday and Wednesday in each subsamples shows that markets are not perfectly efficient. Further results showed that for the return of KSE-100 index there exist asymmetry and especially bad news has more effect than good news on the volatility of stock.

The phenomena of volatility spillover are quite clear from the results. KSE-100 index and terrorism have statistically significant impact on the volatility of exchange rate. Moreover, both have an exciting effect on the volatility in exchange rate. Further there exists significant day-of-week effect for whole sample period. Further there exists significant day-of-week effect for Monday, Thursday and Friday in each subsamples shows that markets are not perfectly efficient. There exist asymmetry in currency markets and especially depreciation in the Pakistani currency (RS) has more effect than of appreciation on the volatility of foreign exchange rate.

Therefore study concluded that there exist the phenomena of volatility spillover in financial markets of Pakistan. If volatility in KSE-100 index increases then it also causes increase in volatility of exchange rate. But on the other hand if there is volatility in the exchange rate then it has calm effects on the volatility in the stock markets. . But in last subsample it has an exciting effect on the volatility of equity markets. On the other hand, terrorism also played a role towards the financial markets in Pakistan. In equity market, Terrorism has significant effect in each subsample period on the volatility in KSE-100 index. But it has only exciting effect in the second sample period. One possible reason may be that in the first sample period majority of the

blasts were in notherian areas of Pakistan but in the second period there were lot of terrorism related activities observed throughout the Pakistan. Terrorism has an exciting effect on the volatility in exchange rate. So terrorist attacks enhances the volatility in currency markets while in local equity markets it has overall calm effect. Both the markets are inefficient in the context of day-of-the-week effect. Therefore the foreign investor, fund manager and policy maker should be aware such volatility spillover and role of terrorism in financial markets.

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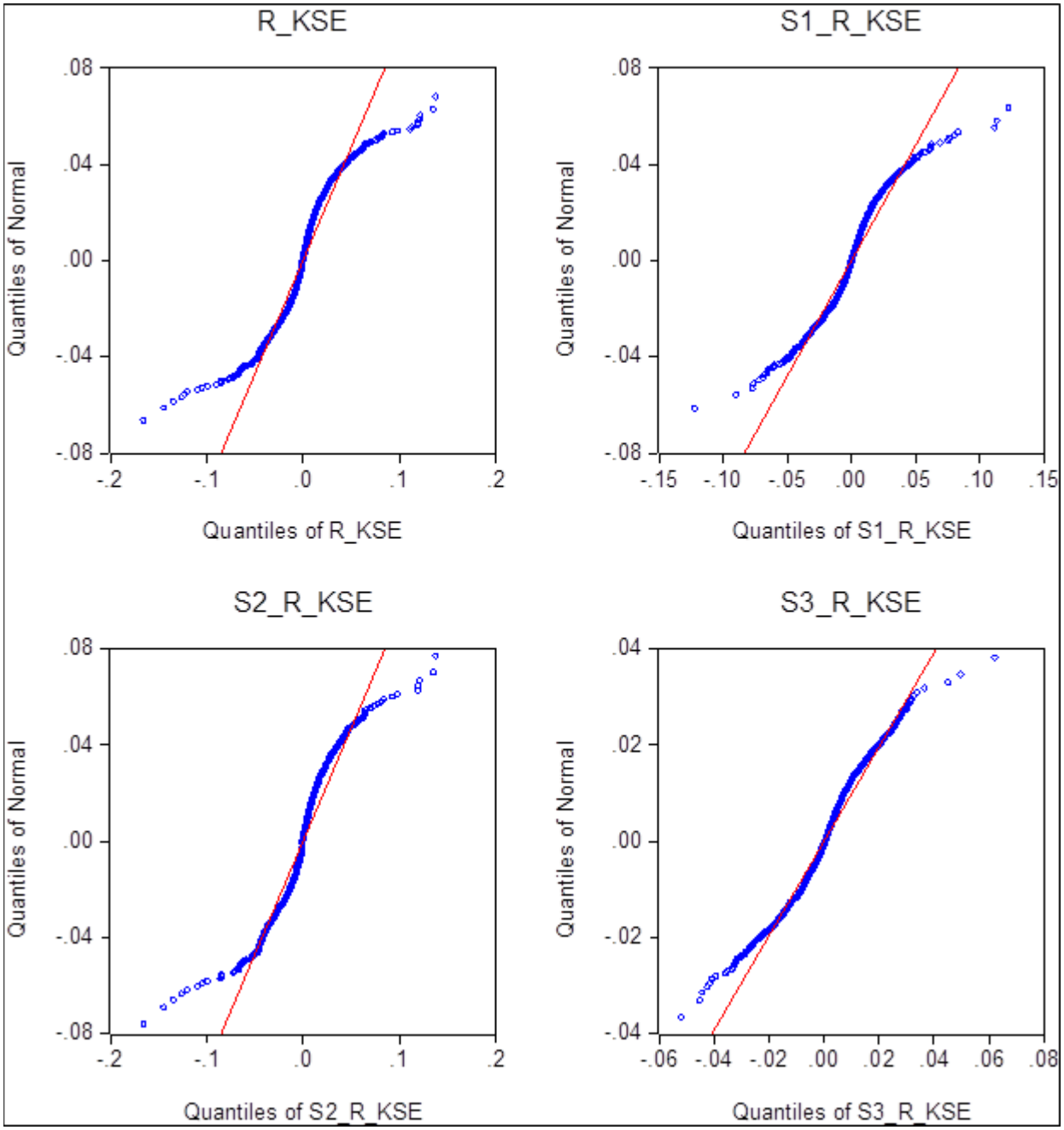
Appendix:


R_KSE
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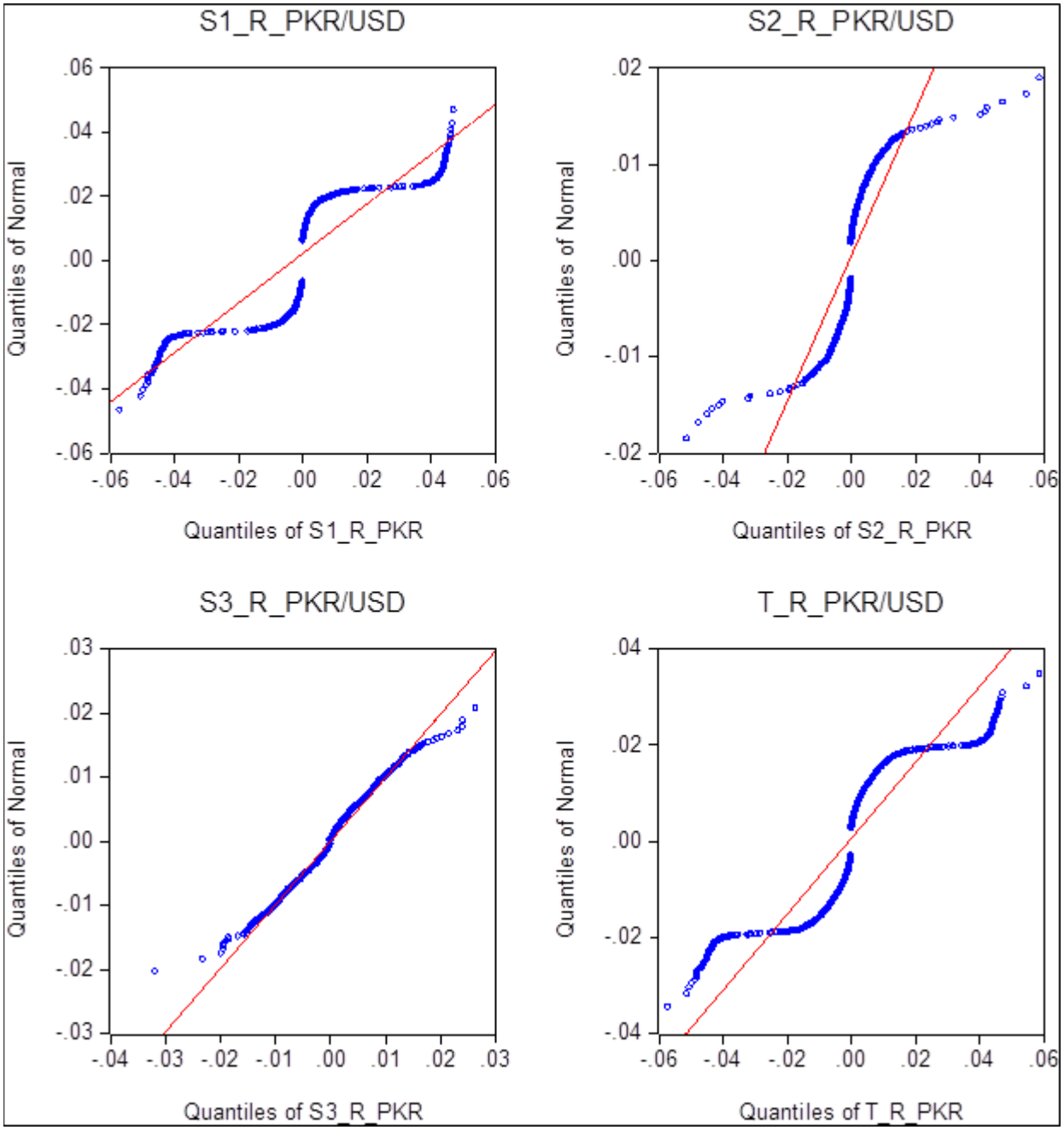
Appendix:


S1_R_PKR/USD
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T_R_PKR/USD
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