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Empirical Analyses of Volatility Spillover from G5 Stock Markets to Karachi Stock Exchange

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Abstract

This study made a pioneering attempt to investigate volatility spillover from G5 countries stock markets to Karachi Stock Exchange (KSE) considering weekly data from 5th January, 2004 to 30th December, 2013. The G5 countries included in this study are France, Germany, Japan, UK and US. Johansen and Juselius cointegration test was applied to explore long run relationship between KSE and G5 equity markets. The volatility spillover has been analyzed by GARCH (generalized autoregressive conditional heteroskedasticity) model. We found long run relationship of KSE with equity markets of Germany and United Kingdom. The GARCH (1, 1) model reveals significant volatility spillover effect from all G5 equity markets to KSE. Based on empirical results, we suggest that there are low diversification opportunities for investors in Pakistan.

Keywords: KSE, volatility spillover, G5 stock markets, GARCH.

1. Introduction

Globalization and liberalization has opened different opportunities for investors. Liberalization provided investors access to different international equity markets through which investors can earn risk adjusted returns. Besides the positive aspect, liberalization has led to increase the economic integration of international financial markets. The integration of international capital markets has decreased the opportunities of portfolio diversification (Taşdemir & Yalama, 2014). The transmission of shocks from one financial market to other market reflects the phenomena of volatility spillover. The information about volatility spillover between different equity markets play important role in portfolio diversification. The investors can benefit from portfolio diversification only if their allocated assets have no or weak financial integration (in terms of volatility spillover). Investors will be able to have well managed portfolios, if they have knowledge about financial integration (Joshi, 2011).

The concept of portfolio diversification has been explained by Markowitz (1952) in his famous Portfolio theory. He was the pioneer researcher and best known for his work in portfolio theory. He worked on the selection of portfolios among different portfolios having different risk and return. He said that risk can be diversified by investing in non-

integrated assets. So if one of the assets performs inefficient, so its loss can be compensated by gain in other assets. So investors can diversify their risk by having well diversified portfolio, if they carefully select their portfolios among different assets. It is important for investor to have knowledge about the integration of equity markets because two integrated markets will not give the benefit of portfolio diversification (Jebran, 2014).

The volatility spillover is an important phenomena to study transmission mechanism of information between financial markets. If markets are financially integrated, so the shocks from one market will be transmitted to other market (Choo et al., 2011). Investor may minimize their risk by adding those assets that are not financially integrated. This will provide them benefits, if some of the assets earn abnormal returns in certain period. Furthermore, it is argued that shocks flow in integrated markets is greater than in nonintegrated markets, so in this aspect, investing in nonintegrated markets may allow investors to prevent themselves in crises situation. In support Li & Giles (2015) concluded that volatility spillover between financial markets is larger in crises situation.

This study aimed to explore the volatility spillover across G5 equity markets to Karachi Stock Exchange. The literature provides studies that have only examined long run relationship of Karachi Stock Exchange and global developed countries. The G5 represents the global big 5 equity markets by capitalization in the world which includes France, Germany, Japan, Pakistan, United Kingdom and United States of America. Our study distinguishes from the existing literature from four aspects. First, this study to the best of our knowledge is the first attempt to explore volatility transmission mechanism across G5 stock markets to Karachi Stock Exchange. The G5 markets have been extensively studied in finance literature. But the literature doesn't provide a single study that examined the volatility spillover phenomena between KSE and G5 equity markets. Second, it will add to the literature of volatility spillover across developed market to an emerging market. Third, we applied individual market volatility spillover to KSE using bivariate model because in multivariate model the individual market effect is observed. Fourth, we also examined long run relationship between the selected markets. This study will provide knowledge to investors about integration between developed and an emerging market. This study will be important for developed equity market investors because they will be able to have insights of volatility spillover and can have effective portfolios by adding emerging market of Pakistan. Furthermore, investors from Pakistan will also benefit from portfolio diversification by investing in developed equity markets.

The remainder of the paper reviews relevant literature, data and methodology, empirical results, conclusions and recommendations.

2. Review of Literature

The finance literature is rich with empirical studies examining transmission mechanism of volatility spillovers across different equity markets. Most of the studies in this area examined developed equity markets. The purpose of these studies was to explore diversification opportunities for investors in developed equity markets. The researchers also argued that developed equity markets are likely to transmit more volatility shocks than developing and emerging markets. The US, Japan and UK stock markets have been extensively studied stock markets in this specific area. Hamao et al. (1990) empirically investigated US, Japan and UK stock markets for cross market volatility spillover effect.

By applying GARCH-M model, they found some evidence of spillover of volatility from UK and US markets to stock market of Japan. They also concluded that the volatility spillover effect is clear for Japan market. In other study, Karolyi (1995) analyzed return and volatility effect between US and Canada stock markets using M-GARCH and VAR model. They found volatility spillover from US to Canada equity market. They argued that the magnitude of shocks spillover was negligible. In similar study, Hoque and Chiou (2011) empirically found lead lag relationship between stock market of US, UK and Japan considering period 1997 to 2007. Savva et al., (2004) extended the literature for US and European equity markets including France, Germany, Italy, and UK. The analyses show evidence of integration of US stock market with European equity markets. In other study, AL-Zeaud & Alshgiel (2012) investigated US and European equity markets using EGARCH model. They concluded spillover effect of volatility from London to the Paris, Frankfurt and US equity market. Ng (2000) found significant volatility spillover from Japan and US to pacific-basin stock markets (i.e. Singapore, Taiwan, Malaysia and Thailand) from bivariate GARCH model. Sheu & Cheng (2011) examined US, Taiwan, China and Hong Kong stock markets for volatility spillover. Their results reveal no evidence of China stock market volatility spillover. However, US stock market show volatility spillover to Hong Kong and Taiwan equity market. Wang & Wang (2010) empirically found volatility spillover from stock market of US & Japan to China equity market. Wang et al., (2005) empirically found shock spillover from Japan and US to south Asian equity markets. Brailsford (1996) examined the equity markets of Australia and New Zealand. By employing GARCH model, they found some evidence of bidirectional spillover of volatility. Choo et al., (2011) found volatility spillover between different indices in the same country of Malaysia. They also concluded that the large caps volatility was more than small caps. Al-Rjoub & Azzam (2012) examined the effect of financial crises on Jordan equity market. They found significant results and concluded that all the financial sectors are effect by financial crises but banking sector absorbs more shocks than other sectors. Sakthivel et al., (2012) examined integration among US, Japan, UK, India and Australia equity markets. From GARCH model, they found volatility spillover between US and Indian equity market. They also found shock spillover from Japan and UK to Indian equity markets. Mukherjee & Mishra (2010) examined Indian equity market with 12 Asian stock markets. Their analyses reveal significant volatility spillover from most of the stock markets to Indian equity market. They also concluded that Indian equity market strongly influence the stock market of Srilanka and Pakistan. Joshi (2011) investigated six Asian stock markets (i.e. China, Korea, Jakarta, Hong Kong, India, and Japan). By applying GARCH BEKK model, they found some evidence of volatility spillover between equity markets of Asia. Recently, Li & Giles (2015) examined volatility spillover across US and Japan to emerging equity markets of Asia. They found volatility spillover from Japan and US equity market to emerging market of Asia. They concluded that the volatility spillover was stronger during Asian financial crises. Majdoub & Mansour (2014) empirically found new evidence of volatility spillover from US stock markets to 5 emerging Islamic equity markets indices (namely, Qatar, Pakistan, Turkey, Malaysia and Malaysia). Their analyses show weak integration in selected markets in terms of volatility spillover.

In sum, most of the empirical studies have examined developed equity markets. The extensive research on developed equity markets was because these markets remained the target markets for most of investors in order to earn more benefits. Furthermore, It has

been found that developed equity markets are high volatility transmitter. However, the increasing integration between developed markets led the researchers to examine emerging equity markets integration. The main aim of all the studies was to provide information about integration of emerging markets which will benefit investors in making international portfolio diversification decisions. In this aspect the emerging equity market of Pakistan serve an important testing ground.

2.1 Hypothesis

Based on the studies discussed in the above literature, we have developed the following hypothesis. The null and alternative hypothesis can be written as follow.

- **H_0:** There is no volatility spillover from G5 stock markets to Karachi Stock Exchange.
- **H_1:** There is volatility spillover from G5 stock markets to Karachi Stock Exchange.

3. Data and Methodology

3.1 Data and Sample

The data set of this study comprises of weekly closing stock market indices. The data set is of 10 years from January 5, 2004 to December 30 2013. We used weekly data se in order to avoid day of the week effect and also non-synchronous trading between KSE and G5 stock markets. The data set was collected from Yahoo Finance.com. The sample includes the following countries; France, Germany, Japan, Pakistan, United Kingdom and United States of America. Table 1, reviews the list of countries, their stocks markets and symbols used in this study.

Table 1: List of Countries, Stock Markets and Symbols

Country	Stock Markets	Symbols
France	Cotation Assistée en Continu	CAC
Germany	Deutscher Aktien Index	DAX
Japan	Tokyo Stock Exchange	NIKKEI
Pakistan	Karachi Stock Exchange	KSE
United Kingdom	Financial Times Stock Exchange	FTSE
United States of America	Standard and Poor's 500	S&P 500

3.2 Unit root test

Prior to the major analyses of the study, stationary tests have been carried out to examine the data. We examined data for stationarity by two widely used unit root tests; Augmented Dickey and Fuller (1979) (ADF) test and Phillips and Perron (1988) (PP) test. The Dickey & Fuller (ADF) test has been applied by the regression in equation 1.

$$\Delta Y_t = a_0 + \delta Y_{t-1} + \beta_i \sum_{i=1}^{m} \Delta Y_{t-1} + \mu_t \qquad (1)$$

In equation 1, Δ represents the change, a_0 , ϭ represents coefficients and Y is underlying variable. The *m* represents the lag length, which is selected, when the null hypothesis of no serial correlation is rejected. The (PP) test is considered as robust as compared to ADF test because of its applicability. The PP test is based regression shown in equation 2.

$$\Delta Yt = a_0 + \beta Y_{t-1} + \mu_t \qquad (2)$$

In equation 1, Δ represents the change, a_0 represents coefficients, β represents slope and y represents underlying variable.

3.3 Johansen and Juselius (1990) Cointegration Test

We also examined the long run integration between KSE and G5 equity markets. The analyses has been carried out by cointegration method proposed by Johansen and Juselius (1990). This method is divided into two tests; Maximum Eigen Value test and Trace test. Both of these tests are following maximum likelihood procedure for analyzing long run association among variables. The Trace test is following the regression model in equation (3), while Maximum Eigen value test is following regression model in equation (4).

$$\lambda trace = -T \sum ln\,(1 - \lambda i) \qquad (3)$$

$$\lambda max = -T\, ln\,(1 - \lambda r + 1) \qquad (4)$$

In equation (3) and (4), T represents number of observations, λ_{r+1}, λ_{r+2}+…….λ_n represents n-r smallest squared canonical correlations.

The Johansen and Juselius Cointegration test takes suitable lag order through which the test is estimated. The suitable lag value is selected on the basis of VAR Statistics by considering minimum value of Schwartz Criterion. So, we also applied VAR statistics to know about suitable lag order.

3.4 GARCH (Generalized Autoregressive Conditional Heteroskedasticity) Model

In this study, volatility spillover has been analyzed by opting Arch family frame work. The Arch family provides variety of tests that measures volatility effect among different variables. One of the basic assumptions of applicability of these tests is that the underlying variables must contain heteroskedasticity and autocorrelation. The autocorrelation represents the correlation of a series with its own lagged values. The heteroskedasticity exists in a variable, when the variance of error term of a series is not constant. We examined heteroskedasticity and autocorrelation issues in our data by employing autoregressive (AR) 1 model. We applied AR (1) model in each set of stock market indices and examined the problem of heteroskedasticity and autocorrelation using equation 5. In other words, ARCH effect has been tested in all variables. In AR (1) model, the significant value of Chi-square represents the ARCH effect in a variable. We found evidence supporting ARCH effect in all variables.

After checking ARCH effect in each series, we employed Generalized Autoregressive Conditional Heteroskedasticity (GARCH (1, 1)) model for exploring volatility spillover effect. We measured volatility spillover in two steps. In first step, we created volatility residual series for a single stock market using GARCH (1, 1) model. In this way, we created volatility series for all G5 stock markets individually. In second step, we then allowed each volatility series as a proxy of shocks emanating from G5 stock markets to KSE. We used positive volatility residuals because in GARCH (1, 1) model, volatility is considered to be positive. We applied Bivariate GARCH (1, 1) model to capture volatility

spillover from each G5 Stock Market to Karachi Stock Exchange. The equation (5) and (6) represents the Bivariate GARCH (1, 1) model to be estimated. The equation (5) is the mean equation, while equation (6) is volatility spillover equation.

$$Y_t = \alpha_0 + \gamma Y_{t-1} + \varepsilon_t \quad (5)$$

$$h_t(\text{KSE}) = \beta_0 + \beta_1 \varepsilon^2_{t-1} + \alpha_1 h_{t-1} + \delta_{\text{Resid (G5 stock indices)}} \quad (6)$$

In equation (5), Y_t represents the return of KSE at time t, α_0 represents the intercept, Y_{t-1} represents the previous day return and ε_t is disturbance term. In equation (6), h_t(KSE) represent the conditional variance of KSE, h_{t-1} represents previous period forecast variance, ε^2_{t-1} measures the volatility from previous period, as lag of squared residual of mean equation. In equation (6), the parameter δ represents volatility spillover coefficient of G5 stock markets. The Resid (G5 stock indices) represents volatility residual series of each G5 stock market which has been created from specific GARCH (1,1) model.

4. Empirical Results

Prior to major analyses, we conducted unit root analyses for examining order of stationary of variables. The unit root analysis has been carried out by PP test and ADF test. The unit root results have been reported in Table 2. The analyses reveal that all the stock market indices are non-stationary at levels while rejects the null hypothesis of stationary at 1st difference. The ADF test and also PP test reports same results. Hence, all the variables are stationary at same order, therefore, Johansen and Juselius Cointegration test is applicable for examining long run association.

Table 2: Unit root Tests

Variables	PP level	PP 1st diff	ADF level	ADF 1st diff
CAC	-1.778884	-25.77815	-1.654275	-25.77815
DAX	-1.317120	-24.93680	-1.394155	-24.99913
FTSE	-2.331562	-43.07324	-2.164710	-18.21873
KSE	-1.123372	-19.47067	-1.007666	-19.47067
NIKKEI	-1.333732	-22.93917	-1.266640	-14.29741
S & P	-1.033856	-23.98458	-1.056581	-24.00490

Critical values are -3.442698, -2.866879 and -2.569674 at 1%, 5% and 10% respectively.

The next step is to identify long run association between KSE and G5 equity market using Johansen and Juselius Cointegration test. First, we applied multivariate cointegration test to identify long run association of KSE with G5 equity markets. We then applied bivariate cointegration test to examine long run association of KSE with individual G5 equity market. For Johansen and Juselius Cointegration test, the suitable lag order was selected on the basis of VAR Statistics by minimum value of Schwartz Criterion. The VAR statistics showed minimum value of Lag 1 to estimate cointegration. Table (3) reports the results of Johansen and Juselius Multivariate Cointegration test. The Trace statistics and Maximum Eigen Value statistics have been represented in the same

Table. The analyses show evidence of one long run equation. The Trace and Maximum Eigen Value statistics provides similar result i.e. one long run equation. The analyses reveal one long run equation between KSE and G5 equity markets but we don't know which of the markets exhibits long run relationship. For this purpose, we applied Bivariate Cointegration test.

Table 3: Johansen and Juselius Multivariate Cointegration Test

Trace Test				**Maximum Eigen Value Test**			
No of CE(s)	Trace Statistics	Critical value	Prob.	No of CE(s)	Max-Eigen Statistics	Critical value	Prob.
None	157.5121	103.8473	0.0000	None	89.74796	40.95680	0.0000
At most 1	67.76417	76.97277	0.2046	At most 1	32.17869	34.80587	0.0997
At most 2	35.58549	54.07904	0.6947	At most 2	15.86522	28.58808	0.7530
At most 3	19.72027	35.19275	0.7441	At most 3	8.845617	22.29962	0.9128
At most 4	10.87465	20.26184	0.5542	At most 4	8.167160	15.89210	0.5279
At most 5	2.707490	9.164546	0.6367	At most 5	2.707490	9.164546	0.6367

MacKinnon-Haug-Michelis (1999) p-values

In next step, we applied Bivariate Cointegration test in order to identify long run relationship between KSE and individual G5 equity market. For Bivariate Cointegration test, we also identified suitable lag value from VAR statistics. The results of VAR statistics showed suitable lag value of 1 for estimating cointegration. The Bivariate Johansen and Juselius cointegration test results are represented in Table (4). The Trace and Maximum Eigen Value test have been reported in the same Table (4). The analyses show that there is long run integration between the KSE and FTSE stock market. There is also long run relationship between KSE and DAX stock exchanges. The analyses show evidence of no long run association of KSE with S&P 500, NIKKEI and CAC. The evidence of long run integration between markets imply that there are less diversification opportunities for investors.

Table 4: Bivariate Johansen and Juselius Cointegration Test

	Hypothesis	Trace test	Max-Eigen test	0.05 Critical Value
KSE- FTSE	None*	20.84143	19.80284	15.49
	At most 1	1.038590	1.038590	3.84
KSE-DAX	None*	24.83248	24.16649	15.49
	At most 1	0.665986	0.665986	3.84
KSE- CAC	None	3.921360	2.981004	15.49
	At most 1	0.940356	0.940356	3.84
KSE- NIKKEI	None	3.464917	2.768026	15.49
	At most 1	0.696891	0.696891	3.84
KSE- S&P 500	None	11.17309	10.98580	15.49
	At most 1	0.187290	0.187290	3.84

*MacKinnon-Haug-Michelis (1999) p-values

In next step, we examined volatility spillover from G5 equity market to KSE. First, we have estimated AR (1) model, to know about heteroskedasticity and autocorrelation issues in our underlying equity market indices. The GARCH (1, 1) can be applied on data in which ARCH effect exist. The significant value of Chi-square in AR(1) model represents ARCH effect in data. The results of AR(1) model have been reported in Table (5). The analyses imply that probability of Chi-square is significant for all stock market indices, which show evidence of ARCH effect in data set of KSE and G5 stock markets indices. In this aspect, the GARCH (1, 1) model is applicable to analyze volatility spillover. The analyses also show evidence that previous day returns effects today return for the following markets: KSE, CAC, FTSE and DAX equity markets. However, the two markets i.e. NIKKEI and S&P 500 have insignificant results and there is no effect of previous day return on today return.

Table 5: AR (1) model

	Constant	AR(1)	Arch Effect
KSE	0.002728	0.163760	38.64702
	(0.0603)	(0.0002)	(0.0000)
CAC	0.000344	-0.123201	11.87146
	(0.7969)	(0.0049)	(0.0078)
DAX	0.001754	-0.093422	8.605774
	(0.2003)	(0.0332)	0.0034
FTSE	0.000868	-0.111362	26.87835
	(0.4397)	(0.0110)	(0.0000)
NIKKEI	0.000728	-0.007799	7.710928
	(0.5965)	(0.8592)	(0.0055)
S&P 500	0.000962	-0.052944	41.85089
	(0.3852)	(0.2280)	(0.0000)

Probabilities are shown in parenthesis.

The results of volatility spillovers from G5 equity markets to KSE have been reported in Table (6). We applied Bivariate GARCH (1, 1) model to capture volatility spillover from each G5 Stock Market to Karachi Stock Exchange. In our first Bivariate GARCH (1, 1) model, we analyzed volatility spillover from CAC to KSE, which show evidence of significant volatility spillover from CAC to KSE. The results show that volatility spillover parameter δ is positive, which imply that CAC volatility is enhancing Karachi Stock Exchange volatility.

In our second Bivariate GARCH (1, 1) model, we analyzed spillover of volatility from DAX to KSE which reveal significant volatility spillover effect from the stock exchange of DAX to Karachi stock exchange. The results also reveal that volatility spillover coefficient is positive, which imply that DAX stock market volatility increases volatility of Karachi Stock Market.

In our third Bivariate GARCH (1, 1) model, we examined volatility spillover from FTSE to Karachi Stock Exchange which shows some evidence of volatility spillover. The result show positive coefficient of volatility which imply that FTSE volatility is increasing KSE volatility.

In our third Bivariate GARCH (1, 1) model, we investigated volatility spillover from stock market of NIKKEI to KSE which represents significant volatility spillover. The

positive volatility spillover coefficient of NIKKEI represents that NIKKEI stock market is enhancing Karachi Stock Market volatility.

In our last Bivariate GARCH (1, 1) model, we examined spillover of volatility from S&P 500 to KSE which reveal significant volatility spillover. The result reveal negative coefficient of volatility which imply that S&P 500 is decreasing Karachi stock market volatility.

In sum, we found evidence of volatility spillover from all G5 equity markets to Karachi Stock Exchange. The significant volatility spillover among the selected markets reveals less diversification opportunities for investors in Pakistan in G5 equity markets. There are also less opportunities of diversification for investors in G5 stock markets in emerging market of Pakistan.

Table 6: Volatility Spillover from G5 Stock Markets to Karachi Stock Exchange

Coefficients	**CAC→KSE**	**DAX →KSE**	**FTSE→KSE**	**Nikkei→KSE**	**S&P→KSE**
α_0	0.131554	0.163331	0.238567	0.123330	0.452106
	(0.3888)	(0.5069)	(0.1645)	(0.5643)	(0.0001)
Γ	0.198565	0.159744	0.166281	0.169359	0.143453
	(0.000)	(0.0092)	(0.0054)	(0.0010)	(0.0023)
β_0	5.540801	7.256289	6.972014	6.224776	0.348437
	(0.000)	(0.000)	(0.0001)	(0.0000)	(0.000)
β_1	0.201941	0.117468	0.116437	0.085526	0.090558
	(0.000)	(0.000)	(0.0266)	(0.0228)	(0.000)
α_1	0.285854	0.453864	0.447967	0.453179	0.872379
	(0.000)	(0.000)	(0.0015)	(0.0005)	(0.000)
Δ	0.295756	0.485959	0.491891	0.360448	-0.380577
	(0.000)	(0.000)	(0.0031)	(0.0000)	(0.000)

Probabilities are shown in parenthesis.
δ is the volatility spillover coefficient
→ represents volatility spillover from the respective stock market
For coefficients, go to equation 5, 6.
For abbreviation go to Table (1)

5. Conclusion and Recommendation

The study is pioneering attempt to examine the volatility spillover from G5 stock markets to Karachi Stock Exchange. We used weekly time series data set from 5th January, 2004 to 30th December 2013. The long run relationship between Karachi Stock Exchange and

G5 stock markets is analyzed by using Johansen and Juselius cointegration analyses. The G5 countries included in this study are France, Germany, Japan, UK and US. This study used GARCH (1, 1) model for examining volatility spillover from G5 stock markets to Karachi Stock Exchange. The cointegration analyses reveal that there exist long run relationship of Karachi Stock Exchange with stock market of Germany and UK. By examining volatility spillover from G5 equity markets to Karachi Stock Exchange, this study found that there is volatility spillover effect from all G5 countries to Karachi Stock Exchange. This reveals that fluctuations in G5 equity markets will affect Karachi Stock Exchange. The analyses also reveal that in G5 stock markets including France, Germany, United Kingdom and Japan stock markets is increasing the volatility of Karachi Stock Exchange while US stock market is decreasing the volatility of Karachi Stock Exchange. The integration of G5 and Karachi Stock Exchange reveal less diversification opportunities for investors.

Based on empirical results, it is suggested that investors of Karachi Stock Exchange have no favorable opportunity to diversify their risk by investing in G5 equity markets. Furthermore, investors from G5 equity markets cannot benefit by investing in emerging market of Karachi Stock Exchange. The volatility spillover between KSE and G5 equity markets serve as underlying basis of implication of the study.

This study was limited to examining economic integration of Karachi Stock Exchange with only G5 equity markets covering period of only 10 years. We can only set the future research direction of the study by suggesting to explore the financial integration of KSE with more developed equity markets and also regional equity markets.

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