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Global Financial Crisis: An EGARCH Approach to Examine the Spillover Effect on Emerging Financial Markets

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Abstract: This study examines the spillover effect of US stock returns on emerging markets stock returns (China, India and Pakistan) and the effect of volatility in US stock on the emerging stock market particularly during the period of global financial crisis. For the analysis, we have used the daily stock returns of these markets from the period of 1st January 2007 to 30th September 2011. We have divided our analysis into three parts (before, during and after) financial crisis. The econometric technique such as EGARCH model is applied for examination. The results show a weak spillover effect on BSE whereas mean spillover for SSE is insignificant but it shows a volatility spillover from US financial market to China's financial market. In case of KSE returns we find a spillover effect from the US stock returns to KSE stock returns.

Key words: Financial crisis, US financial market, emerging financial market, spillover effect, EGARCH model

INTRODUCTION

An evident attribute of recent global financial crisis is the speed by which it spread out to other economies. The global financial crisis arises in the US real estate market led its banking system to collapse and become a cause of crumple in stock markets around the globe in 2008 and it had an enormous impact on major economies. The world has become a global village where things produced in one place are easily traded and available at the other part of the world. After the 80's most of the emerging economies have adopted the policies of free trade and financial liberalization. Since then financial crisis has became an integral feature of these economies in the shape of debt, exchange rate and currency crisis (Agosin and Huaita, 2011). Financial liberalization has its long term benefits but in short term it persuades the domestic financial institutions to make risky decision (Hellmann *et al*., 2000; Demetriades and Andrianova, 2004). In the era of globalization the investment in foreign markets has increased that became the cause of cointegration among these financial markets (Kayani *et al*., 2013). The high integration among the financial markets leads to the spillover effect from one economy to other.

Financial markets have gone through many crisis over the last few decades as the "black Monday" of October 1987 but the global financial crisis of 2008 is considered as worst crisis after the great depression (Claessens *et al*., 2010). The financial crisis sparkled in 2008 have given an opportunity to economists to study the relationship among the financial markets. This study examines the spillover effect of US stock returns on the Stock returns of emerging financial markets during the phase of global financial crisis. Emerging economies always have a vital role to cater down the effects of the crisis. Over the recent few years the Chinese and Indian financial markets have shown the performance to be called as the emerging financial markets and have portrayed to be the new drivers of change. Pakistan has always been a key market economically and strategically. It shows an 8% growth in 2005 and its stock market climbed to 15000 indexes in the same era. "China and India possess the weight and dynamism to transform the 21st century global economy" (Engardio, 2005). However, numerous studies have been done on the Cointegration analysis between US financial market and emerging markets. Hansda and Ray (2002), Nath and Verma (2003) and Wong *et al*. (2005) have shown the integration of Indian stock exchange with the stock markets of developed countries. Aloui *et al*. (2011) studied on BRIC, shows the dependence between these economies during global financial crisis. This is evident that financial markets have become closer or cointegrated during this globalization. It is therefore perceived that these relationships have increased the probability of shock transmission from one financial market to other. Generalized Autoregressive Conditional Heteroskedastic (GARCH) models introduced by Engle (1982) and Bollerslev (1986) are useful for the model of time-varying volatility of financial assets.

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Nelson (1991) introduced the exponential GARCH (EGARCH) models with a conditional variance formulation that can accumulate the asymmetric response in conditional variance. In our study, we analyzed the spillover effect of US stock returns to stock returns of emerging financial market Alexander (2008) used an EGARCH model and showed it to be a best estimator than other computing models of asymmetric conditional variance.

METHODOLOGY

Data and preliminary analysis: We examined the daily observations of US financial market (NYSE composite index) and several other emerging economies like China (SSE composite index) and India (BSE). The sample is from January 2, 2007 to September 30, 2011. Descriptive statistics is shown in Table 1.

The data was collected from their official websites. We have taken logarithm of the data in order to minimize the variation. In general these markets were growing steadily until 2008 when US markets started crumbling. In that period the financial crises were generated from US financial market and it transmitted its effect to emerging economies whereas these markets have a decent recovery till the end of 2011.

Econometric methodology: First we have applied Augumented Dickey Fuller test on the returns of NYSE, SSE, BSE and KSE to test the unit root hypothesis. To tackle the problem of volatility Autoregressive Conditional Hetroskedasticity (ARCH) models were used. These models are used when there variation in time series occurs due to some autoregressive process. Autoregressive models are based on the supposition that an error term is a function of its earlier value. Variance is a proxy of squared prior improvements. According to Bollerslev (1986), a model is GARCH if an ARMA is assumed for the error variance. The equation of standard GARCH model is as follows.

Mean equation:

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

Variance equation:

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

where, σ^2_t is forecasted variance based on its prior information sometime called as conditional variance and γ_0 is a mean term. The e^2_{t-1} is an ARCH term which

Table 1: Descriptive statistics

Parameters	NYSE	SSE	BSE
Mean	0.0004	0.0002	0.0009
Median	0.0008	0.0005	0.0006
Maximum	0.1221	0.1510	0.1155
Minimum	-0.0972	-0.1131	-0.0540
Std. dev	0.0178	0.0242	0.0149
Skewness	-0.0887	0.0613	0.9410
Kurtosis	9.5996	5.8608	10.5061
Jarque-Bera statistic	2137.5	402.1	1549.5

captured the effect of newsflash from the volatility of the previous period, implies that:

$$\sum_{i=1}^{s} \delta_i e_{t-i}^2$$

Variance of the last period's conditional variance is σ^2_{t-1} a GARCH term, implies:

$$\sum_{i=1}^{r} \gamma_i \sigma_{t-i}^2$$

Different values of p and q can be applied but according to Bollerslev *et al.* (1992) r = s = -1 is more appropriate than any other in financial time series. First order ARCH and GARCH term referred towards the term (1, 1) which means e^2_{t-1} and σ^2_{t-1}, respectively.

When procedures of maximum likelihood are used to estimate ARCH models then assumptions related error term holds true. Log likelihood form for GARCH (1, 1) is:

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

Where:

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

Sometimes negative shocks increase more volatility than positive shocks. In this case even simple GARCH usually suggest a negative conditional volatility that is clearly not suitable for further inferences. By taking the log of the both sides of the GARCH equation can solve the problem of above mentioned negativity. An exponential function is positive all the times, so now our left hand side of the equation becomes an exponential function. From the reason of solving the problem of negative conditional volatility EGARCH model become into presence. In financial time series EGARCH models are used to capture the leverage effect. Mean and variance equations of EGARCH are as follows:

Mean equation:

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

Variance equation:

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

RESULTS

Econometric model is used for three different times distributed as pre financial crisis, during financial crisis and post financial crisis. We have estimated following mean and variance equations by using EGARCH model to find the impact of NYSE on Bombay Stock Exchange (BSE) (Table 2):

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

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

Values of F-statistic 1.2791, 2.0001 and 1.9641 for pre, during and post financial crisis respectively, are evidently showing the overall significance of the model. Values of Durbin-Watson are also representing that there is no problem of autocorrelation in errors. Coefficients of pre, during and post financial crises are 0.0023, -0.0028 and 0.0006, respectively signifying that all other consequence of NYSE and lag of BSE set equal to zero then there would be 0.23, -0.28 and 0.06% average rate of return on BSE. Past values of BSE have significant impact on current rate of return in the time of pre, during and post financial crisis. Coefficient of NYSE returns in pre, during and post financial crisis period is clearly suggesting that one percent increase in NYSE rate of returns would lead to 12.24, 9.39 and 0.03% increase in BSE however the value of probability is evidently negating this spillover effect. The results suggest that this spillover effect is very weak. Value of standard deviation of NYSE is indicating towards positive and significant impact on BSE which means the volatility of the NYSE rate of return has significant spillover impact on means rate of returns of BSE.

By looking at the results of variance equation $\varepsilon_{t-1}/\sigma_{t-1}$ is statistically positive and insignificant which is clearly showing that there is asymmetric effect during financial crisis. Alexander (2000) in his study revealed that EGARCH is superior as compared to other models while computing asymmetric conditional variance. Results are also suggesting that former observed volatility have a significant effect on foretold volatility. Mean rate of return of NYSE have a significant and positive effect on mean rate of returns of BSE in post financial crisis period but it is insignificant in pre and during financial crisis period. Moreover, volatility in NYSE returns has a positive and significant impact on volatility in return of BSE in pre and post crisis period but negative and significant in during crisis period. Keeping all the information in hand we can say that NYSE has a significant impact on mean rate of returns and volatility in BSE.

To find the impact of NYSE on Shanghai Stock Exchange (SSE) (Table 3), we have estimated following mean and variance equations by using EGARCH model:

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

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

Durbin-Watson is also visibly represented that there is no problem of autocorrelation in errors. Values of F-statistic 1.6713, 1.9890 and 2.0138 for pre, during and

Table 2: Effect of NYSE on BSE

	Pre crisis		During crisis		Post crisis	
Parameters	Coefficient	Probability	Coefficient	Probability	Coefficient	Probability
Estimates of mean equation						
C	0.0023	0.0974	-0.0028	0.2105	0.0006	0.8783
$R_{(NYSE)}$	0.1224	0.0591	0.0939	0.1840	0.0032	0.9215
$R_{BSE(-1)}$	-0.0520	0.0422	-0.0060	0.0944	0.0161	0.05773
$\sigma_{(NYSE)}$	0.2245	0.0540	0.0403	0.0440	0.5030	0.0053
Estimates of variance equation						
C	1.5957	0.0000	0.5014	0.0000	-0.1633	0.0000
$\left\|\frac{\varepsilon_{t-1}}{\sigma_{t-1}}\right\|$	0.2726	0.0003	0.2048	0.0000	0.0340	0.0294
$\varepsilon_{t-1}/\sigma_{t-1}$	0.8312	0.0000	0.0044	0.9630	0.0817	0.0000
$\log \sigma^2_{t-1}$	-0.2764	0.0000	0.9214	0.0000	0.9804	0.0000
$\log R^2_{(NYSE)}$	6.0109	0.2671	0.5910	0.2413	5.7332	0.0005
$\log \sigma^2_{(NYSE)}$	6.0324	0.0367	-3.1940	0.0000	0.6817	0.0003

Table 3: Effect of NYSE on SSE

	Pre crisis		During crisis		Post crisis	
Parameters	Coefficient	Probability	Coefficient	Probability	Coefficient	Probability
Estimates of mean equation						
C	0.0010	0.4579	0.0028	0.3143	-7.54E-05	0.9103
$R_{(NYSE)}$	0.0883	0.3876	0.0138	0.8528	0.0162	0.7412
$R_{SSE(-1)}$	0.0522	0.0768	-0.2239	0.0160	-0.0732	0.0804
$\sigma_{(NYSE)}$	0.0145	0.0040	0.1503	0.0500	0.6139	0.0042
Estimates of variance equation						
C	-0.6752	0.0127	-10.0246	0.0015	-0.4447	0.0024
$\lvert\frac{\varepsilon_{t-1}}{\sigma_{t-1}}\rvert$	0.1358	0.0601	0.3116	0.1030	0.1452	0.0000
$\varepsilon_{t-1}/\sigma_{t-1}$	-0.1644	0.0005	-0.0115	0.9331	-0.0430	0.0206
$\log \sigma^2_{t-1}$	0.9169	0.0000	-0.3671	0.4113	0.9593	0.0000
$\log R^2_{(NYSE)}$	0.1705	0.5849	8.1076	0.2154	0.2234	0.8904
$\log \sigma^2_{(NYSE)}$	2.7330	0.2141	4.7000	0.8791	-4.4339	0.9281

Table 4: Effect of NYSE on KSE

	Pre crisis		During crisis		Post crisis	
Parameters	Coefficient	Probability	Coefficient	Probability	Coefficient	Probability
Estimates of mean equation						
C	0.0020	0.6728	0.0004	0.0404	0.0004	0.1995
$R_{(NYSE)}$	0.0374	0.3127	0.0100	0.0000	0.0018	0.9313
$R_{KSE(-1)}$	0.1538	0.0014	0.8167	0.0000	0.0042	0.0188
$\sigma_{(NYSE)}$	0.0688	0.0480	0.4512	0.0502	0.9231	0.0133
Estimates of variance equation						
C	1.4063	0.0006	1.2503	0.0000	1.1322	0.0062
$\lvert\frac{\varepsilon_{t-1}}{\sigma_{t-1}}\rvert$	0.3456	0.0013	1.2602	0.0000	0.0393	0.0672
$\varepsilon_{t-1}/\sigma_{t-1}$	-0.2467	0.0006	-0.1756	0.0387	-0.0903	0.0018
$\log \sigma^2_{t-1}$	0.8657	0.0000	0.9311	0.0000	0.8700	0.0000
$\log R^2_{(NYSE)}$	1.6654	0.4854	9.3828	0.0000	0.2704	0.0817
$\log \sigma^2_{(NYSE)}$	6.4522	0.3676	35.3976	0.8865	6.4954	0.0036

post financial crisis, respectively are patently showing the overall significance of the model. Coefficients of pre, during and post financial crises are 0.0010, 0.0028 and -7.54E-05, respectively signifying that all other consequence of NYSE and lag of SSE set equal to zero then there would be small change in average rate of return on BSE would occur. Past values of SSE have almost significant impact on current rate of return in the time of pre, during and post financial crisis. Coefficients of NYSE returns in pre, during and post financial crisis period are noticeably signifying that one percent increase in NYSE rate of returns would lead to 8.83, 1.38 and 1.62% increase in SSE, however, the values of probability is evidently negating this spillover effect. Value of standard deviation of NYSE is indicating towards positive and significant impact on SSE. Which means the volatility of NYSE rate of returns have significantly impact on mean rate of returns of SSE index. By looking at the results of variance equation $\varepsilon_{t-1}/\sigma_{t-1}$ is non-zero and insignificant during financial crisis and validates the presence of asymmetric effect. It has also been supported by Awartani and Corradi (2005) and Stentoft (2005) while discussing the role of asymmetries in S and P 500 stock index. Mean rate of return of NYSE have an insignificant and positive effect on mean rate of returns of SSE. Moreover, volatility in NYSE returns has a positive and insignificant impact on volatility in return of SSE in pre, during and post crisis period. Keeping all the information in hand we can say that NYSE has virtually impact on mean rate of returns and volatility in SSE.

We have estimated following mean and variance equations by using EGARCH model to find the appropriate results for Karachi Stock Exchange (KSE):

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

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

Coefficients of mean equation for pre, during and post financial crises are 0.0020, 0.0004 and 0.0004, respectively, signifying that all other consequence of NYSE and lag of KSE fixed equal to zero then there would be 0.2, 0.04 and 0.04% average rate of return on NYSE (Table 4). Past values of KSE have significant impact on

current rate of return in every period. Coefficients of NYSE returns in pre, during and post financial crisis period are suggesting that 1% increase in NYSE rate of returns would lead to 3.74, 1.00 and 0.018% increase in KSE however, the values of probability are evidently negating this spillover effect in pre and post financial crisis but it has a significant effect during the financial crisis. Values of standard deviation of NYSE are indicating towards positive and significant impact on KSE mean rate of returns in each period of estimation. When we look at the results of variance equation $\varepsilon_{t-1}/\sigma_{t-1}$ is negative and significant only in each period. This is showing that there is no asymmetric effect in these periods. Mean rate of return of NYSE have an insignificant and positive effect on mean rate of returns of KSE only during the financial crisis period. Moreover, volatility in NYSE returns has a positive and significant impact on volatility in return of KSE.

Keeping all the information in hand we can say that NYSE has a significant effect on mean rate of returns of KSE but it has some effect on volatility in KSE. F-statistic for pre, during and post financial crisis is evidently showing the overall significance of the models. Values of Durbin-Watson are also visibly demonstrating that there is no problem of autocorrelation in errors.

CONCLUSION

We studied the spillover effect of US financial market to Emerging financial markets (China, India and Pakistan). Moreover, it is equally important to know the response of these financial markets to US. We used the daily observations from January 1st 2007 to September 30th 2011. It shows a weak spillover effect in the returns in case of India and China but in case of Pakistan we find a significant spillover effect from the returns of US stock market to the returns of Pakistani stock market (KSE) and also volatility spillover effect from US to India and China. In case of China the results of mean equation are insignificant but we found significant results and asymmetric effect in variance equation. The volatility of NYSE rate of returns have significant impact on mean rate of returns of SSE also the volatility in NYSE returns has a positive and significant impact on volatility in return of KSE. It is more persuadable explanation that financial crisis have more significant effect on less export based economies. The timely intervention of governments also plays a vital role to melt down the impact of financial crisis.

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