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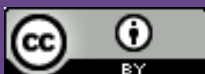
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Tracing Return and Volatility Spillover Effect between Exchange Rate and Pakistan Stock Exchange Index

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Abstract

The volatility spillover is broadly measured as the transmission of variability from one financial market to other markets. This study explores the spillover effect between the newly emerged index of the Pakistan stock exchange (PSX) and exchange rate by using the newly proposed alternative methodology by Ghouse et al. (2019) and GARCH model. Furthermore, the index under study is more concise in its composition than other readily used indices. The study finds shreds of evidence for the bidirectional spillover effect between PSX and exchange rate, which will be helpful for central policy makers and markets players in designing effective policy frameworks.

Keywords: ARDL; GARCH; spillover effect

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1. Introduction

In the current era, it is indispensable to undermine the potential global impacts of equity markets, while Pakistan certainly possesses the capability to grow tremendously in market capitalization and equity investments. This also reflects that those who are investing in stocks or stock mutual funds have unprecedented access to growth through equity investments. This rapid growth in investors' interest has increased the demand and supply of foreign currencies. The equity flows and the greater demand for foreign currencies have generated interdependence between exchange rate and stock market prices. These phenomena lead to developing information transmission between the

financial markets. The growing linkages between the foreign exchange market and the stock market have increased volatility spillovers the stock market and foreign exchange market. It is in urgent need of time to explore the linkages and estimate spillover magnitudes. On a theoretical basis, these linkages between foreign exchange rates and stock market prices could be commonly derived from two well-known models; stock-oriented model and flow-oriented model. The stock-oriented model presented by (Frankel, [1983](#); Branson & Henderson, [1985](#)) explains that the determination of exchange rate depends upon the financial assets; bonds and equity. It is further categorized into the monetary model and portfolio model.

The monetary model assumes weak association of foreign exchange rate and stock market prices. This model considers the exchange rate as an asset's price and the assets prices are determined through future expected prices. In the same way the future foreign exchange rate prices are determined exchange rates. If factor effects the future expected prices of exchange rate will impacts the current value of foreign exchange rate. It is quite possible that the data generating process of exchange rate and stock prices are different or may not be. If they are same at some extent then both markets are interlinked otherwise not (Kanas, [2000](#); Yang & Doong, [2004](#); O'Donnell & Morales, [2009](#)). The portfolio model suggests negative association between foreign exchange rate and stock prices and it refers the causality direction from stock prices to foreign exchange rate. This model also explains that the investors grip domestic and foreign assets comprising foreign and domestic currencies. When the stock prices which is domestic assets increases, the investor wants to buy additional domestic assets, which induce investors to sell foreign assets in order to keep domestic currency to buy extra domestic assets. This increases the wealth of investors because of increase in stock prices, this motivates investors to grow their domestic assets which further leads to rise in interest rate, and further appreciation of domestic currency value (Kanas, [2000](#), Adjasi et al., [2008](#)).

The flow-oriented model presented by Dornbusch and Fischer ([1980](#)) suggests that the exchange rate and stock prices are positively associated. The exchange rate depends upon trade balance or current account balance of a country. Their model also suggests that international competitiveness and trade balances could be affected by

changing in exchange rate and therefore it effects the input and real income of a country. It can be elaborated as; the depreciation of domestic currency makes domestic firms more competitive by getting inexpensive exports in the international trade. The higher exports increase the wealth of domestic firms by appreciating the national stock prices of local firms. The direction of causality is from exchange rate to stock prices. Many financial and institutional reforms have been emerged throughout last three decades in the economy of Pakistan. The purpose behind of these rational reforms were to increase the depth and efficiency of financial markets and to lessen local financial imbalances. The alteration to free flexible exchange rate and openness of stock markets makes them interlinked. The stock market openness came up with increase in portfolio investment inflows (Qayyum & Khan, [2014](#)).

While the increment in investment supports in uprising investable found, which leads to huge volatility in stock indices. We can see the example from historical stock market and exchange rate data in 1995 the KSE 100 points were 2600 but decayed abruptly to 879 in 1998. The reason is that most of the investors has outflowed their assets amid to recent financial crisis. Consequently, low level in early 2005 was observed and the KSE 100 index traversed 10 thousand marks. However, just after few months in May 2005, it further declined again to approximately 7 thousand marks (Qayyum & Kamal, 2007). Later, in 2008 KSE 100 shown incredible performance by taking a flight of 15676.3 point. The effect could not sustain for long and declined to 10677.5 points, particularly owing to the global financial crisis. The issue remains that the inherent mechanism of world of global equity investing can be pretty bewildering which brings multi-fold impacts. Example being the later global financial crisis of 2008, which has gravely impacted the economy and stock markets of Pakistan (Ghouse & Khan, [2017](#)). The situation got further worsen off in 2009, when the KSE 100 stood at 4,929.54 with total capitalization of market was Rs. 1.58 trillion (Din et al., 2010). Same situation emerged since end of last year, the stock market indices points are still facing uncertain swings.

Conversely, similar events prevailed in exchange market and huge volatility in 1998 was observed. In 1998 the Pakistani rupee exchange rate against US dollar was Rs. 43.19 but it was gone to Rs. 61.4 in 2001-02. It got appreciated and the exchange rate went to Rs. 57.5 per

US dollar in Aug 2004. After that it again got volatile between Rs. 61.41 per US dollar to Rs. 57.5 per US dollar from 2004 to 2007. Subsequently in 2007, the exchange rate depreciated to Rs. 85.5 per US dollar. Same situation emerged again when the exchange rate depreciated and it went to Rs. 138.50 on 27 Dec, 2018. This clearly indicates that both markets are interlinked and may have repercussions on each other. Studies have explored the empirical and theoretical settings in exploring the volatility spillover effect between stock market prices and exchange rate, in case of Pakistan see for example (Qayyum & Kamal, 2007; Qayyum & Khan [2014](#); Din et al., 2010; Ghouse & Khan, [2017](#); Jebran & Iqbal, [2016](#); Bhat & Shah [2015](#); Dar et al., [2013](#); Aslam, [2104](#); Ali, [2015](#)). On the other hand, many researchers explored causal linkages between these variables in case of Pakistan see for example (Zubair, [2013](#); Khan & Ali, [2015](#); Zia & Rahman, [2011](#)).

The linkages of KSE 100 index and exchange rate prices have been extensively as indicated by above mentioned literature. However, much has been explored in only these domains, and hardly any significant study, which explores the mean and volatility spillover effect between Pakistan stock exchange new index (PSX) and exchange rate. This index is newly developed and it yet remains unexplored in the domains of research. The newly developed is representative of indexes at main stations in Pakistan i.e., Lahore, Karachi and Islamabad, which further adds to its versatility and efficiency as compared to other indices. Considering the above lag in literature, the present study aims at analyzing the linkages between PSX and exchange rate. These linkages will be representative also help us to make more effective policy regarding these associations. Not only that, but to further add in the reliability and efficiency of results, the study employs newly explored alternative technique of Ghouse & Khan ([2017](#)), which has the ability to explore the linkages among the highly volatile series, unlike the GARCH type modeling. They proposed that ARDL model can be used to test the relationship among the series which have ARCH effect (volatility clustering), as an alternative of GARCH type modeling. Moreover, they concluded that ARDL modeling is most general as compared to GARCH type modeling and it also provides us an opportunity to check the relationship among the financial series even if when only one of both series have ARCH effect. Considering the above two prominent gaps in literature, the significant contribution of

this study is to explore the mean and volatility spillover effect between PSX and exchange rate, which will hopefully be the first study to explore such linkages while incorporating above mentioned advanced techniques.

2. Literature Review

This section contains the reviews of previous studies which have been done related to the objective of this study. Aloui (2007) investigated the volatility and price spillover effect between stock prices and exchange rate for the pre and post euro period. The multivariate EGARCH model has been used to estimate the spillover effects. The results are indicating persistence volatility spillover effect and also refers the causal linkages between stock markets returns and exchange rates in pre and post euro periods. Kumar (2013) explored the volatility spillover effect between exchange rate volatility and volatility of stock markets in case of IBSA countries (India, Brazil, and South Africa). The VAR model and multivariate GARCH-BEKK model are used to trace out the mean and volatility spillover effect between the series. Majumder and Nag (2015) studied the spillover effect between stock prices and exchange rate in case of India. The bivariate EGARCH model has been used to estimate the spillover effects. The results are demonstrating volatility spillover effect and also refers the causal linkages between stock markets returns and exchange rates in pre and post financial crisis periods.

Sui and Sun (2016) examined the spillover effect amongst stock market prices, interest differentials and exchange rate in case of BRICS by considering recent global financial crisis. The results are indicating that there is volatility spillover effect from US stock markets to China, Brazil, and South Africa stock markets. Yu and Liao (2017) studied the volatility spillover effect between money market and currency market and volatility of stock markets in case China. The VAR model and asymmetric GARCH-BEKK model are used to trace out bidirectional spillover effect between the financial series. Mitra (2017) explored the volatility spillover effect between exchange rate of four currencies in India (USD-INR, GBPINR, JPY-INR, and EURO-INR) and stock markets in case of India. The GARCH model and cointegration procedure are used and they found bidirectional spillover effect between the four exchange rates and stock market prices and found that

these markets are cointegrated. Yen-Hsien et al. (2017) investigated the effect of hot money on exchange rate and stock markets in case of China. The VECM-BEKK model is used to trace out the spillover effect between these series. They found bidirectional spillover effect between the exchange rates and stock market prices and also found that the hot money has significant impact on stock market prices.

In case of Pakistan some empirical studies have been done to explore the correlation among exchange rate and stock prices. Farooq et al. (2004) explored the relationship between Pakistan stock market and exchange foreign exchange rate market. By using Johanson cointegration and Granger causality test they concluded that there is causal relation between stock market index and exchange rate. Bhat and Shah (2015) examined the relationship between Karachi stock market 100 index and exchange rate and employed GARCH models, Johanson cointegration, and Granger causality test. They explored that both financial series are cointegrated and Granger causality test shows that there is two-way causality between the financial variables. Ali (2015) examined the relationship among exchange rates NEER, REER, and PKR vs \$US and stock market KSE 100 index. They concluded that there is information transmission between the markets. Zubair (2013) inspected the causal relationship between volatility of exchange rate, stock market, and M2. He used stock market index and exchange rate data from the period of 2001 to 2011 and found bidirectional causality between the financial variables. There is volatility spillover effect and causal linkages between stock prices and exchange rate in case of Pakistan (Qayyum & Khan, 2014; Aslam, 2014). The bidirectional causal linkages and cointegration had been found between exchange rate and KSE 100 index by (Khan & Ali, 2015; Masood & Sarwar, 2015). Jebran and Iqbal (2016) explored the volatility spillover effect between money market and currency market and volatility of stock markets in case selected ASIAN countries India, Pakistan, China, Sri Lanka, Japan and Hong Kong. They found bidirectional mean and volatility spillover effect between the financial series. Khalid (2017) anticipated the effect of macroeconomic variables interest rate, exchange rate on stock market KSE 100 index. He used KSE 100 index and macroeconomic variables data from the period of 1990 to 2017, used Granger causality test, Error Correction Mechanism (ECM) model and Johanson cointegration procedure. The Granger causality

test shows that there is causality between the interest rate, exchange rate and stock prices and these financial series are also cointegrated. He found that there is short run relationship between the variables.

There are some studies which concluded that there is no relationship between exchange rate and stock prices in case of Pakistan. Zia and Rehman (2011) examined the relationship among exchange rates and stock market KSE 100 index. They found that both financial series are not cointegrated and Granger causality test shows that there is no causality between the financial variables. Dar et al. (2013) traced out the relationship between stock market returns and exchange rate. They used Wavelet analysis and quantile regression model and explored the similar results from both methodologies that there is no long run relationship between financial series and their asymmetric effect because the coefficients are changing with each quantile. Saleem and Alifiah (2017) studied the causal relationship amongst macroeconomic variables interest rate, exchange rate and stock market KSE 100 index. They used KSE 100 index and macroeconomic variables data from the period of 1990 to 2015, employed Granger causality test. The Granger causality test shows that there is only causality between the interest rate and stock prices but not causal link with other variables.

In this section we reviewed the previous studies which had been done to find out the information transmission between the exchange rate market and stock market. Most of the studies concluded that there is significant spillover effect between the markets. Particularly, in case of Pakistan. All the studies which are done previous in case of Pakistan on KSE 100 index. There is no study which explored the relationship between newly developed index of Pakistan stock market PSX and exchange rate which is the combination of all indices. So, this is the gap in literature can be fulfilled through this study.

3. Methodology

The financial econometric models examine the historic nature of financial time series, volatility forecasting, volatility clustering, leverage effect and persistence of shock. Theoretical financial econometric models are also being used for estimation of mean and volatility spillover effect between financial time series. The spillover effect explores either the return or volatility of one financial series, which may affect the return and volatility of other financial time series.

Generally, these linkages are developed due to information transmission between the financial markets. The purpose of this study is to model the variant volatility of exchange rate and spillover effect between financial markets. Considering above, the financial time series are commonly trendy and nonstationary in nature as predicted by Ghose and Khan (2017). The study at first, visualize the data through graphical analysis and then employs the unit testing to test the stationary of series, which would enable us to use GARCH type model for the volatility of series. Furthermore, GARCH type model also explores the spillover effect between financial markets. After employing GARCH type model, residual analysis is further used for the validation of model results.

The financial series are commonly having trend and it could not be possible to get valid results from trendy series. Considering above, log difference of series. is taken to de-trend the series and reduce the dispersion of series.

$$R_t = \log\left(\frac{p_t}{p_{t-1}}\right) \quad (3.1)$$

p_t = Series at level i.e. exchange rates and stock indices at time t. p_{t-1} = First lag of raw series.

3.1 GARCH Model

The GARCH model is an extension of ARCH process. The ARCH model has long length problem of ARCH term. This problem creates the problem of loss of degree of freedom. To deal with this issue; Bollerslev (1986) introduced generalized autoregressive conditional hetroscedastic (GARCH) model. Ghose and Khan (2017) employed GARCH model to model the volatility of stock market prices. Sajid et al. (2014) used GARCH model to inflation and uncertainty in inflation. Jebeen and Khan (2016) used GARCH model to measure the volatility of exchange rate due to macroeconomic fundamentals in Pakistan. The extension in GARCH model is that it includes the lag value of conditional variance as independent variable in conditional variance equation. The representation of GARCH (p, q) equations is following:

Conditional mean

$$R_t = \theta_0 + \theta_1 X_t + \varepsilon_t \quad (3.2)$$

Where $\varepsilon_t = z_t \sigma_t$, $z_t \sim N(0,1)$

Conditional variance

$$\sigma_t^2 = \gamma_0 + \sum_{i=1}^q \gamma_i \varepsilon_{t-i}^2 + \sum_{i=1}^p \delta_j \sigma_{t-i}^2 + u_t \quad (3.3)$$

The restriction on the parameters of conditional variance equation is that they must be positive. The R_t shows return series and θ_1 indicates the parameters vector. The $\theta_1 X_t$ empirically illustrates ARMA (p, q) process. It could be ARMA (0, 0) in some specific cases. There is some restriction attached with ARCH model are that it deals only with symmetric effects and the parameters of conditional variance equation must be positive. The ε_t shows innovation process and ε_{t-1}^2 is considered as ARCH term. The σ_{t-i}^2 is the lag value of conditional variance which is used as independent variable. For the exploration of spillover effect, we follow the procedure proposed by Ghose and Khan (2017). In which for mean spillover effect they include return of other series in mean equation and for volatility spillover effect they introduce square return of other series in conditional variance equation.

3.2 ARDL Model

The autoregressive distributed lag model (ARDL) model proposed by Davidson et al. (1978) to model the consumption function of economy of UK. It is a general model in nature in which the dependent variable determined by the present and lag value of independent variable and own lag value. The ARDL model is dynamic in nature and general which be modified into various forms by imposing linear and nonlinear restriction (Charemza & Deadman, 1997). It has lag values of dependent and independent variables so that is why it may control basic econometric problems like autocorrelation and misspecification. The simplest form of ARDL model is ARDL (1, 1). The equation of an ARDL (1, 1) model is following:

$$y_t = a + \gamma_1 x_t + \gamma_2 x_{t-1} + \theta_1 y_{t-1} + \varepsilon_t \quad (3.4)$$

Where y_t and x_t are variables and γ_1 , γ_2 , and θ_1 are parameters while the ε is known as error term. To explore the spillover effect, we

introduce the return series of one market into the equation of other market. The equation of ARDL model for spillover effect is following:

$$R_{EXR,t} = a + \gamma_1 R_{PSX,t} + \gamma_2 R_{PSX,t-1} + \theta_1 R_{EXR,t-1} + \varepsilon_{EXR,t} \quad (3.5)$$

Where $R_{EXR,t}$ the return series of exchange is rate and $R_{PSX,t}$ is the return of PSX series.

The validation of the results the post estimation analysis is also used. The Jarque-Bera test is used to check the normality of residuals. Q-stat employed to check the autocorrelation in residuals. Q-stat square test used to test the heteroscedasticity in residuals. The LM ARCH model is used to test the ARCH effect in residuals.

3.3 Description of Data and Sources

The daily data are used for all indices from the period of Nov, 2016 to Dec, 2018. The data set contains the data on exchange rate of PKR against \$US, and PSX. The data is collected from State Bank of Pakistan, and Pakistan Stock Exchange sites. The spillover effect is a transmission of information from one market to other market.

4. Results and Discussion

This section contains the empirical analysis of study. At first, we visualized the data to understand the trend and nature of series. At second we employed descriptive statistics to comprehend the initial statistics of series. At third we employed the regression analysis to trace out the spillover effect between Pakistan stock exchange and exchange market. To find out spillover effect between financial series we used GARCH model and ARDL model. The data visualization is commonly used to visualize the basic characteristics of the series. In this analysis we employed data visualization on PSXI series only for convenience and it can be employed on other series also.

In figure 1 both series are showing trendy behavior with some fluctuations. The first series which is of PSX is showing downward trend due to bearish market behavior from several month. It is due to some political instability in country and exchange rate fluctuations. While the second series which is of exchange rate showing upward trend due to devaluation in Pakistan currency.

After that we are just showing the visualization of PSX series for the sake of convenience it can be made for exchange rate in same manner.

Figure 1: The Raw Series of PSX and Exchange Rate (EXR)

The figure 2 shows the returns series of PSX index which is clearly indicating that there is bunch of fluctuations. It means there is volatility clustering which leads to ARCH effect. The dash line circles are indicating high volatility clustering and plane line circle is indicating about low volatility clustering.

In figure 3 the red bars show the autocorrelation function (ACF) and blue bars show the partial autocorrelation function (PACF) of PSX. The ACF indicates about the moving average (MA) which indicates about the relationship between current and previous variations (error). The PACF explains about the autoregressive (AR) behavior which shows the relationship between current and previous value. The 1st and 3rd lag bars are outside the bend which means that probably these lag values are significant.

Figure 2: The Returns Series of PSX

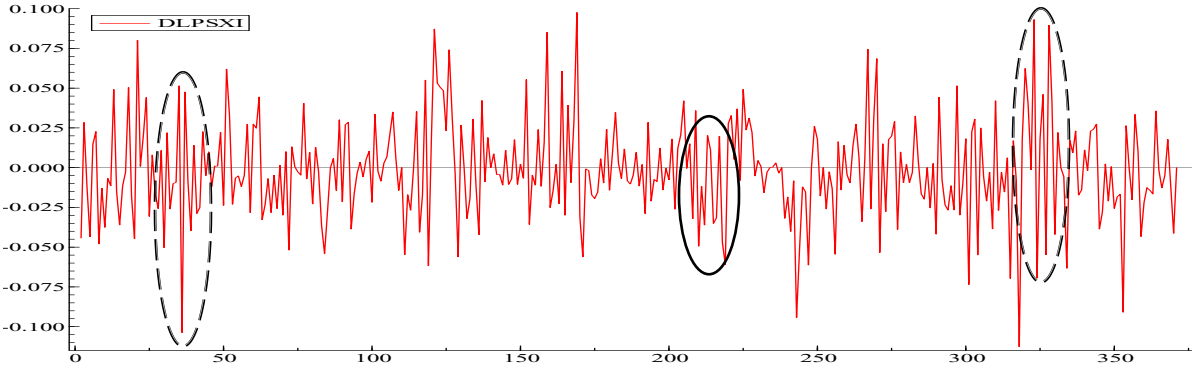
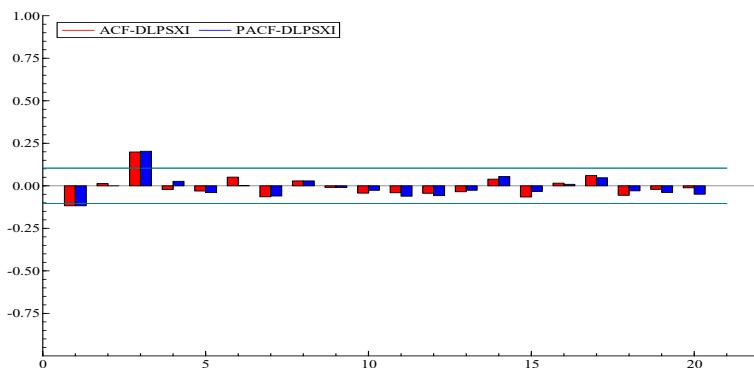
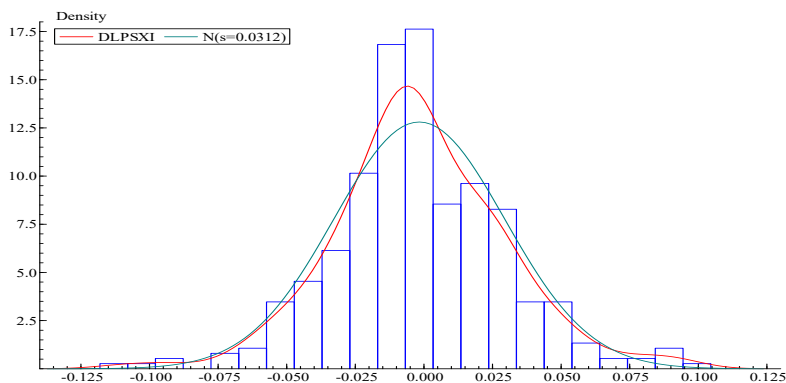


Figure 3: The ACF and PACF of Return Series of PSX



The figure 4 show the distribution of return series of PSX which can be seen in red line while the green is about the reference normal distribution. The red line is having higher peak and lengthy tails as compare to normal distribution. It all because of market players and extreme values which indicates that the distribution of PSX is not normal.

Figure 4: The distribution of Return Series of PSX



The Summary of Statistics

The summary of statistics provides the basic statistics of series which helps a lot to understand the nature of series. The table 1 explains the initial statistics of PSX and EXR. The mean of both series is around zero which shows that there is mean reversion behavior of series.

Table 1: Summary of Statistics of PSXI and EXR

Series	Mean	Standard deviation	Skewness	Jarque Bera	Excess Kurtosis	Q-stat (5)	Q2-stat (5)	ARCH 1-2	KPSS
PSX	-0.0071	0.0311	0.0836 (0.5099)	16.865 (0.0021)	1.0325 (0.0000)	20.5913 (0.0009)	27.1305 (0.0000)	4.8491 (0.0003)	0.1474
EXR	0.0008	0.0068	2.0749 (0.0000)	19311 (0.0000)	35.148 (0.0000)	4.33321 (0.5025)	1.35624 (0.9290)	0.26663 (0.9312)	0.1580

Null Hypotheses (All Null Hypotheses are for nth order)

“KPSS H0: Return series is level stationary, Asymptotic significant values 1% (0.739), 5% (0.463), 10% (0.347). Q-stat (return series) there is no serial autocorrelation. Q2-stat (square return series) H0: there is no serial autocorrelation. Jarque-Bera H0: distribution of series is normal. LM-ARCH H0: there is no ARCH effect. Use these Asymptotic Significance values of t-stat 1% (0.01), 5% (0.05), 10% (0.1) and compare these critical values with P-values (Probability values). P-values are in the parenthesis.”

The skewness test is indication that the PSX series has no skewness while the EXR distribution is positively skewed. The Kurtosis shows that peak of each distribution is leptokurtic, which mean that peak of distribution is higher than the normal distribution peak. It shows both distributions are non-normal in nature. The Jarque-Bera test is used to test the normality of the distribution which clearly indicates that both distributions are non-normal. The Q test is used to test the autoregressive behavior in return series which shows that there is autoregressive behavior only in returns of PSXI. The Q square return used to test the autoregressive behavior in square series which check the heteroscedasticity. It indicates that there is heteroscedasticity on PSXI series. The ARCH test shows the ARCH effect in series the statistics shows that the only PSXI series has ARCH effect. The KPSS test is used to check stationary which shows that both return series are stationary.

Tracing Spillover Effect

In this section regression model are used to trace out the spillover effect between the financial series. The descriptive statistics show that the PSXI series has ARCH effect that is why we used GARCH model to trace out the spillover effect from EXR to PSXI and EXR return series has no ARCH effect that is why we used ARDL model to find out the spillover effect from PSXI to EXR. The table 2 explains the results of GARCH model.

The table 2 shows the results of GARCH model which is used to trace out the spillover effect from EXR to PSXI. This model traces out the mean and volatility spillover effect, the first equation of model is conditional mean equation which is used to find out means spillover effect and second equation is conditional variance equation which is used to check the volatility spillover effect. In mean equation we introduced the return series of EXR as independent variable if it is significant it indicates there is mean spillover effect from EXR to PSXI. The π_1 is the coefficient of EXR return series which is significant at 7% nominal level of significance.

Table 2: Results of Spillover Effect from EXR to PSXI

	Parameters	Coefficient	Std.Error	t-value	t-prob		
Conditional Mean Equation	Constant θ_0	-0.0024	0.0016	-1.706	0.0891*		
	DLEXR (M) π_1	-0.6121	0.3663	-1.872	0.0653*		
	AR(1) ϑ_1	-0.1515	0.0561	-2.701	0.0072***		
	MA(1) ϕ_1	-----	-----	-----	-----		
Conditional Variance Equation	Constant γ_0	1.760	0.603	2.921	0.004***		
	DLEXRSQ (V) π_2	0.767	0.4437	1.9800	0.0441**		
	ARCH(1) γ_1	0.136	0.053	2.571	0.011**		
	GARCH(1) δ_1	0.691	0.068	10.100	0.000***		
	Student (DF)	5.298	1.524	3.476	0.001***		
	Persistence of shock	0.8455					
<p>“Null Hypotheses(All Null Hypotheses are for nth order) AR (p) H0: $\vartheta_i=0$ No AR Process, MA (q) H0: $\phi_i=0$ No MA Process, ARCH H0: $\theta_i=0$ No ARCH effect, GARCH H0: $\varphi_i=0$ No GARCH effect. The *, ** and *** are showing the significance at 10%, 5% and 1% respectively”.</p>							
Residual Analysis							
Tests	Jarque Bera	Q-Stat (5)	Q-Stat (10)	Q²-Stat (5)	Q²-Stat (10)	LM –ARCH (1-2)	LM-ARCH (1-5)
Values	6.0271 (0.0000)	0.1019 (0.9978)	0.0124 (0.8090)	0.7020 (0.9690)	0.0139 (1.0000)	0.0054 (0.9967)	0.0043 (0.9000)
<p>“Null Hypotheses (All Null Hypotheses are for nth order) Q-stat (return series) there is no serial autocorrelation. Q²-stat (square return series) H0: there is no serial autocorrelation. Jarque-Bera H0: distribution of series is normal. LM-ARCH H0: there is no ARCH effect. P-values are in the parenthesis”.</p>							

It indicates that there is weak mean spillover effect from EXR to PSXI. The sign of the coefficient is negative which indicates that there is negative relationship between the series. It can be validated from figure 1 where EXR series going downward and PSXI is going upward. The AR term shows the autoregressive term which is also significant 5% level of significance. The moving average term is equal to zero.

The conditional variance equation is the second equation in the model which trace out the path of volatility. To trace out the volatility spillover effect we introduced square of return series of EXR in PSXI series. The π_2 is the coefficient of square term which is significant at 5% level of significance. It shows that their volatility spillover effect from EXR to PSXI. The sign of coefficient is positive which indicates that there is positive relationship between volatility of EXR and volatility of PSXI. It indicates that if the volatility of EXR is increase the volatility of PSXI is also increaser and same in reverse. The employed GARCH model has GARCH (1, 1) specification that is there is only one term of ARCH and one term of GARCH. The ARCH term is significant at 5% level of significance which indicates there is ARCH effect in PSXI series. The sign of γ_1 coefficient of ARCH term is positive which meets the assumption of GARCH model. The GARCH term is significant at 5% level of significance which indicates there is GARCH effect in PSXI series. The sign of γ_2 coefficient of GARCH term is positive which meets the assumption of GARCH model. The distribution of PSXI series is non normal as we have seen in descriptive statistics and in graphic analysis that is why we used student t distribution. The student t distribution is commonly behaved well in presence of extreme values. The student t term is also significant which indicates that it can be used for this analysis. The persistence of shock is 0.8455 which is less than one it means the ARCH and GARCH effect decay after in short period of time.

The residual analysis is used to validate the results of regression model. The third panel of table 2 shows the results of residual analysis after GARCH model. The Jarque-Bera test statistics is still significant which means that the distribution of error is not normal which is no necessary to be normal. The Q stats are insignificant at 5th and 10th lags which means that there is no more autocorrelation in residuals. The Q square stat are also insignificant at 5th and 10th lags which shows that there is no more heteroscedasticity in residuals. The LM-ARCH test statistics

also insignificant which at 1st and 5th lags. It means there is no more ARCH effect in residuals.

We are using ARDL model instead of GARCH model because our dependent series is exchange rate series which has no ARCH effect. That is why we cannot use GARCH model. According to Ghose et al. (2018) the ARDL model has more power to detect relationship among the stationary series as compare to ordinary least square (OLS).

The table 3 shows the results of ARDL model which is being used for tracing spillover effect from PSXI to EXR. The ARDL model used because the dependent variable EXR has no ARCH effect. The results indicate that there is significant spillover effect from PSXI to EXR. The specification of ARDL model is ARDL (1, 1) which means one lag of dependent variable and current and first lag value of independent variable. The DLEXR_1 is the first lag value term of dependent variable which is insignificant at any level of significance. The constant term is significant at 5% level of significance. The DLPSX is the current term of PSX which is significant at 5% level of significance.

Table 3: Results of Spillover Effect from PSX to EXR

Variables	Coefficient	Std.Error	t-value	t-prob
DLEXR_1	-0.0489	0.0523	-0.9350	0.3502
Constant	0.0008	0.0004	2.1400	0.0328**
DLPSX	-0.0316	0.0114	-2.7700	0.0059***
DLPSX_1	-0.0040	0.0115	-2.3460	0.0295**
Diagnostic Statistics				
AR 1-2 test	0.2325 (0.7926)	ARCH 1-1 test	0.4742 (0.4915)	
Hetero test	4.2190 (0.1408)	RESET23 test	1.3737 (0.2545)	

The sign of the coefficient is negative which means that the current values of EXR and PSX are negatively associated. It is validating the results of conditional mean equation of GARCH model. It means that

the return of both series is negatively associated. The lag value of PSX DLPSX_1 is also significant at 5% level of significance. It means that the lag value of PSX is significantly affects the current value of EXR.

The second panel of table 3 indicating that there is no econometric problem left in residuals. The AR test statistics are insignificant which means that there is autocorrelation in residuals. The Hetero test results are indicating that there is no heteroscedasticity in residual. The ARCH test results are also indicating that there is no ARCH effect left in residuals. The tests are showing insignificant results.

5. Conclusion and Policy Implications

This study is done to trace out the spillover effect between exchange rate market and Pakistan's stock market from the daily data of November 2016 to December 2018. The GARCH model and ARDL model are employed to explore the spillover effect of between foreign exchange rate market and Pakistan stock market. The results suggest spillover effect between these two markets. The main findings of this study are indicting that the path of exchange rate series are Pakistan stock market index series, which is moving in opposite direction, however, it is associated at some extent. There is mean spillover effect from exchange rate series are Pakistan stock market series and the reverse are also observed. The volatilities of both markets are positively interlinked reflecting that the increase in the volatility of one market leads to increase volatility in other market. It concludes that there is significant interaction between exchange rate series and Pakistan stock market series. The volatility spillover effect is more dominants are comparing to mean spillover effect. The results indicate that the portfolio model which is further extension of stock-oriented model is applicable in case of Pakistan. The portfolio model suggests negative association between foreign exchange rate and stock prices and it refers the causality direction from stock prices to foreign exchange rate.

The results may provide a guide line in making policy regarding these markets. The results of this study may also play very important role for market players. These results may also be considered by the state bank of Pakistan when changing the policy regarding exchange rate as the study may provide an indication that the evaluation or devaluation in currency impacts the stock markets. These conclusions might provide a guide line to policymakers to stabilize the volatilities in both markets,

which can lead to effective policy to minimize the adverse effects spillover effects. The effective policy may stabilize the both markets; which has potential to increase the foreign direct investment and portfolio investment. In study work can be extended by including structural changing the distributions of both markets.

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