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Volatility Spillovers from the Larger to Smaller Stock Market in the Context of Global Financial Crisis

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Abstract

The aim of this paper is to analyze the spillover effects of larger equity market (North American) on smaller equity market (South Asian) in the context of Global Financial Crisis. The mathematical economic techniques of Univariate (EGARCH) and Multivariate (VAR) models have been incorporated to analyze the wide-ranging spillover effects of both the markets. The empirical results immediately before and after the global financial crisis suggest that the asset returns of larger market are having significant impact on a smaller market, whereas the volatilities of larger market have no significant spillover impact on the volatility of a smaller market. The results during the era of global financial crisis are quite captivating and in contrast with the stylized facts of volatility transmissions. The results suggest that the asset returns of larger stock market are not having significant impact on a smaller market whereas the volatilities of larger market have significant but negative spillover impact on the volatilities of a smaller market. Keeping in view the significant results of econometric techniques during the last financial crisis, this study may serve as a benchmark to explore the pattern of spillover between large and small markets.

Keywords: Spillover, global financial crisis, EGARCH, VAR

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1. Introduction

The recent global financial crisis has originated from the US real estate and resulted into a stock market collision in September, 2008 and further it impacted on other financial systems across the globe. The crisis was triggered by the collapse of housing market and ensuing crash of subprime mortgages market in the United States, which was considered as the first major global financial crisis since the Great Depression of 1930s (Claessens, et al. 2010). There is ample evidence during the past few decades that stock markets have become more connected with each other in respect of cross border trade and capital flows (Forbes and Chinn, 2004).

Allen and Carletti (2010) argue that the recent financial crisis was a result of an excessive bubble in the real estate market, cheap credit availability, sub-prime mortgages and weak regulatory structure. The fall in prices of real estate led to a plunge in the prices of securitized sub-prime mortgages, which in turn affected the worldwide financial markets. The financial systems across the globe came under tremendous pressure when Lehman's demise forced markets to reassess the risk. By reassessing the risk, the investors withdrew their investments from the market and liquidity dried up. Similarly, Karunanayake et al. (2010) examine the mean return and volatility during the era of Asian and Global Financial Crises by using ARCH/GARCH Models. They find that the mean returns were not significantly affected by Asian and Global Financial crises but their volatilities are significantly affected by these crises.

An influential study by King and Wadhwani (1990) examines the difference between the correlation coefficients of the stock market returns of Japan, UK, and US for the periods before and after the stock market crash in 1987. The study finds that there had been a phenomenal increase in the coefficients of correlations after the stock market crash. Bekaert, Hodrick & Zhang (2005) examine the degree of regional and global integration using stock market returns in twenty two countries during the period starting from January 1980 and ending in December 1998. They find that the degree of integration of stock returns in these twenty two countries is not as great as was generally thought at the time. Hamao, et al. (1990) apply GARCH model in testing for returns and volatility spillovers among international stock markets. The findings of the study suggest that the New York Stock Exchange has dominant influence on other equity markets in the world. On the other hand, Booth, Martikainen & Tse (1997) apply the EGARCH framework to analyze the spillover effects between four Scandinavian stock exchanges. The study finds low inter-market correlations and spillover transmissions despite close economic integration among the countries.

There have been very few studies conducted to measure the mean return and volatility spillover effects on Pakistani Stock Market. Choudhry (2004) finds the empirical evidence on the international transmission of stock returns and volatility between friends and foes. Similarly, Qayyum and Kemal (2006), examine the volatility spillovers between the Pakistani markets of stock exchanges and foreign exchanges. Moreover, Kanasro et al. (2009), analyze the volatility of Karachi Stock Exchange 100 index through ARCH and GARCH models. However, in the context of the recent global financial crisis, no study has formally analyzed the spillover from the US stock market to Pakistani stock market.

The objective of present study is to measure the spillover effect of the larger (US) stock market on smaller (Pakistani) stock market, particularly during the era of global financial crisis by applying the techniques of mathematical economics. The study is aimed at examining the effect of the rate of returns and its volatility in US stock market on both the rate of returns and its volatility in the Pakistani stock market in the eras immediately before, during and immediately after the global financial crisis. This spillover effect from the US stock market to the Pakistani stock market would be examined by using the econometric techniques of Univariate (EGARCH) and Multivariate (VAR) Models. This study may be taken as benchmark to explore the pattern of spillover between large and small markets. Such an analysis may be beneficial for investors to make their investment relatively less risky in the wake of financial crises.

The rest of the paper is divided into five sections. In section 2, the literature review is presented and section 3 presents theoretical framework and methodology. Section 4 incorporates the data and preliminary statistics and section 5 presents and discusses the empirical results. Finally, the summary and conclusions of the study are drawn in section 6.

2. Literature Review

The literature review of this paper is divided into three parts. First part presents empirical methodologies used in the literature. Second part describes literature on spillover effects, while third part contains literature on financial crises.

2.1 Literature on Methodology

Financial markets data often pose a number of challenges to financial analysts who endeavor to find an appropriate model for a given time series. The analysis of spillover effects in financial markets can be performed on the basis of ARMA and ARCH classes of models, while ARMA models have been incorporated to trace the time paths of financial and economic variables, ARCH family of models has been developed specifically to analyze the dynamic structure of volatility of the variables under consideration as represented by variance.

Engel (1982) is extensively credited with the development of the Autoregressive Conditional Heteroskedasticity (ARCH) framework for modeling time dependent volatility in financial time series. ARCH was subsequently extended by Bollerslev (1986) with his generalized ARCH model, lately known as GARCH model, to account for long-run volatility and it was found to significantly improve the accuracy of volatility modelling.

Christie (1982) and Nelson (1991) had indicated the evidence of asymmetric responses, suggesting the leverage effect and differential financial risk depending on the direction of price change movements. In response to the weakness of symmetric assumption, Nelson (1991) brought out exponential GARCH (EGARCH) models with a conditional variance formulation that successfully captured asymmetric response in conditional variance. He attuned the GARCH framework for asymmetric effects augmenting it to the exponential GARCH (EGARCH) model. Since then, various kinds of ARCH-family models have been developed and most of them have become standard tools in modeling Heteroskedasticity in financial time series. Alexander (2009) pointed out that EGARCH models had been established to be superior as compared to other competing models of asymmetric conditional variance in many studies.

The above formulation is known as univariate time-series modelling. In contrast, a more elaborate approach would be to construct a multivariate model. In this context, VAR models and its various extensions provide a very rich analytical framework. Most of the recent developments in time series econometrics, especially co-integration analysis are the hallmark of the VAR modelling. Sims (1980) first introduced VAR models as an alternative to the large scale macro econometric models. Since then the methodology has gained widespread use in applied macroeconomic research. The idea behind the traditional macro econometric procedure was that variables could be classified as either endogenous or exogenous. The exogenous variables were determined outside the system and could therefore be treated independently of the other variables.

Vector Autoregression (VAR) Model is a multiple time series which is basically generalization of Autoregressive Model. The VAR model is a multi-equation system wherein all the variables are considered as endogenous. So, there is one equation for each dependent variable and each equation has lagged values of all the included variables as independent variables. Since there are no contemporaneous variables included as explanatory variables on the right-hand side of the equations, the model is in reduced form. Thus, except for the left hand side variables, all the equations have the same form since they share the same right-hand side variables. In accordance with this feature, Sims (1980) supports the application of VAR models as a theory free method to interpolate the economic relationships. Consequently, he proposes the use of impulse response function (IRF) and variance decomposition in the logical interpretation of the VAR system.

The Granger (1969) presented a causality test for testing statistical hypothesis for determining usefulness of one time series in forecasting another. In this study, the causality test of Granger is used to test the effects of the rate of returns in the US stock market to the rate of returns in the Pakistani stock market causes or vice versa Granger causality test is used by applying a VAR model on the system of equations and testing the statistical hypothesis for zero restrictions on the VAR coefficients.

2.2 Literature on Spillover Effect

Various empirical studies have tested the scope of co-movements in stock prices across different countries. These tests have been applied to study the financial market integration, stock market interdependence, the transmission of shocks and financial spillovers across national borders.

Ample evidence exists during the past few decades suggesting that stock markets have become more correlated with each other in respect of international trade and capital flows (Forbes and Chinn, 2004). It stipulates that the cross-border trade and capital flows have increased the likelihood for the transmission of shocks originated in an economically and financially important country to the international market. Hence, it could be anticipated that there would be significant effect of the spillover from the recent US financial crisis to the economies and financial markets of other countries. Regarding this particular crisis, there is some degree of empirical evidence supporting such an argument so far. Bekaert, Hodrick & Zhang (2005) examine the degree of regional and global integration using stock market returns in twenty two countries during the period starting from January 1980 and ending in December 1998. They find that the degree of integration of stock returns in these twenty two countries is not as great as was generally thought at the time.

An influential study by King and Wadhwani (1990) examines the difference between the correlation coefficients of the stock market returns of Japan, UK, and US for the periods before and after the stock market crash in 1987. The study finds that there had been a phenomenal increase in the coefficients of correlations after the crash. The study further argues that the stock returns in these markets fell together after the incidence of stock market crash because the private information set contains both idiosyncratic and systematic components.

Hamao, *et al*. (1990) apply GARCH model in testing for returns and volatility spillovers among international stock markets. They use daily stock market index data from the Tokyo, London, and New York stock exchanges between the years 1985 and 1988 and conclude that the New York stock exchange exhibits higher return and volatility spillover effects onto the other two markets compared to opposite spillovers. The finding suggests that the New York Stock Exchange has dominant influence on other equity markets in the world. On the other hand, Booth, Martikainen & Tse (1997) apply the EGARCH framework to analyze the spillover effects between four Scandinavian stock exchanges. The study finds low inter-market correlations and spillover transmissions despite close economic integration among the countries.

Neidhardt (2009) analyzes the stock market spillover effects between Namibia and South Africa. The study suggests that extensive returns spillovers are transmitted from South African stock market to Namibian stock market. Karolyi (1995) analyzes the short-run dynamics of return and volatility of stocks in the stock exchanges of Toronto and New York. The study finds that the persistence and magnitude of shocks originated in one market are transmitted into the other market. Further, it is found that the transmissions of said shocks or innovations are in weaker form for the dually listed stocks.

2.3 Literature on Financial Crises

The most recent financial crisis in the US stock market provides a good prospect to re-assess the scope to which any interdependencies among the returns of world stock markets might exist, especially prior to, during, and after the crises periods. Claessens, *et al* (2010) argues that the global financial crisis was triggered by the collapse of US housing market and ensuing crash of subprime mortgages market which was termed as the first major global crisis since 1930.

Allen and Carletti (2010) argue that the financial crisis was the result of excessive bubble in the real estate market, cheap credit availability, sub-prime mortgages and weak regulatory structure. They consider the possible reforms to reduce the impact of financial crises by suggesting strong regulatory structure, reducing global imbalances and changes in the regulations of banking sector. King (2001) examines the causes of Asian Financial Crises. The study finds that the financial crisis was triggered when Japanese banks reduced their exposure from Thailand and South Korea and further withdrew their investment from the real estate and stock markets. This sentiment was further signaled to other foreign commercial banks that also withdrew their money and consequently the crisis was further aggravated.

Furceri and Zdzienicka (2010) examine the impact of global financial crises on the European transition economies. The study suggests that the crises had significant and permanent adverse effects on lowering the output of European economies and this effect was larger in smaller countries. On the other hand, Karunanayake *et al*. (2010) examine the mean return and volatility during the era of Asian and Global Financial Crises by using ARCH/GARCH Models. They find that the mean returns are not significantly affected by Asian and Global financial crises but their volatilities are significantly affected by these crises.

This section is concluded on the observation that there is no formal empirical study that analyzes the possible spillover effects of recent global financial crisis on the Pakistan stock market. Furthermore, it is observed that the literature provides a variety of econometric tools that can be utilized to study the spillover of the financial crisis on the Pakistani stock market. In this respect, the ARCH and VAR type models can be used to analyze how the rate of return at Karachi Stock Exchange and its volatility could have been affected by the financial crisis.

3. Theoretical Framework & Methodology

Generally, spillover effect can be analyzed by using simple correlation technique on the price indices of two markets, which only provides a vague idea about true market integration. However, there are more sophisticated econometric models to estimate spillover effects of random 'news' or 'innovations' originating in one market on to the other markets. Such spillover effects can be modeled with regard to returns and volatility. There are two categories of econometric framework that can be used to analyze spillover, that is, univariate and multivariate models. This study employs both the frameworks to ensure robustness of the empirical results.

3.1 Univariate Framework

In this context, the mean return and volatility spillover can be quantified to measure the extent of the influence from one market to the other. The Threshold (Asymmetric) Exponential General Autoregressive Conditional Heteroskedasticity (EGARCH) specification is used to test the asymmetric effects of volatility spillovers which postulate that the effects of 'bad news' of stock market are greater than the effects of 'good news' (Nelson, 1991). The present study considers Threshold EGARCH model as the most appropriate technique. Donnell and Morales (2006) stipulates that these models serve as benchmark models, based on which spillover analyses can be conducted. The methodology measures the effects of 'news' or 'events' occurring in US stock market on the rate of returns of Pakistani stock market.

Since the objective of this study is to analyze the spillover effects of US stock market on Pakistani stock market in the context of Global Financial Crises, the study intends to explore the following four potential spillover effects.

(i) The effect of the volatility of rate of return in US on the rate of return in Pakistan; and

(ii) The effect of the volatility of rate of return in US on the volatility of rate of return in Pakistan.

3.1.1 The ARCH/EGARCH Model

Autoregressive Conditional Heteroscedasticity (ARCH) models are incorporated to illustrate the volatility in the time series data. These models are applied when the size of variation in the series as measured by its variance follow certain autoregressive process. In particular, ARCH models assume that the variance of the current innovations is a function of the past variances. Usually, the variance is proxied by squaring the previous error terms and these models are usually termed as ARCH models(Engle, 1982).

The standard GARCH(r,s) specification consist of two equations:

Mean Equation-

$$Y_t = \alpha_0 + \sum_{i=1}^{p} \alpha_i X_{t-i} + \sum_{i=0}^{q} \beta_i \varepsilon_{t-i} \qquad , \beta_0 = 1 \tag{1}$$

Variance Equation-

$$\sigma_t^2 = \gamma_0 + \sum_{i=1}^{r} \gamma_i \sigma_{t-i}^2 + \sum_{i=1}^{s} \delta_i e_{t-i}^2 \tag{2}$$

The mean equation given above is written as an ARMA model, but it may be extended to include exogenous variables as well. This will yield an extended ARMA structure, often referred as ARMA-X model. Since, the term σ_t^2 is the forecasted variance of one period ahead based on previous information that is why, it is called as the conditional variance. Its equation specified above is a function of following three terms.

(a) The parameter characterizing mean: γ_0 ;

(b) Volatility News from the past: e_{t-i}^2 (the ARCH term); and

(c) Last period's forecasted variance : σ_{t-i}^2 (the GARCH term)

The ARCH models are estimated by the Maximum likelihood method with the assumption that the errors are normally distributed conditionally. The log likelihood function of GARCH(1,1) model is

$$l_t = -\frac{1}{2}\log(2\pi) - \frac{1}{2}\log(\sigma_t^2) - \frac{(Y_t - \gamma_0 - \gamma_1 X_{1t} - \ldots - \gamma_k X_{kt})^2}{2\sigma_t^2} \qquad (3)$$

where $\sigma_t^2 = \omega + \alpha(Y_t - \gamma_0 - \gamma_1 X_{1t} - \ldots - \gamma_k X_{kt})^2 + \beta\, \sigma_{t-1}^2$

When negative shocks often increase volatility to a greater extent than positive shocks, then regular GARCH model usually imply a negative conditional volatility which will not be a suitable formulation. This issue of negativity is resolved by taking logarithm on both sides of the GARCH equation. The left hand side of the equation is in logarithm form which is called exponential function and it is positive at all times. The issue of negative conditional volatility is solved by this exponential functional which yields EGARCH model. EGARCH is an empirical approach mostly used in financial modeling. It is mostly used for modeling leverage effect in financial time series. Whenever other variables, which can take on negative values, are included in the specification of the conditional variance, it is useful to use EGARCH model instead of the regular GARCH model.

While the mean equation in EGARCH specification remains the same as given above (Equation 4), the variance equation is modified as:

$$\log \sigma_t^2 = \gamma_0 + \sum_{i=1}^{r} \gamma_i \log \sigma_{t-i}^2 + \theta_1 \sum_{i=2}^{s} \delta_i \left| \frac{\varepsilon_{t-1}}{\sigma_{t-1}} \right| + \delta_1 \left| \frac{\varepsilon_{t-1}}{\sigma_{t-1}} \right| + \lambda_1 \frac{\varepsilon_{t-1}}{\sigma_{t-1}} \qquad (4)$$

The leverage effects presence can be verified by testing the statistical hypothesis that $\lambda_1 = 0$ against the alternate hypothesis that $\lambda_1 < 0$. The impact is asymmetric if the null hypothesis is rejected. Also note that the proposed specification allows asymmetric at lag one only, though it is possible to explore asymmetry at higher lags as well. In order to estimate the spillover effects of US stock market on Pakistani stock market in the context of Global Financial Crises, the above EGARCH model is extended to include mean and volatility of the rate of return in the US stock market as additional explanatory variables in the mean and variance equation.

For this purpose, an EGARCH model is first estimated for the US rate of return. The specification for this model is the same as given above, that is equation 1 and 2. Once this model is estimated, a series of estimated conditional variance for US rate of return is derived. Using the realized rate of return and the estimated conditional variance of the rate of return for the US stock market, we can now extend the EGARCH model for Pakistan. The proposed (final) specification of the model for Pakistan is given by:

Mean Equation :

$$R_{kse,t} = \alpha_0 + \sum_{i=1}^{p} \alpha_i R_{(kse,t-i)} + \sum_{i=0}^{q} \beta_i \varepsilon_{t-i} + \pi . R_{[NYSE,t]} + \phi . \sigma_{[NYSE,t]}, \beta_0 = 1 \quad (5)$$

Variance Equation :

$$\log \sigma_t^2 = \gamma_0 + \sum_{i=1}^{r} \gamma_i \log \sigma_{t-i}^2 + \theta_1 \sum_{i=2}^{s} \delta_i \left| \frac{\varepsilon_{t-1}}{\sigma_{t-1}} \right| + \delta_1 \left| \frac{\varepsilon_{t-1}}{\sigma_{t-1}} \right| + \lambda_1 \frac{\varepsilon_{t-1}}{\sigma_{t-1}} + \pi . R_{[NYSE,t]}^2 + \rho . \sigma_{[NYSE,t]}^2 \quad (6)$$

This completes mathematical structure of ARCH model. To address the four spillover channels, the following null hypotheses are setup.

$H_0^1 : \delta = 0$ *[There is no spillover from the US volatility to the Pakistani* *volatility]*

$H_0^2 : \phi = 0$ *[There is no spillover from the US volatility to the Pakistani rate of returns]*

$H_0^3 : \omega = 0$ *[There is no spillover from the US rate of return to the Pakistani volatility]*

3.2 Multivariate Framework

In the multivariate context, a two variable Vector Autoregression (VAR) model is considered in which the rates of return of two markets under consideration are regressed on past rate of return of both the markets. This framework allows for four types of serial correlations that can be used to address the question of spillover. These serial correlations are as follows.

(i) Correlation of current rate of return in US with past rate of return in US itself (Autocorrelation within US stock market).

(ii) Correlation of current rate of return in Pakistan with past rate of return in US (Cross serial correlation representing the potential spillover from the US to the Pakistani stock market).

(iii) Correlation of current rate of return in US with past rate of return in Pakistan (Cross serial correlation representing the potential spillover from Pakistani stock market to the US stock market).

3.2.1 The Vector Auto Regression (VAR) Model

Vector Auto Regression (VAR) Model is a multiple time series which is the generalization of Autoregressive (AR) Model. The VAR model is a multi-equation system wherein all the variables are treated as endogenous. So, there is one equation for each dependent variable. Each equation has lagged values of all the included variables as independent variables. Since there are no contemporaneous variables included as explanatory variables on right hand side of the equations, the model is in reduced form. Thus, except for the left hand side variables, all the equations have the same form since they share the same right hand side variables.

In this study, we have two variables: returns at KSE, $R_{(KSE)}$, and the returns at NYSE, $R_{(NYSE)}$; hence the VAR model would be:

$$R_{(KSE,t)} = \alpha_0 + \sum_{i=1}^{p} \alpha_i R_{(KSE,t-i)} + \sum_{i=1}^{p} \beta_i R_{(NYSE,t-i)}. + e_{(KSE,t)} \qquad (7)$$

$$R_{(NYSE,t)} = \gamma_0 + \sum_{i=1}^{p} \gamma_i R_{(KSE,t-i)} + \sum_{i=1}^{p} \theta_i R_{(NYSE,t-i)}. + e_{(NYSE,t)} \qquad (8)$$

As mentioned above, these equations (equation 7 and 8) represent a reduced form VAR model. The corresponding structure model can be written as

$$R_{(KSE,t)} = a + a_0 R_{(NYSE,t)} + \sum_{i=1}^{p} a_i R_{(KSE,t-i)} + \sum_{i=1}^{p} b_i R_{(NYSE,t-i)}. + e_{(KSE,t)} \qquad (9)$$

$$R_{(NYSE,t)} = c + c_0 R_{(KSE,t)} + \sum_{i=1}^{p} c_i R_{(KSE,t-i)} + \sum_{i=1}^{p} d_i R_{(NYSE,t-i)}. + e_{(NYSE,t)} \qquad (10)$$

As is well known in the literature, the standard procedure is to estimate the reduced form model which is identified and the parameter of structural model and the structural shocks ($e_{(KSE,t)}$ and $e_{(NYSE,t)}$) can then be obtained by imposing identifying restrictions. The most common identifying restriction is Cholesky restriction by which the coefficient of one of the contemporary variables (a_0 or c_0) is set equal to zero. Once the above tasks are performed, it becomes straight forward to analyze spillover in three alternative ways which are explained as follows.

Granger Causality Tests: Theoretically, the Granger Causality test can be applied to determine the causality in both ways from the US to Pakistan and from Pakistan to US. But in practice, it makes sense to apply the test in one way, that is, from US to Pakistan. The test is based on following null hypothesis restricting certain parameters of reduced form VAR model.

H_0: $\beta_i = 0$ *for all* $i = 1,2,\ldots..,p$
H_1: β_i # 0 *for at least one i*

The rejection of null hypothesis would indicate the presence of spillover from US to Pakistani stock market.

Impulse Response Functions: It is a numerical method to predict the effects of random shocks on the variables included in a VAR model. An impulse response function predicts the effect of one standard deviation shock in one of the random shocks on current and future values of an endogenous variable. Shocks to the variables not only directly affects the variable itself but also transmitted to all endogenous variables through the dynamic lag structure of VAR model. This obviously means that Impulse Response Analysis is carried over using the structural rather than reduced form VAR model. In our specific context, Impulse Response Function of Pakistani stock returns with respect to innovations within Pakistan as well as innovations in the US are derived. These functions will indicate the time pattern by which innovations in Pakistan or the US market are transmitted to Pakistani stock market.

Variance Decomposition: Variance decomposition splits variations in an endogenous variable into the component shocks to the endogenous variables in the VAR framework. It calculates the percentage of forecast variance due to each shock and, hence, provides information about the relative significance of each random shocks in affecting the variables in a VAR model. In the context of present study, variance of forecasted variance of rate of return in Pakistan will be decomposed into two comparisons. First component representing the influence of shocks originating within Pakistan, while the second component represents the contribution of shocks originating from the US market.

4. Data & Preliminary Statistics

This section describes the data and preliminary statistics of the stock markets of the USA and Pakistan.

4.1 Data

The data on KSE 100 index and NYSE composite index are collected from the official sites of Karachi Stock Exchange and New York Stock Exchange respectively. The challenge of equating data from the two stock markets has been achieved by using database software like MS Access**.** A sample period containing 1310 daily observations from NYSE and KSE indices have been selected to represent the epoch before, during and after the financial crisis period. Econometric software EVIEWS 5.0 has been used to analyze the data. The graphic summary of the stock price movements of KSE and NYSE during the period under study is shown in figure1.

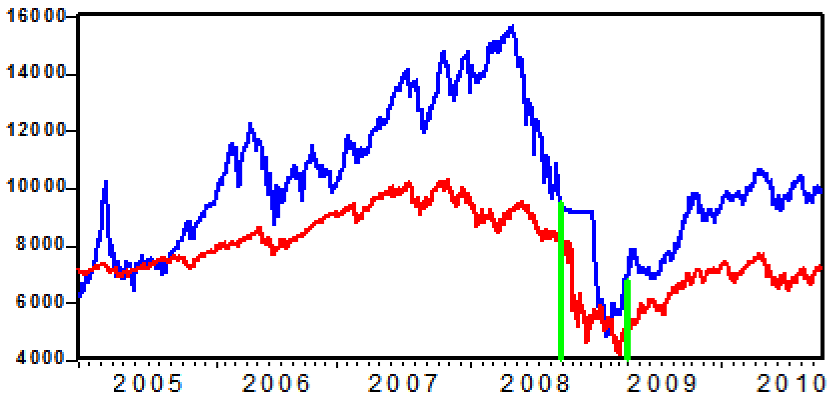

Fig. 1: Time Paths of KSE-100 index and NYSE Composite Index

The above figure shows that the time paths of KSE-100 and NYSE composite indices from January 1, 2005 to September 15, 2008 are having a strong correlation but the same is not consistent during the period of financial crisis starting from September 16, 2008 and ending at March 31, 2009. Moreover, after the crisis period starting from March 31, 2009, the correlation between their movements have increased as it is evident from the above figure.

4.2 Preliminary Statistics

The preliminary statistics of KSE and NYSE price indices are shown in the following Figures 2 and 3.

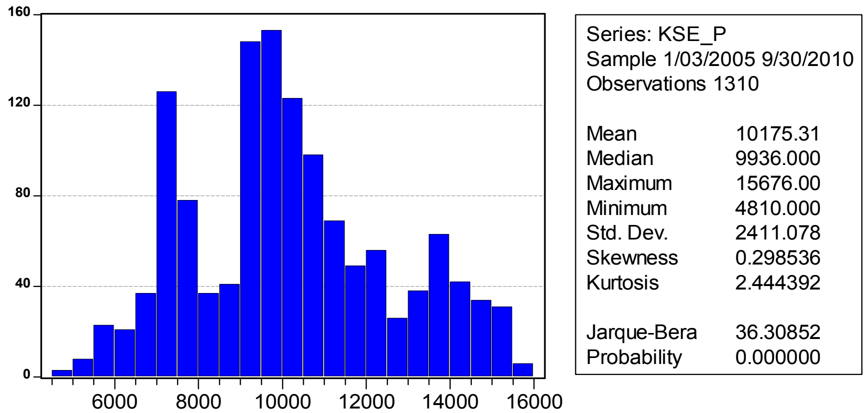

Fig. 2: Basic Statistics of KSE 100 Index

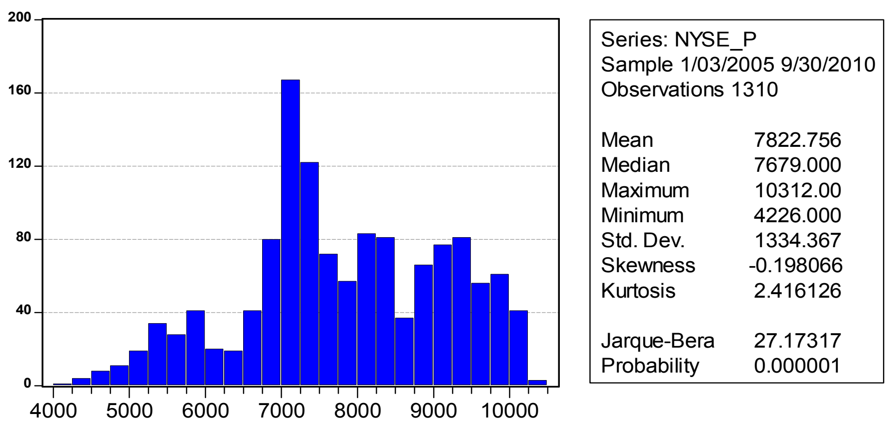

Fig 3 Basic Statistics of NYSE Composite Index

Figure 2 shows the preliminary statistics on the daily stock indices of KSE. The average stock prices during the whole study period come to 10,157 with the standard deviation of 2411. The Jarque Bera test rejects normality of the prices of Pakistani stock market.

Figure 3 shows preliminary statistics on the daily stock indices of NYSE. The average stock prices at NYSE during the whole study period come to 7823 with the standard deviation of 1334. The Jarque Bera test rejects normality of the prices of US stock market.

The daily stock returns are computed by taking the first difference of the natural logarithm of the stock price indices for each market with the equation shown below.

$$R_t = \log (Pt / Pt\text{-}1) = \log (Pt) – \log (Pt\text{-}1)$$

where, R_t is the daily rate of return and Pt is the stock price index on day *t*

4.3 Unit Root Test

The ADF test is applied to check the unit root in the prices and returns of NYSE and KSE and the empirical results of the ADF test are given in Table 1.

Table 1
Results of ADF Unit Root Test

Variables	t-statistic	Prob.*
P_{KSE} : Prices at KSE-100 Index	-1.887059	0.3386
R_{KSE} : Returns on KSE-100 Index	-30.92956	0.0000
P_{NYSE} : Prices at NYSE Composite Index	-1.355206	0.6054
R_{NYSE} : Returns on NYSE Composite Index	-1.355206	0.6054

It is found from the above stated results that both the price series have unit roots and thus are not stationary at level. On the other hand, the returns (first differences of prices) do not have unit root and thus are stationary.

5. Empirical Results & Discussion

In order to achieve the distinct results, the econometric techniques have been divided into Univariate and Multivariate models. The larger market has been represented by NYSE in USA and smaller market has been represented by KSE in Pakistan. Furthermore, the models of this study have been applied to three periods separately as depicted below.

(a) Pre financial crisis era covering results before the crisis period

(b) Global financial crisis era covering results during the crisis period

(c) Post financial crisis era covering results after the crisis period

5.1 Empirical Results for the Pre-Crisis Period

The empirical results for the pre-crisis period are further divided into two categories of Univariate and Multivariate models and its results are as follows.

5.1.1 The Results of Univariate (EGARCH) Model

The econometric techniques of EGARCH Model have been used for the period before the financial crisis and their results are appended below.

Estimated Mean Equation:

$$R_{(KSE)} = 0.0043 + 0.0701*R_{(NYSE)} - 0.2245*\sigma_{(NYSE)} + 0.1603\ R_{(KSE-1)} \tag{11}$$

Estimated Variance Equation:

$$\log \sigma_t^2 = 2.1838 - 0.4254 \left| \frac{\varepsilon_{t-1}}{\sigma_{t-1}} \right| + 0.1621 \frac{\varepsilon_{t-1}}{\sigma_{t-1}} - 0.8248 \log \sigma_{t-1}^2 + 0.0109 \log R^2_{(NYSE)} + 2.0324 \log \sigma^2_{(NYSE)} \tag{12}$$

Full details of the results are presented in Appendix Table 1. The regression results show that the overall fitness of the estimated equation is marginally good as revealed by the computed t-statistics of the individual regression coefficients and F-statistic for the overall significance of regression parameters. There is no significant problem of autocorrelation present in error as shown by the value of Durbin-Watson statistic.

In the mean equation, the value of intercept is 0.0043, which shows that before the period of global financial crisis, the average daily rate of return at KSE would be 0.43 percent if the effects of US market and the lag effects from Pak market were set equal to zero. The past values of rate of returns of KSE have significant impact on the current rate of returns as depicted by the coefficient of the lag value of KSE rate of return. The results further show that in the pre-financial crisis period, the effect of one percentage point increase in the rate of return of US market on the rate of return in Pak stock market has been 0.07 percentage points and this spillover has been statistically insignificant. It follows, therefore, that this spillover of mean rate of return from the US market has been weak. The effect of standard deviation of the rate of return of NYSE on the mean rate of return of KSE has been marginally significant, which means the volatility of the NYSE rate of returns has adverse spillover impact on the mean rate of returns of the KSE.

In the variance equation before the period of global financial crisis, non-zero and statistically insignificant coefficient of $\frac{\varepsilon_{t-1}}{\sigma_{t-1}}$ shows the existence of asymmetric effect of past shocks on expected volatility. The results show that past observed volatility had significant impact on the current predicted volatility. The results also show that predicted volatility had strong autocorrelation which has been highly significant as well. The mean rate of return in the US market did not have significant impact on the volatility of the rate of returns at KSE, whereas the variance in the US rate of return had a significant positive effect on the volatility of the rate of returns of KSE. This means that the volatility of the rate of return in US had significant adverse effects both on the rate of return and its volatility in Pakistan.

5.1.2 The Results of Multivariate (VAR) Model

The Vector Autoregressive model is also estimated for the period before the financial crisis period. By using VAR lag order selection criteria, it is found that Lag-01 is an optimal lag. So, the lag length of 01 is adopted in the estimation of VAR equation model. The results of VAR equation model with lag one is shown in the appendix at Table 1A. The results of Test of Granger Causality are presented in Appendix Table 2. The test statistic shows significant result for the long term effects of NYSE returns on KSE returns. It means that being the bigger stock market, returns of NYSE significantly had affected the returns of smaller stock market, that is, KSE.

The impulse response functions for the period before the crisis era are presented in Appendix Figure 1 (a, b). The figures show the response of KSE returns to the one standard variation in NYSE returns and to one standard deviation variation in KSE returns. As it is evident from the Impulse Responses, shock in NYSE returns resulted into positive changes in the KSE returns instantaneously and with lag of one day. However, the lag effect is estimated to be larger than the instantaneous effect. Nevertheless, the lag responses after one lag turns out to be insignificant. It is also evident from the Appendix Figure 1 (a, b) that 95 percent confidence interval of the Impulse Response with one and two periods lag completely lies in positive range, indicating the presence of significant spillover from NYSE to KSE. The response of KSE return to its own shocks has been obviously more sizeable as compared to the response discussed above.

The Variance Decomposition depicts information about the relative importance of each random shock in affecting the variation of the variables in the VAR. Variance Decomposition of KSE is calculated for one to 10 periods. The results are shown in Appendix Table 3. The table shows that variance of the KSE return has been pre-dominantly driven by shocks originating at the KSE itself. The innovations/shocks in the NYSE contribute a little more than 2 percent of the total variations at KSE, which however becomes statistically significant after just one period.

The main conclusion that emerges from the univariate as well as multivariate analyses is that before the global financial crisis, there has been significant effect of spillover from the NYSE to the KSE. This result appears quite robust as it remains consistent throughout the analysis, that is, univariate as well as multivariate analyses. Furthermore, within multivariate analyses, all the three techniques, that is, Granger Causality, Impulse Response and Variance Decomposition; confirm the same result. Finally, the spillovers occurred only in three forms which are; from the predicted volatility of rate of return in NYSE to the average rate of return at KSE, from the predicted volatility at NYSE to the predicted volatility at KSE and from random shocks/innovations at NYSE to the rate of return at KSE.

5.2 Empirical Results for the Crisis Period

As before, the empirical results in this section are also divided into two categories of Univariate and Multivariate model, which are as follows:-

5.2.1 The Results of Univariate Model

Applying the econometric techniques of EGARCH Model to the data for the period of financial crisis, the following results are obtained.

Estimated Mean Equation

$$R_{(KSE)} = 0.0087 + 0.0004^{*}R_{(NYSE)} + 0.1559^{*}\sigma_{(NYSE)} + 0.3379\, R_{(KSE-1)} \quad (13)$$

Estimated Variance Equation:

$$\log \sigma_t^2 = -39.6059 + 0.4246 \left| \frac{\varepsilon_{t-1}}{\sigma_{t-1}} \right| - 0.3517 \frac{\varepsilon_{t-1}}{\sigma_{t-1}} - 0.1787 \log \sigma_{t-1}^2$$
$$+ 0.0927 \log R^2_{(NYSE)} - 4.2572 \log \sigma^2_{(NYSE)} \quad (14)$$

Full details of the estimated Exponential GARCH model results are presented in Appendix Table 4. Overall fitness of the estimated equation is good as is revealed by the computed t-statistics of the individual regression coefficients and F-statistic for the overall significance of regression parameters. Furthermore, there is no significant problem of autocorrelation present in error as shown by the value of Durbin-Watson statistic.

In the mean equation, the intercept value of -0.0087 shows that during the period of global financial crisis, the average daily rate of return at KSE would have been negative 0.87 percent if the effects of US market at the lag effects from Pak market were set equal to zero. The past values of rate of returns of KSE have significant impact on the current rate of returns as depicted by the coefficient of the lag value of KSE rate of returns. The results further show that in the period of financial crisis, the effect of one percentage point increase in the rate of return of US market on the rate of return in Pak stock market has been 0.04 percentage points and this spillover has been statistically insignificant. It follows that the spillover of mean rate of return from the US market has been weakened. The effect of standard deviation of the rate of return of NYSE on the mean rate of return of KSE has also been statistically insignificant which means that the volatility spillover from the US market on the rate of returns of the Pakistani stock market has also been weakened.

In the variance equation during the period of global financial crisis, non-zero and statistically insignificant coefficient of $\frac{\varepsilon_{t-1}}{\sigma_{t-1}}$ shows the existence of asymmetric effect of past shocks on the expected volatility. The results show that past observed volatility had significant impact on the current predicted volatility. The results also show that predicted volatility had strong autocorrelation which is highly significant as well. The mean rate of return in the US market had a marginally significant effect on the volatility of the rate of returns at KSE, whereas the variance in the US rate of return had a significant negative effect on the volatility of the rate of returns of KSE. This means that the volatility of the rate of return in US had significant favorable effects both on the rate of return and its volatility in Pakistan. This means that during the era of the crisis, the impact of the volatility of the rate of return of US stock market is opposite to the rate of return of Pakistani stock market. This unusual phenomenon could be due to two reasons. The first reason may be attributed to the behavior of the Pakistani investors who had invested in US stock market. It may be the case that following the financial crises, these investors withdrew their investment from US stock market and invested in Pakistani stock market as investment place, which is having relatively less foreign influence. The second reason may be attributed to the government's intervention during the crisis era by imposing anti-crash measures and institutional investment in the Pakistani stock market.

5.2.2 The Results of Multivariate Model

The VAR model is estimated for the financial crisis period. By incorporating VAR lag order selection criteria, it is revealed that Akaike Information Criterion, Schwarz Information Criterion and Hannan-Quinn Information Criterion show optimal values at lag two. So the lag length of two is used in the estimation of VAR model. The results of VAR equation model with lag are shown in the appendices at Appendix Table 4A. The results of Granger Causality Test for the era of global financial crisis are presented in the Appendix Table 5. The VAR Granger Causality Tests shows insignificant result for the long-run effects of NYSE returns on KSE returns. It means that the returns of the US stock market did not significantly affect the returns of Pakistani stock market.

The impulse response function for the period during the crisis era are presented in Figure 2 (a, b), which manifest that the shocks in NYSE returns did not result into any significant changes in the KSE returns instantaneously. However, past shocks in KSE itself seem to have significant influence on the current rate of return, indicating significant inertia. The response of KSE return to its own shocks is obviously more sizeable as compared to the response of NYSE returns. It is also evident from the figure that 95 percent confidence interval of the Impulse Response to NYSE shocks with one and two period lags does not lie entirely in the positive or negative range, indicating the insignificant spillover from the NYSE to the KSE.

The results of Variance Decomposition for one to 10 periods are shown in Appendix Table 6. The tabular results of Variance Decomposition show, as before, that the variance of the KSE return had been pre-dominantly driven by shocks originating at the KSE itself. The innovations/shocks in the NYSE contributed less than 2 percent of the total variations at KSE in first four periods and crosses 2 percent in the fifth period onward. Moreover, this is statistically insignificant after just one period.

The main conclusion for the global financial crisis is that, there have been no significant spillover effects of returns from the NYSE to the KSE. However, in univariate analysis, it is found that the volatility of the returns of NYSE had negative significant impact on the volatility of the returns at the KSE. Furthermore, within multivariate analyses, all the three techniques, that is, Granger Causality, Impulse Response and Variance Decomposition; confirm that the returns of NYSE had no significant effect on the returns of KSE during the period of financial crisis. The spillovers during the crisis era occurred only from the predicted volatility at NYSE to the predicted volatility at the KSE and to the rate of return at the KSE.

5.3 Empirical Results for the Post Crisis Period

As discussed before the results of the univariate and multivariate analyses in two sub-sections.

5.3.1 The Results of Univariate Model

The estimated EGARCH model for the period after the financial crisis is presented in equation 15 and 16 and Appendix Table 7.

Mean Equation:

$$R_{(KSE)} = 0.0063 - 0.0355*R_{(NYSE)} - 0.4132*\sigma_{(NYSE)} \quad (15)$$

Estimated Variance Equation:

$$\log \sigma_t^2 = -0.3031 + 0.1256 \left| \frac{\varepsilon_{t-1}}{\sigma_{t-1}} \right| - 0.0546 \frac{\varepsilon_{t-1}}{\sigma_{t-1}} + 0.9383 \log \sigma_{t-1}^2$$
$$+ 0.0318 \log R^2_{(NYSE)} + 0.0023 \log \sigma^2_{(NYSE)} \qquad (16)$$

The results show that the overall fitness of the estimated equation is not good as revealed by the value of F-statistic for the overall significance of regression parameters. There is no significant problem of autocorrelation present in error as shown by the value of Durbin-Watson statistic.

In the mean equation, the value of intercept indicates that immediately after the period of global financial crisis, the average daily rate of return at KSE would be 0.63 percent if the effects of US market at the lag effects from Pak market are set equal to zero. The past values of rate of returns of KSE did not have significant impact on the current rate of returns. Furthermore, the results show that the effect of one percentage point increase in the rate of return at the US market on the rate of return at the Pak stock market has been 0.04 percentage points and this spillover is statistically insignificant. The effect of standard deviation of the rate of return of NYSE on the mean rate of return of KSE has been negatively significant, which means the volatility of the NYSE rate of returns had spillover impact on the mean rate of returns of the KSE.

The variance equation shows the existence of asymmetric effect after the period of global financial crisis as is evident from the non-zero and statistically insignificant coefficient of $\frac{\varepsilon_{t-1}}{\sigma_{t-1}}$. It is inferred from the EGARCH results that observed volatility had significant impact on the current predicted volatility. The results also show that predicted volatility had strong autocorrelation, which is highly significant as well. The mean rate of return in the US market had a significant impact on the volatility of the rate of returns at KSE, whereas the variance in the US rate of return did not have significant positive effect on the volatility of the rate of returns of KSE. This means that immediately after the financial crisis era, the volatility of the rate of return in US did not have significant effect on the volatility of the rate of return in Pakistan but mean rate of return in US had significant effect on the volatility of rate of return in Pakistan.

5.3.2 The Results of Multivariate Model

By using VAR Lag Order Selection Criteria, the lag length of 02 is used in the estimation of VAR equation model. The results of VAR equation model with lag-02 are shown in the appendices at Appendix Table 7A. However, the results of Granger causality test are shown here in Appendix Table 8, which shows the significant result for the long term effects of NYSE returns on KSE returns. It can be inferred from the results that being the bigger stock market, returns of NYSE significantly affects the returns of smaller stock market, that is, KSE.

The impulse response function for the period after the crisis era is presented in the Appendix Figure 3 (a, b). The figure shows the response of the returns at the KSE to the one standard variation in the NYSE returns and to one standard deviation variation in the KSE returns. It is evident from the figure that the shock in NYSE returns result into positive changes in the KSE returns with one day lag. The lag effect is estimated to be larger than the instantaneous effect. However, the lag responses after one lag turns out to be insignificant. The result indicates the presence of significant spillover from the returns of NYSE to the returns of KSE.

The results of Variance Decomposition for the post crisis era are shown in Appendix Table 9. The results show that the variance of the KSE return has been pre-dominantly driven by shocks originating at the KSE itself. The innovations/ shocks in the NYSE contribute a little less than 3 percent of the total variations at KSE which, however, becomes statistically significant after just one period.

The results of univariate as well as multivariate analyses for the period immediately after the global financial crisis depict that there have been significant effect of spillover from the returns of NYSE to the KSE returns.

Furthermore, within multivariate analyses, all the three techniques, that is, Granger Causality, Impulse Response Functions and Variance Decomposition; confirm the same result. Finally, the spillovers occur only in two forms which are; from the predicted volatility of rate of return in NYSE to the average rate of return at KSE and from random shocks/innovations at NYSE to the rate of return at KSE.

6. Summary & Conclusion

6.1 Results Summary

This study focuses on finding the effect of rate of return of the larger (US) stock market and its volatility on both the mean and volatility of the rate of return of the smaller (Pakistan) stock market.

Table 2
Results of Univariate (EGARCH) Analysis

Tests / Statements	Pre-Crisis Era	During Crisis Era	Post-Crisis Era
Overall significance of regression parameters	Marginally Good	Good	Not Good
The effect of rate of return in US on the rate of return in Pakistan	No Significant Effect	No Significant Effect	No Significant Effect
The effect of rate of return in US on the volatility of rate of return in Pakistan	No Significant Effect	Marginal Effect	Negative Significant Effect
The effect of volatility of rate of return in US on the rate of return in Pakistan	Marginal Effect	No Significant Effect	Positive Significant Effect
The effect of volatility of rate of return in US on the volatility of rate of return in Pakistan	Positive Significant Effect	Negative Significant Effect	No Significant Effect

In this respect, methodology of Exponential General Autoregressive Conditional Heteroskedasticity (EGARCH) and Vector Autoregression (VAR) type models are applied to the rate of returns of the US and Pakistani stock market for the three distinct period, that correspond to the time periods before, during and after the global financial crisis. The main findings of the study are summarized in Table 2 and 3.

Table 3
Summary of Results of Multivariate (VAR) Analysis

Description of Tests	Pre-Crisis Era	During Crisis Era	Post-Crisis Era
Granger Causality Test	Mean Spillover	No Significant Effect	Mean Spillover
Impulse Response Function	Mean Spillover	No Significant Effect	Mean Spillover
Variance Decomposition	Mean Spillover	No Significant Effect	Mean Spillover

6.2 Conclusion

The aim of this paper was to analyze the spillover effects from a larger to a smaller stock market in the context of Global Financial Crisis by applying the techniques of mathematical economics. The study comprised of three distinct eras, that is, immediately before, during and immediately after the global financial crisis. The mathematical economic techniques of EGARCH and VAR models were incorporated to analyze the wide-ranging spillovers effects of both the markets. The empirical results suggest that the volatility of returns had significant spillover impact on the volatility of smaller market returns particularly during the era of global financial crisis. Moreover, the results of Granger Causality stipulate that the returns of larger market had significant impact on smaller market' returns except during the period of financial crises when they have been independent of each other. The results from the volatility modelling are attention-grabbing which are in contrast with the stylized fact of asset returns and volatility transmissions. The returns of smaller stock market have been affected by the volatility of larger stock market during the era of financial crisis. There is strong relationship between the volatility of returns of two stock markets. It implies the existence of mean return spillover from the larger to a smaller stock market for the periods before and after the financial crisis and negative volatility spillover only during the era of global financial crisis.

There are two plausible explanations for the captivated results during the era of financial crisis. First rationale is due to the government intervention and institutional buying of stocks to mitigate the negative effects of global financial crisis on a smaller stock market. The second plausible explanation is due to the behavior of investors who had invested in the larger stock markets and moved towards a smaller stock market during the era of global financial crisis.

Results obtained provide ample evidence for the transmission of volatility from the larger market to a smaller market that too negative during the era of global financial crisis. This study may be taken as benchmark to explore the pattern of spillover between other large and small markets and its remedial measures as explained above in the plausible explanations. Such an analysis may be beneficial for investors to make their investment relatively less risky in the wake of financial crises.

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Appendix Tables

Table 1
Estimates of EGARCH Model for the Pre Financial Crisis Period

Dependent Variable: $R_{(KSE)}$				
Method: ML – ARCH	Coefficient	Std. Error	z-Statistic	Prob.
Mean Equation				
C	0.004282	0.001660	2.579834	0.0099
$R_{(NYSE)}$	0.070092	0.044230	1.584730	0.1130
$\Sigma_{(NYSE)}$	-0.244480	0.124929	-1.956949	0.0504
$R_{(KSE-1)}$	0.160310	0.037042	4.327813	0.0000
Variance Equation				
C	2.183766	0.951737	2.294505	0.0218
$\left\| \frac{\varepsilon_{t-1}}{\sigma_{t-1}} \right\|$	-0.425442	0.092128	-4.617926	0.0000
$\frac{\varepsilon_{t-1}}{\sigma_{t-1}}$	0.162099	0.050301	3.222557	0.0013
$\log \sigma^2_{t-1}$	-0.824831	0.180195	-4.577427	0.0000
$\log R^2_{(NYSE)}$	0.010956	0.013030	0.840876	0.4004
$\log \sigma^2_{(NYSE)}$	2.032357	0.227642	8.927882	0.0000
Log likelihood	2409.857	F-statistic		1.752436
Durbin-Watson stat	2.079038	Prob(F-statistic)		0.07365

Table 1A
Vector Autoregression Estimates for the Pre Financial Crisis Period

Standard Errors in ( ) & t-statistics in [ ]		
	KSE_RET	NYSE_RET
KSE_RET(-1)	0.137305	-0.002326
	(0.03371)	(0.01904)
	[4.07363]	[-0.12212]
NYSE_RET(-1)	0.189780	-0.129413
	(0.06011)	(0.03397)
	[3.15699]	[-3.81005]
C	0.000360	0.000172
	(0.00059)	(0.00033)
	[0.61106]	[0.51459]

Table 2
VAR Granger Causality Tests (Pre Crisis Era)

Dependent Variable: R_{KSE}			
Null Hypothesis	Chi-sq	Df	Prob.
R_{NYSE} does not cause R_{KSE}	9.966603	1	0.0016

Table 3
Results of Variance Decomposition of $R_{(KSE)}$

Period	S.E.	$R_{(KSE)}$	$R_{(NYSE)}$
1	0.017276	99.35100	0.649004
2	0.017565	97.89530	2.104695
3	0.017583	97.70827	2.291732
4	0.017584	97.70788	2.292121
5	0.017584	97.70742	2.292578
6	0.017584	97.70736	2.292636
7	0.017584	97.70736	2.292637
8	0.017584	97.70736	2.292637
9	0.017584	97.70736	2.292637
10	0.017584	97.70736	2.292637

Table 4
Estimates of EGARCH Model for the Financial Crisis Period

Dependent Variable: $R_{(KSE)}$				
	Coefficient	Std. Error	z-Statistic	Prob.
Mean Equation				
C	-0.008699	0.014633	-0.594480	0.5522
$R_{(NYSE)}$	0.000404	0.013554	0.029832	0.9762
$\sigma_{(NYSE)}$	0.155866	0.325581	0.478731	0.6321
$R_{(KSE - 1)}$	0.337885	0.073687	4.585422	0.0000
Variance Equation				
C	-39.60587	7.058774	-5.610871	0.0000
$\left\| \frac{\varepsilon_{t-1}}{\sigma_{t-1}} \right\|$	0.424628	0.206899	2.052345	0.0401
$\frac{\varepsilon_{t-1}}{\sigma_{t-1}}$	-0.351686	0.129159	-2.722887	0.0065
$\log \sigma^2_{t-1}$	-0.178594	0.189777	-0.941071	0.3467
$\log R^2_{(NYSE)}$	-0.092701	0.049732	-1.864025	0.0623
$\log \sigma^2_{(NYSE)}$	-4.257245	0.880108	-4.837185	0.0000

Log likelihood	311.3482	F-statistic	3.5889
Durbin-Watson stat	1.740984	Prob(F-statistic)	0.0007

Table 4A
Vector Autoregression Estimates for the Financial Crisis Period

Standard errors in ( ) & t-statistics in [ ]		
	KSE_RET	NYSE_RET
KSE_RET(-1)	0.362462	-0.119503
	(0.09634)	(0.26340)
	[3.76227]	[-0.45369]
KSE_RET(-2)	0.323922	-0.078974
	(0.09760)	(0.26683)
	[3.31897]	[-0.29597]
NYSE_RET(-1)	0.021227	-0.251328
	(0.03641)	(0.09955)
	[0.58296]	[-2.52460]
NYSE_RET(-2)	0.029211	0.048507
	(0.03631)	(0.09926)
	[0.80458]	[0.48867]
C	-0.000701	-0.006089
	(0.00171)	(0.00467)
	[-0.41015]	[-1.30256]

Table 5
VAR Granger Causality Tests (During the Crisis Era)

Dependent Variable: R_{KSE}			
Null Hypothesis	Chi-sq	Df	Prob.
R_{NYSE} does not cause R_{KSE}	0.789125	2	0.6740

Table 6
Results of Variance Decomposition of $R_{(KSE)}$

Period	S.E.	$R_{(KSE)}$	$R_{(NYSE)}$
1	0.017455	99.55256	0.447435
2	0.018616	99.00916	0.990842
3	0.020321	98.15042	1.849585
4	0.020904	98.04026	1.959742
5	0.021355	97.85226	2.147736

6	0.021579	97.80248	2.197524
7	0.021723	97.75429	2.245706
8	0.021804	97.73376	2.266244
9	0.021853	97.71918	2.280818
10	0.021881	97.71151	2.288488

Table 7
Estimates of EGARCH Model after the Financial Crisis Period

Dependent Variable: $R_{(KSE)}$				
Method: ML – ARCH	Coefficient	Std. Error	z-Statistic	Prob.
Mean Equation				
C	0.006277	0.002445	2.567853	0.0102
$R_{(NYSE)}$	0.035495	0.047496	0.747326	0.4549
$\sigma_{(NYSE)}$	-0.413205	0.184615	-2.238194	0.0252
Variance Equation				
C	-0.303077	0.241845	-1.253184	0.2101
$\lvert \frac{\varepsilon_{t-1}}{\sigma_{t-1}} \rvert$	0.125658	0.058354	2.153356	0.0313
$\frac{\varepsilon_{t-1}}{\sigma_{t-1}}$	-0.054639	0.032704	-1.670709	0.0948
$\log \sigma^2_{t-1}$	0.938255	0.026430	35.49943	0.0000
$\log R^2_{(NYSE)}$	0.031804	0.015528	2.048187	0.0405
$\log \sigma^2_{(NYSE)}$	0.002289	0.037649	0.060787	0.9515
Log likelihood	1019.586	F-statistic		0.2721
Durbin-Watson stat	1.986704	Prob (F-statistic)		0.9746

Table 7A
Vector Autoregression Estimates after the Financial Crisis Period

Standard errors in ( ) & t-statistics in [ ]		
	KSE_RET	NYSE_RET
KSE_RET(-1)	-0.002771	-0.085986
	(0.05309)	(0.05706)
	[-0.05219]	[-1.50691]
NYSE_RET(-1)	0.166538	-0.058935
	(0.05007)	(0.05381)
	[3.32635]	[-1.09521]

C	0.000909	0.001262
	(0.00074)	(0.00079)
	[1.23282]	[1.59249]

Table 8
VAR Granger Causality Tests (Post Crisis Era)

Dependent Variable: R_{KSE}			
Null Hypothesis	Chi-sq	Df	Prob.
R_{NYSE} does not cause R_{KSE}	11.06461	1	0.0009

Table 9
Results of Variance Decomposition of $R_{(KSE)}$

Period	S.E.	$R_{(KSE)}$	$R_{(NYSE)}$
1	0.013471	99.98281	0.017190
2	0.013648	97.50580	2.494197
3	0.013675	97.18337	2.816629
4	0.013675	97.18326	2.816744
5	0.013675	97.18299	2.817015
6	0.013675	97.18298	2.817016
7	0.013675	97.18298	2.817020
8	0.013675	97.18298	2.817020
9	0.013675	97.18298	2.817020
10	0.013675	97.18298	2.817020

Appendix Figures

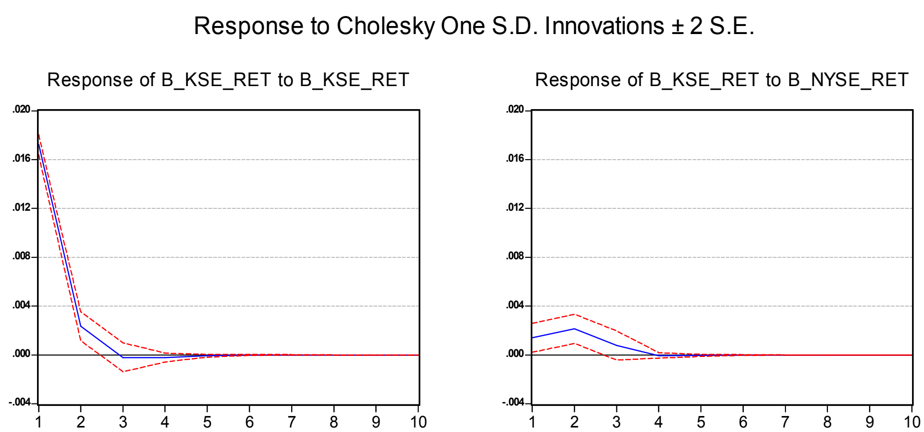

Fig. 1(a,b) Impulse Response Function before the Financial Crisis Era

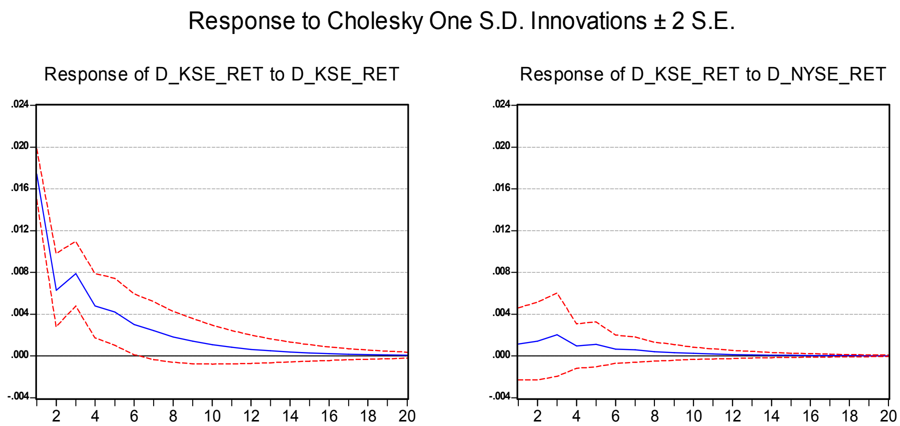

Fig. 2 (a, b) Impulse Response Function during the Financial Crisis Era

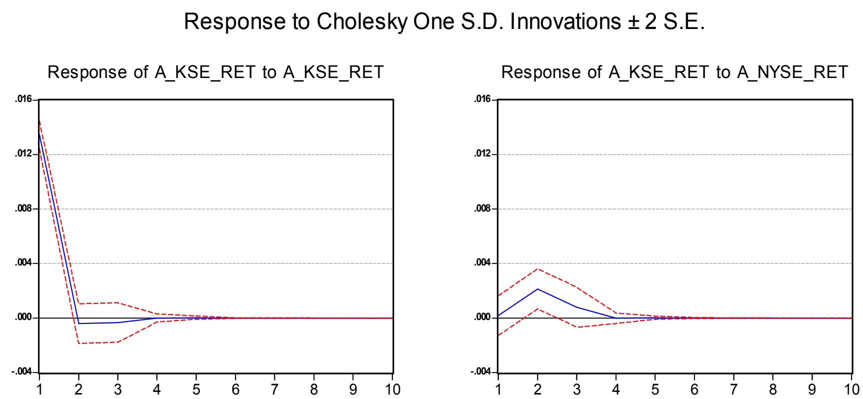

Fig. 3 (a, b) Impulse Response Function after the Financial Crisis Era