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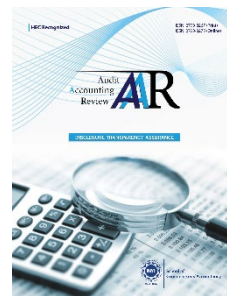|	
Title:	**Exploring Asymmetric Linkages and Volatility Transmission between Stock Market and Foreign Exchange (FOREX)**
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Exploring Asymmetric Linkages and Volatility Transmission between Stock Market and Foreign Exchange (FOREX)

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Abstract

This study examines the direction and nature of volatility transmission between the stock market and the foreign exchange market (FOREX) of Pakistan. For this purpose, daily data is gathered to conduct the analysis for both markets. Stock market returns are measured by using the KSE-100 index and the daily Pakistan Rupee-PKR to the United States Dollar-USD exchange rate is used for the foreign exchange market. Noticeably, both the variables are stationary at their first difference. Normality is examined through Skewness and Kurtosis, Autocorrelation through Correlogram Q-statistics, and the ARCH effect through the ARCH-LM test. Volatility transmission between the two markets is examined by using bivariate diagonal BEKK-GARCH and bivariate E-GARCH models. The results of the study indicate that bi-directional volatility transmission exists between the stock market and the foreign exchange market (FOREX) of Pakistan. Results from the E-GARCH model further indicate that the nature of volatility transmission between these two markets is asymmetric, which means bad news of one market has a greater impact on the volatility of another market than the good news. Hence, the results of this study also indicate that past variances of the stock market and foreign exchange market has a significant effect on their own current volatility.

Keywords: asymmetric linkages, BEKK-GARCH, E-GARCH, Foreign Exchange Market (FOREX), volatility transmission

Introduction

The current study intents to determine the direction and nature of volatility transmission between the Foreign Exchange Market (FOREX) and the stock market of Pakistan. The returns in FOREX and the stock market are highly unpredictable due to the high level of fluctuation in Pakistan. The fluctuation in both markets is interlinked (Dua & Tuteja, 2016). The volatility transmission between two markets can be an outcome of volatility,

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which can cause and effect the feedback relationship between both markets (Ebrahim, 2000). This study considers the previous effect of volatility in the stock market on the current volatility of FOREX and the effect of previous volatility in FOREX on the current volatility of the stock market, which is considered as a transmission. Previous study argues that there is a greater impact of bad news than the good news of one market to the volatility of the second market (Koutmos & Booth, 1995). This means that negative and positive returns in one market do not have the same impact on returns in another market. This study has also analyzed asymmetric linkages between the two financial markets of Pakistan.

The presence of volatility transmission between two markets in Pakistan needs to be verified for a comprehensive understanding of the market behaviour. Investors without having knowledge of the existence and nature of volatility transmission cannot devise effective investment strategies, which in turn may cause them to face heavy losses. Hence, this study determines; whether volatility transmission between two financial markets is one-sided or two-sided also the transmission is symmetric or asymmetric.Furthermore, the findings of this study would help local and international investors in making hedging and investment related decisions. Table-1 shows a brief profile of PSX for five years and Table-2 shows the performance of the KSE-100 Index.

The function of the foreign exchange market (FOREX) in any economy is to manage the flow of foreign currencies, specifically, the currency of a country, which is held for fulfilling the financial obligation of a country. Through a foreign exchange market (FOREX), a country can avoid abnormal changes in the exchange rate, which can also facilitate investors to hedge their risk (Abbas & Pasha, 2011).

Initially, since the independence PKR was linked with Sterling Pound till 1971, since that PKR was linked with USD the official exchange rate PRK/USD was 4.76. During early 1972, PKR has depreciated against gold by 56.7% (Abbas & Pasha, 2011). The results of this study would be helpful for policymakers in formulating foreign exchange policy. As in case policymakers want to depreciate their currency, they would know the effect of this step on the stock market. It will also be helpful for policy makers that how appreciation of currency changes the direction of the stock market.

Table 1
Profile of Pakistan Stock Exchange

Description	Up to 31-12-2011	Up to 31-12-2012	Up to 31-12-2013	Up to 31-12-2014	Up to 31-12-2015	Up to 31-12-2016	Up to 31-12-2017	Up to 31-12-2018	Up to 31-12-2019	Up to 31-12-2020
Total Listed Companies	638	573	569	557	560	558	559	560	534	531
New companies listed	4	4	4	5	9	4	1	1	1	3
Total Listed Capital (Rs. In Million)	1,048,443.9	1,094,367.4	1,129,787.3	1,168,484.88	1,165,183.9	1,291,040	1,300,256	1,297,159	1,386,590	1,421,090
Total Market Capitalization (Rs. In Million)	2,945,784.5	4,242,278.0	6,056,506.0	7,380,531.74	7,081,220.8	9,628,514	10,095,160	9,594,806	7,811,810	8,035,360
Total shares volume (Million)	24,434.4	49,282.42	54,319	56,581	57,204	55,430	56,370	56,255	57,645	108,426
Average daily shares volume (Million)	96.91	196.68	221	229	233	221	222	224	163.98	323.51

Table 2
Leading Stock Market Indicators on KSE-100 Index

	2017/18			2018/19			2019/20		
	Market Capitalization (Rs. Billion)	KSE-100 (End Month)	Turnover of Shares (Billion)	KSE-100 (End Month)	Market Capitalization (Rs. Billion)	Turnover of Shares (Billion)	KSE-100 Index (End Month)	Market Capitalization (Rs. Billion)	Turnover of Shares (Billion)
July	9,460.71	46,010.45	3.68	42,712.43	8,869.17	3.75	31,938.48	6,384.30	1.76
August	8,558.63	41,206.99	4.44	41.742.24	8,800.62	3.60	29,672.12	6,082.04	2.03
September	8,890.37	42,409.27	2.91	40,998.59	8,554.98	2.49	32,078.85	6,406.55	2.18
October	8,385.30	39,617.9	3.26	41,649.36	8,567.18	5.03	34,203.68	6,690.04	4.37
November	8,496.88	40,010.36	2.47	40,496.03	8,299.56	4.16	39,287.55	7,511.97	6.40
December	8,690.95	40,471.48	2.93	37,066.67	7,899.56	2.71	40,735.08	7,811.81	6.45
January	9,261.46	44,049.05	5.50	40,799.52	8,357.10	3.15	41,630.93	7,851.16	5.68
February	9,154.87	43,239.44	3.87	39,054.60	8,034.66	2.88	37,983.62	7,094.67	2.91
March	9,489.73	45,560.30	4.04	38,649.34	7,911.84	2.17	29,231.63	5,620.94	4.71
April	9,515.55	45,488.86	4.39	36,784.44	7,505.31	3.29	34,111.64	6,376.72	4.60
May	9,031.66	42,846.64	2.96	35,974.79	7,240.44	2.77	33,931.23	6,484.96	2.33
June	8,779.96	41,910.90	2.95	33,901.58	6,887.30	2.57	34,421.92	6,529.70	2.23

Note. Source: *Ministary of Finance (Economy Survey of Pakistan)*

Objectives

1. To determine volatility transmission between the stock market and the foreign exchange market of Pakistan.

2. To determine asymmetric linkages between the stock market and the foreign exchange market of Pakistan.

Literature Review

There are different theories, which have explained the nature of the relationship between these two financial markets. Two theories, which are mostly referred to explain the relationship between these two markets, are Portfolio Balance Theory and the Goods Market Approach. According to the Goods Market Approach, depreciation is expected to increase the exporting firms' value, while appreciation is expected to increase the value of the import-based industry; therefore, the relationship is expected to be positive (Dornbusch & Fischer, 1980). Many companies are exposed to foreign current risk when they involve in imports and exports. According to this theory, such transactions affect the profitability of companies, which in turn affects the stock price as a whole. Therefore, according to this theory, flow of relationship between these two markets is from foreign exchange market to stock market. In this study, the direction of volatility transmission between two markets was examined and the viewpoint of this theory was used to explain the logic of the relationship between these two markets.

Another theory, which is Portfolio Balance Approach, explained the abiding relationship between these two markets. This theory suggested that it is the stock market of any country, which affect behaviour of the foreign exchange market of a country. This is because investors seek to make decisions, which minimize their risk and maximize their return. This theory was first developed by Branson et al. (1977); whereas other contributors to the model were Dorubusch (1976), and Frankel and Rodriguez (1975). Furthermore, this model suggested that the primary problem faced by investors is the right combination of different securities to minimize their risk.

The above theories had explained the relationship between two financial markets. The goods market approach argued that the flow of relationship is from the stock market to the exchange market; whereas the Portfolio balance approach claimed that it is way around. However, there are studies, which have suggested that both markets can affect each other at the same

time (Azman-Saini et al., 2003). In this study, all these approaches were examined.

There is no consensus in the findings of previous research regarding the volatility transmission of these two financial markets. A few studies concluded that volatility transmission is unidirectional and move from FOREX to the stock market. While, few other studies concluded the contrary volatility transmission, which moves from the stock market to FOREX (Horobet et al., 2007). However, the literature was unable to conclude the direction and nature of the relationship between these two financial markets.

In the stock market of Japan transmission from the foreign exchange market existed for eight sectors; whereas in five sectors nature of transmission was asymmetric in nature (Luo & Wang, 2011). Bukhari (2013) in his study found for London Stock Exchange (LSE) that all eighteen stocks were exposed due to the volatility of FOREX; however, the level of exposure was not the same for all kinds of stocks.

Daniel et al. (2009) found that in the case of New Zealand volatility transmission moved from the stock market to FOREX of two currencies, which are the Australian and American dollar. The same results were concluded by a few other studies (Yang & Doong, 2004). However, evidence of two-sided volatility transmission was also found for the Australian market with the existence of asymmetric linkages (Hakim & McAleer, 2009).

Zhao (2009) determined that the volatility of the Taiwan dollar exchange rate against the Japanese yen and the stock market of the country were interlinked. In the case of Hong Kong both financial markets had long run relationships and both markets transmitted volatility to each other (Lee, 2012). Another research found that in the case of Japan and China, the flow of volatility transmission was from FOREX to the stock market (Wei, 2009; Wei et al., 2019).

Doong et al. (2011) inferred that in Philipines, Malaysia, Indonesia, and Korea volatility of stock market impacted the FOREX but no evidence was traced from FOREX to the stock market. Ahmedi et al. (2012) studied different sectors of the Tehran stock market and found that sign of a relationship for the food and cement sector was positive with asymmetric nature; for the pharmacy and chemistry sector sign of the relationship was

negative and the nature of the relationship was asymmetric. However, in Japan, it was found that the foreign exchange market has a strong influence on the stock market as compared to the influence of the stock market on the foreign exchange market (Narayan et al., 2020)

In the case of Turkey, the stock market was found to have volatility transmissions on the foreign exchange market and no significant transmission exists from foreign exchange to the stock market (He et al., 2021). In the US market foreign exchange markets found to be a major contributor to the spillover of the stock market (Liu et al., 2022). In some regions, it was found that foreign exchange is a safe heaven for the stock market, as no volatility transmission existed between the two markets. This was found in a study on different markets of Mexico and revealed that foreign exchange and stock market do not have long-term relationships (Singhal et al., 2019).

In the case of South Asian economies, there is no point to address the relationship between two markets. In one study four major South Asian countries were examined and revealed that these countries, India, Pakistan, Bangladesh, and Sri-Lanka, these two financial markets have no relationship either in the short run or in the long run (Naeem & Rasheed, 2002). Similar results were also revealed by other studies for the financial markets of Pakistan and India but in Bangladesh, these two markets revealed that the relationship (Noman et al., 2012; Rehman & Uddin, 2009; Rehan et al., 2019).

The direction and nature of the relationship between FOREX and the stock market of Pakistan is still not yet confirmed. Different studies had shown different results. However, some studies have found that no long-run relationship existed between FOREX and the stock market (Qayyum & Kemal, 2006; Zia & Rahman, 2011). On the other side, few studies concluded that FOREX can predict the nature and direction of the stock market. However, no evidence was found of volatility transmission from the stock market to FOREX. (Khalid & Rajaguru, 2006; Mustafa & Nishat, 2008). Other research has shown that both markets transmitted volatility to each other and past volatility can predict the current behaviour of the second market (Qayyum & Kemal, 2006). Similarly in another study, it was found that the stock market and foreign exchange market in Pakistan had long-term relationship (Naseem et al., 2019). Another study for Pakistan concluded a two-way relationship between the stock market and foreign

exchange market (Akbar et al., 2019). Hanif (2020) found that foreign exchange markets influence the stock market and the nature of the relationship was negative.

As indicated above, there is no consensus regarding the relationship between FOREX and the stock market literature. Specifically, in the case of Pakistan variation results existed and the dynamics of the relationship between these two markets need to be explored.

Methodology

Data of both time series were collected from official websites. Data of stock prices was taken from the website of Pakistan Stock Exchange (PSX). Official website of central bank of Pakistan (SBP) was used to collect daily US dollar rate in terms of Pakistan rupee. The period of this study was from 1 January 2001 to 31 December 2018. Reason to choose this period was due to major international and national economic changes, which occurred during this period.

Stock Prices (SP) = Daily PSX-100 Index

Exchange Rate (ER) = Daily US dollar rate

Augmented Dickey Fuller-ADF Test was applied to determine the stationary level of variables; normality of variables is checked with Jaeque-Bera Test, and Correlogram Q-statistic is used to find out the correlation among squared residuals, such as auto-correlation. The ARCH effect was initially checked and then multivariate BEKK-GARCH was applied. This model was developed by Baba, Engle, Kraft, and Korner in 1995 to find the nature of linkages. Different multivariate GARCH models assumed that correlation between two variables (financial markets) is constant. However, this model does not assume that correlation between variables was constant. This enabled the researcher to explore more dynamics about relationship, which existed between variables. BEKK GARCH model was helpful to find whether volatility transmission between two financial markets existed or not. Secondly, model also explained asymmetric nature of the relationship. Conditional variance equation is as follows:

$$H_{t+1} = C'C + B'H_tB + A'\varepsilon_t \varepsilon'_t A$$

Above conditional variance, equation has H_{t+1} matrix that include coefficients of conditional variance. Constant coefficients are included in lower triangular matrix C. In matrix B diagonal elements captures the effect

of past fluctuations on volatility within the market, whereas off diagonal elements describe the volatility transmission between two markets.

Matrix A determined how past residuals impact current residuals of other market. Reduced form of this model is diagonal BEKK GARCH with few parameters. In this form diagonal elements of A and B matrices capture volatility transmission within the market.

Parameters estimated by full BEKK-GARCH are greater than parameters calculated through diagonal equation. With few numbers of parameters make interpretation is easy to explain. For the purpose, the current study proposed three equations, which was developed to determine volatility transmission within the market and between two markets.

$$H_{11;t+1} = C_{11}^2 + B_{11}^2 H_{11;t} + A_{11}^2 \varepsilon_{1;t}^2 \tag{1}$$

$$H_{22;t+1} = C_{22}^2 + B_{22}^2 H_{22;t} + A_{22}^2 \varepsilon_{2;t}^2 \tag{2}$$

$$H_{12;t+1} = C_{12}^2 + B_{11}B_{22} H_{12;t} + A_{11}A_{22} \varepsilon_{1;t2,t} \tag{3}$$

In the above three equation, the first two equations determined the relationship between past fluctuations and volatility of a market. Equation (1) has estimated conditional variance of stock prices of PSX; whereas equation (2) is for foreign exchange market. Coefficient 'B' in both equations measured the effect of past volatility on conditional variance of market, whereas coefficient 'A' determines how previous shocks effect volatility of a market. However, Co volatility between two markets is determined in equation (3). Coefficient B11B22 determined whether previous years fluctuations in one market effect the volatility of second market or not. This equation also determined the existence of significant effect of previous year's shocks in one market on volatility of second market through parameter A11A22.

This study also intends to determine asymmetric nature of volatility transmission between two markets. For this purpose, Exponential GARCH (E-GARCH) is model used. By measuring asymmetric nature relationship of two markets investors enable to risk level of each market in relation to fluctuation in other market. Variance equations for both markets are given below:

$$\sigma_{s,t}^2 = \alpha + \delta_s ln\sigma_{s;t-1}^2 + \theta_s zs_{t-1} + \beta_s(zs_{t-1} - E(zs_{t-1}) + \theta_x zx_{t-1}$$
$$+ \beta_x(zx_{t-1} - E(zx_{t-1})) \tag{4}$$

$$\sigma_{x,t}^2 = \alpha + \delta_x ln\sigma_{x;t-1}^2 + \theta_x zs_{t-1} + \beta_x(zx_{t-1} - E(zx_{t-1}) + \theta_s zs_{t-1}$$
$$+ \beta_s(zs_{t-1} - E(zs_{t-1})) \tag{5}$$

Equation (4) explained the variance dynamics of stock market and equation (5) is for exchange market. In both variance equations 'θ' is used to measure asymmetric nature of volatility transmission both within the market and between two markets. Negative value of θ means that asymmetric relationship exist within or between the markets. Coefficient δ in both equations' measured the persistence level of volatility in both markets.

Results and Discussion

Descriptive statistics of the study are presented in Table 3. Both time series are not normally distributed. This problem is existing in daily data time series. As values of skewness and kurtosis are not equal to criteria required for normally distributed time series.

Table 3
Descriptive Statistics

	PSX 100 Index	US Dollar
Mean	11,182.46	74.77
Median	10,063.58	64.05
Maximum	34,826.51	108.63
Minimum	1075.16	57.18
Standard Deviation	7989.441	16.69
Skewness	1.10	0.46
Kurtosis	3.76	1.64
Jarque Bera	788.66	389.80
Probability	0.00000	0.0000

Table 4
Stationarity Results

Variables	ADF Test	
	Level	1st Difference
Stock Prices (SP)	1.964816 (0.999)	-50.70845 (0.0001)
Foreign Exchange Rates (FX)	0.482606 (0.9862)	-18.48464 (0.0000)

Heteroscedasticity in Residuals

Residuals of two time series were examined. These residuals are tested to determine the existence of ARCH effect. Existence of normality, conditional Heteroscedasticity, and autocorrelation in residuals of time series means ARCH effect exists in the time series.

Table 5
Normality of Residuals

	Stock Prices	Foreign Exchange Rate
Skewness	1.10	0.46
Kurtosis	3.76	1.64
Jarque Bera	788.66	389.80
Probability	0.0000	0.0000

Value of skewness and kurtosis in Table 5 revealed that residuals of both time series are not normally distributed. Correlogram shows that autocorrelation, which exists in residuals of both time series that indicates that conditional heteroscedasticity exists in residuals. The results of all diagnostic tests had shown that GARCH model should be used to analyze the dynamics of both markets.

Table 6
ARCH LM Test

	Stock Prices (SP)	Foreign Exchange Rate (FX)
F Statistics	3191401 (0.0000)	4238941(0.0000)
Obs. *R* Squared	3466.233 (0.0000)	3467.163 (0.0000)

In the above table ARCH results are shown for both time series. Significant value of F statistics means that element of ARCH is present in both time series used in this study. Existence of ARCH effect in variables means that ordinary least square regression cannot produce valid results. Therefore, multivariate GARCH models are used in this study to conduct the analysis of the selected variables.

Diagonal BEKK-GARCH Results

Results of three variance equations computed by Diagonal BEKK GARCH are given below:

$$H_{11} = 1.53e^{-8} + 0.8592H_{11,t-1} + 0.1754e^2_{1,t-1} \qquad (6)$$

$$H_{22} = 1.0111e^{-5} + 0.8388H_{22,t-1} + 0.1076e^2_{2,\ t-1} \qquad (7)$$

$$H_{12} = 2.29e^{-11} + 0.8464H_{12,t-1} + 0.1374e^2_{2,t-1} \qquad (8)$$

Equation (6) and (7) confirmed that in both markets of Pakistan previous variations and shocks have significant impact on the volatility. Both these financial markets are highly volatile but foreign exchange market (FOREX) was more volatile than stock market. This finding is useful for investors in distributing their funds between two markets.

Co variance equation for both markets confirmed the existence of co volatility between two markets of Pakistan. This means that past volatility and shocks influence the current volatility of other market. Therefore, it can be said that both markets have capability to predict future volatility of other market. This finding is useful for inventors in making decision regarding shifting of their finds from one market to other market. This also shows that in case of Pakistan foreign exchange market cannot be used to hedge investment of stock market as both markets have significant interaction with each other. In equation (9), it was evident that positive volatility transmission exists between two markets, which means that investors cannot use these two markets for their arbitrage activities. Main reason for this may be due to the involvement of foreign investors in stock market of Pakistan.

EGARCH Results

Nature of volatility of these two-time series was also estimated through E-GARCH model. Coefficients of both equations are significant at the 5% level of significance. Equations are given below:

$$H_s = -0.72 + 0.92\delta_s + 0.35\beta_s - 0.99\theta_s + 0.072\beta_x + 0.13\theta_x \qquad (09)$$

$$H_x = -0.30 + 0.92\delta_x + 0.37\beta_x - 0.13\theta_x + 0.043\beta_s + 0.32\theta_s \qquad (10)$$

Equation (9) has estimated covariance of Pakistan equity market. Flow of transmission was existing from currency market to equity market. Both asymmetric term in this equation is significant and positive, which shows that leverage effect does not exist in stock market of a country. Stock markets' response is same for its own both good and bad news and of exchange market.

Equation (10) estimated the currency market of Pakistan. Volatility is transmitted to currency market from stock market of the country. Results of

this equation revealed that currency market response was same for its own good or bad news. However, in the case of stock market news (good or bad) responses are not same as bad news left more impact on market than good news. So, leverage effect is prevailed in currency market in terms of news from stock market.

The findings of both models Diagonal BEKK-GARCH and E GARCH have confirmed that in case of Pakistan volatility transmission between two markets bidirectional. Previous year's volatility and shocks can predict volatility within the market, which can also predict volatility of other market. These findings relate with the previous studies conducted on Pakistan (Qayyum & Kemal, 2006). Through E GARCH model results it is also revealed that leverage effect exists in volatility transmission between the two markets.

ARCH Test

Residuals derived from models were examined for ARCH effect and it was found that residuals of stock market were free from this effect; whereas it was found in residuals of foreign exchange market (FOREX).

Table 7
ARCH LM Test

	Stock Prices (SP)	Foreign Exchange Rate (FX)
F Value	2.0126 (0.1560)	6.804(0.0091)
Obs. *R* Squared	2.0126 (0.1559)	6.795 (0.0091)

Conclusion

Investors of financial market are required to make decision on daily basis. These decisions may be related to hedging or speculative purpose depending upon motives of investors. For making correct decisions, investors are required to know the abiding relationship between different markets. Foreign exchange and stock market are two important markets, which normally market players use to fulfill their objectives. The purpose of this study was to know direction and nature of volatility transmission between stock market and foreign exchange market (FOREX) of Pakistan. The findings of this study have shown that volatility of both markets are affected by the volatility of other market and previous shocks of a market, which have affected the volatility of the second market. Leverage effect is not found for stock market of Pakistan as market response is same for both

types of news (good and bad). Stock market response for its own good or bad news is also same. However, leverage effect is existing for foreign exchange market as market response is not same for both types of news (good or bad). This leverage effect in foreign exchange market exists for both for news in the market and news from stock market.

The findings of this study can be helpful for government bodies, local, and international investors. Investors after knowing how one-market response can change the other market can device-hedging strategies more effectively. Similarly, after knowing the level of integration for both these markets would be help for investors to diversify their investment in both markets. For policymakers' findings of this study would be helpful in making policies for the currency markets. Specifically, when government adopts a fixed rate system for foreign exchange market (FOREX).

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