Modelling Dynamic Volatility Spillovers from the U.S. to the BRIC Countries' Stock Markets During the Subprime Crisis

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Abstract

The term 'BRIC' is a collection of Brazil, Russia, India, and China: the most promising emerging markets. The global investors at the time of making investments and building portfolios across different countries should consider the interlinkages that exist between the countries or the assets concerned. The interlinkages make the stock markets in different countries to co-move in the short as well as the long run, thereby leading to spillover of the returns and volatility. The present study attempted to model the dynamic volatility spillover from the U.S. market to the BRIC (Brazil, Russia, India, and China) countries' stock markets during the subprime crisis by employing the ARMA E-GARCH (1,1) model. The results from the E-GARCH (1,1) model supported the spillover of the U.S. volatility to the Brazilian market only. The study revealed that the volatility in the U.S. market did not have a direct impact on the Russian, Indian, and Chinese stock markets.

Keywords: **asymmetric, BRIC, contagion, EGARCH model, leverage**

JEL Classification: C58, G10, G11

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The volatility in the stock market and even in the other markets like commodity markets, debt markets, and currency markets cannot be defined in one single phrase. It is a different thing for different investors. But in layman terms, volatility can be defined as the fluctuations in an asset price arising due to the indecisive nature of investors. The term 'indecisive' has been used as volatility causing wide swings in an asset price in a particular time frame. Actually, investors are willing to gallop some heavy or even medium amount of risk for some amount of volatility because with wide swings in an asset price, the investors can reap a good chunk of profit. On the other hand, the investors who are very risk averse, like a retired person, keep themselves away from the ups and downs in the equity market and invest in some debt based products, which are lesser volatile in comparison to the equity markets.

Growing globalization and trade relations between the countries have made the stock markets of these countries interlinked with each other, thereby increasing the co-movement among the market indices. The events taking place in one market of one country get transferred to the other markets of a different country. The WTO, IMF, and The World Bank have been playing an important role in the growth and development of trade relations as well as the financial flows from one country to another. The countries and companies in one country in the present time have exposure to the assets as well the liabilities of other companies situated in other countries. These linkages have made the countries more sensitive to the events taking place not only in their own economies, but also in other economies as well. Apart from the fundamental events, the listing of domestic securities to the foreign bourses and

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the opening up of the financial markets for the FIIs has made the markets more driven by the herding behavior of the investors (Rannou, 2010).

The term 'BRIC' is a collection of Brazil, Russia, India and China, the most promising emerging markets. Wilson and Purushothaman (2003) examined and forecasted that by 2025, the BRIC countries could account for over half the size of the G6 countries. The contribution of the BRIC countries to the GDP would increase over a period of time, and the growing middle-class population would act as a hedge to the demanding requirements. A large number of authors have emphasized on the increasing trade relations between the BRIC countries and the rest of the world.

Studies have supported evidence of the contagion impact on the emerging market economies and have raised doubts over the theory of decoupling. A large number of studies have tried to capture the returns and the volatility spillovers from one market to the other. However, the present study attempts to estimate the dynamic volatility spillover from the U.S. to the BRIC (Brazil, Russia, India, and China) countries during the subprime crisis. The study is not restricted only to the volatility spillover impacts from the U.S. to other BRIC countries' stock markets ; yet, an asymmetric response of the volatility to the falling market returns has also been captured in the BRIC countries' markets. The subprime crisis, or in a broader sense, the global financial crisis was triggered in the U.S. due to the subprime lending policies of the banks. The mortgaged backed securities created as a result of the subprime loans added fuel to the fire when the housing prices started decreasing, and the crisis started threrof. The period which has been considered for the purpose of study comprises of the time period from the year 2007 to 2009, during which the recovery in the markets started taking place, making the study a first of its kind.

Global investors, especially the portfolio managers at the time of making investments in foreign markets, should consider the interlinkages that exist between countries or the assets concerned. Solnik, Boucrelle, and Le Fur (1996) studied the correlation between the international stock and bond markets. The authors came out with the findings that the correlation between the markets fluctuated over a period of time and moreover, the correlation increased in the event of increased volatility in the markets, thus making the case of contagion impact on the other economy.

Modelling Volatility Spillover : A Review

Different approaches have been used by researchers over a period of time to model spillover effects. Most of the studies which have been conducted in the past used correlation among the market volatilities and returns to account for linkages and the contagion impact. Bollerslev (1986) introduced the GARCH (generalised autoregressive conditional hetroskedastic) type models to account for the time-varying volatility. A GARCH model is more robust as compared to the correlation coefficients. The univariate GARCH models have further been extended to multivariate GARCH models to capture the volatility spillovers. The present study has used the univariate exponential GARCH (E-GARCH) model, where the U.S. stock market's volatility has been taken as an exogenous variable.

King and Wadhwani (1990) used cross-market correlations between the U.S., U.K., and Japan and found out that the correlation increased significantly after the U.S. market crash. The ARCH or GARCH framework was also employed to estimate the variance-covariance transmission mechanism across countries. Kanas (1998) examined the issue of volatility spillovers across the three largest European stock markets, namely London, Frankfurt, and Paris by using the EGARCH model. The results highlighted reciprocal spillovers between London and Paris and between Paris and Frankfurt, and unidirectional spillovers from London to Frankfurt.

To examine the transmission of equity returns and volatility among the Asian equity markets, Worthington and Higgs (2004) used the multivariate GARCH (MGARCH) model. The results indicated that their own-volatility spillovers were higher than cross-volatility spillovers for all markets, especially in the emerging markets; whereas, Karmakar (2005) examined the conditional volatility in Indian stock markets by emphasizing on the realized as well as forecasted volatility. The conditional volatility of market return series from January 1991 to

June 2003 showed volatility shifting over the period. Kumar and Mukhopadhyay (2007) empirically investigated the short-run dynamic linkages between NSE Nifty in India and NASDAQ Composite in U.S. during the period from 1999-2001 using intra-daily data focusing on the daytime returns and overnight returns. The volatility of the nifty overnight returns was caused by the U.S. daytime returns.

Kenourgios, Samitas, and Paltalidis (2007) used multivariate copula regime-switching model to capture non-linear relationships in four emerging stock markets, namely Brazil, Russia, India, and China (BRIC) and two developed markets (U.S. and U.K.) during five recent financial crises (the Asian crisis, the Russian crisis, the tech bust, and the two episodes in Brazil). The results provided an evidence of an increase in dependence among the markets during the crisis period. Mukherjee and Mishra (2008) spotlighted that the contemporaneous intraday return spillover among India and almost all the sample countries was found to be positively significant and bi-directional. Beirne, Caporale, Schulze-Ghattas, and Spagnolo (2009) explained the volatility spillovers from mature to emerging stock markets and tested for the transmission mechanism during turbulences in mature markets. The tri-variate GARCH-BEKK model was used to track the returns in mature, regional emerging, and local emerging markets. The conditional volatilities between local and mature markets increased during these episodes.

Mulyadi (2009) explored the volatility spillover in Indonesia, USA, and Japan's capital markets by employing an econometric model GARCH (1,1). The result exhibited that there was one way volatility spillover between Indonesia and USA (USA affecting Indonesia). Meanwhile, there wasbidirectional volatility spillover between Indonesia and Japan ; whereas, Dufrénot, Keddad, and Sand-Zantman (2010) provided an evidence of spillover effects from the Indian to the U.S. financial markets by using VAR and Kalman's filter analysis. The results pointed to a significant contagion effect after the period following the collapse of Lehman Brothers. Yonis (2011) examined the co-movement of the U.S. and South African stock markets and volatility spillover between them by means of unrestricted bivariate GARCH-BEKK. The study revealed return spillover from NYSE to JSE by analyzing VAR. The results of the GARCH model depicted that the volatility between the U.S. and SA was persistent, and the direction was from USA to SA.

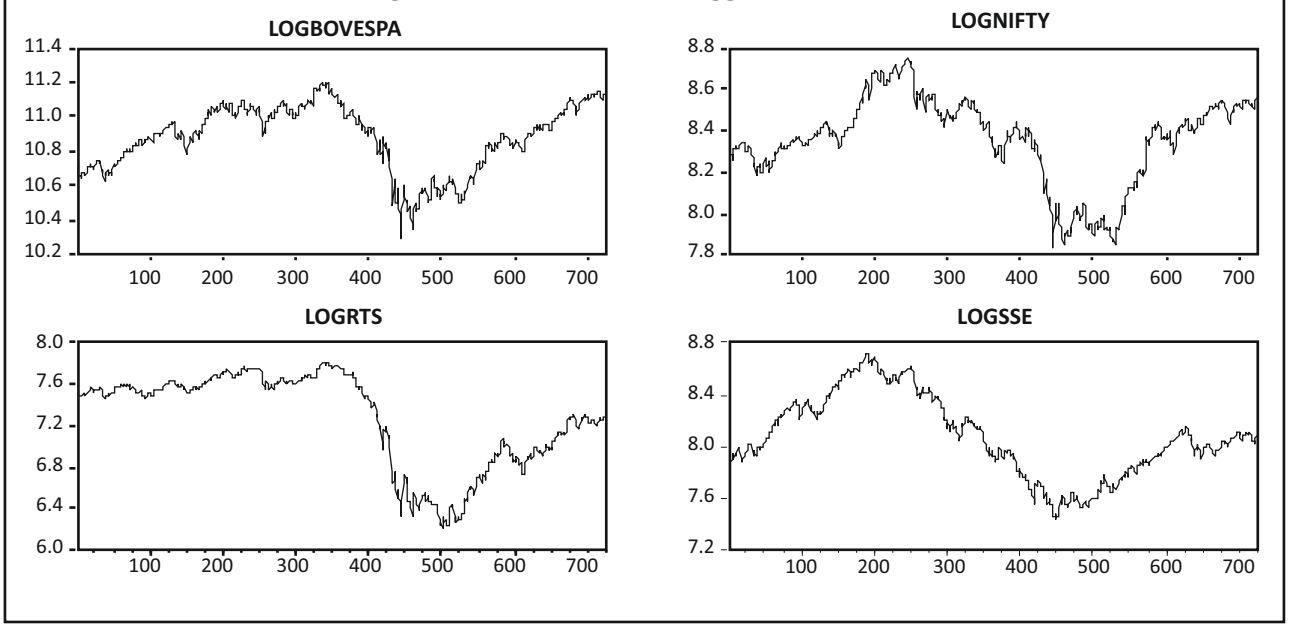
Kharchenko and Tzvetkov (2013) captured the volatility spillover effects between the developed and emerging markets (USA, France, Germany, Russia, India, and China) by employing a CGARCH (1,1) model using the data ranging from January 1995 to April 2013, which was further broken down into two sub samples, respectively representing the periods before and after the global financial crisis. The volatility spillover showed a uni-directional way from the developed to the emerging markets when examining the whole period, but the volatility before the crisis exhibited a flow from the emerging market India to USA, but after the crisis, the volatility spillover was from all the developed markets to India.

The literature review highlights the work done by other authors with regard to the study undertaken. Most of the studies have used the multivariate GARCH models to account for the volatility spillovers, but the present study has used the univariate exponential GARCH model by taking the U.S. market volatility as the exogenous variable during the time period from 2007-2009, when the recovery also started taking place in the market. With the increase in the number of variables, the multivariate GARCH models like BEKK GARCH model, CCC model, and DCC model have become more complex and less flexible.

Research Methodology

To analyze the spillover effect of the stock market volatility from the U.S. market to the BRICs market during the subprime crisis, the major stock market indices have been taken into consideration. The daily indices used in the study are IBOVESPA (Brazil), RTS (Russia), NIFTY (India), Shanghai Composite Index, SSE (China), and S&P500 (USA) ranging from January 2007 to December 2009. The period which has been taken into consideration includes the time period when the markets started reverting from their lows.

Figure 1. Index Values at Logged Price Levels



The Figure 1 explains the movement of the stock indices during the period from 2007-2009 per se. The recovery started from the year 2009 ; hence, the present study attempts to ascertain how the spillovers from the U.S. worked out during this period. As per the Business Cycle Dating Committee of the National Bureau of Economic Research (2010), the recovery from the U.S. crisis started from June 2009. The daily data have been collected from the websites of respective stock exchanges, Yahoo Finance, and The Wall Street Journal. The indices which were taken into view to account for the volatility contagion impact comprised of good quality stocks from respective nations. The stocks which were liquid and had above par fundamentals made way for their entrance in the equity index. The missing figures were filled by taking mean of the nearby two points.

The daily continuously compounding return series (ribovespa, rrts, rnifty, rsse, and rsandp) were calculated by taking the log of the return series for Brazil, Russia, India, China, and the U.S., respectively in the local currency.

$$R = \text{Log}(P_t / P_{t-1}) * 100 \ldots\ldots\ldots (1)$$

where,
R is the daily return, P_t is the current price, and P_{t-1} is the previous day price.

An attempt has been made to study the dynamic volatility spillovers. The dynamic spillovers take place when there are no overlapping trading hours of the stock markets in the respective countries, and the volatility transfers to the next day. As we try to model the volatility spillover from the U.S. to the BRIC countries, there are time differences that exist between the U.S. stock markets and BRIC stock markets. Hence, we focused entirely on the one day lagged spillover effect from the U.S. to the BRIC countries. The technique of ARMA E-GARCH (1,1) was employed so as to analyze the impact. The data collected is a time series data which requires specific attention to be given to the stationarity of the series as well. The analysis has been done with the help of MS EXCEL and EVIEWS.

↳ **ARMA E-GARCH (1,1) :** The financial time series data generally contains a unit root or in other words, we can say that the financial time series data is non-stationary in nature, as pointed out by Gujarati, Porter, and Gunasekar (2013). The data should be made stationary before factoring into any model as the non-stationary data would entail to spurious results. The Augmented Dickey Fuller test was used to check the stationarity of the return series. The

Augmented Dickey Fuller test augments the lagged values of the dependent variable in the series :

$$\Delta Yt = \beta 1 + \beta 2t + \delta Yt - 1 + \Sigma^{m}_{i=i} \alpha i \, \Delta Yt - i + \varepsilon t \ldots\ldots\ldots \quad (2)$$

where,

εt is a pure white noise error term. The null hypothesis is $\delta = 0$ and the alternate hypothesis is $\delta < 0$. The null hypothesis states the presence of a unit root in the series, thus stating that the series is non-stationary in nature ; whereas, the alternate hypothesis supports the non-existence of a unit root in the series, thereby stating that the series is stationary in nature.

After checking the stationarity of the series, ARMA E-GARCH (1,1) model was used to account for the spillover of the volatility and the leverage effects. Under ARMA, a dependent variable is a function of its own lagged values *(p)* as well as its error terms *(q)*. The *(p)* and *(q)* lagged values have been decided on the basis of correlograms.

$$Y_t = a_0 + \alpha_1 Y_{t-i} + \beta \, \varepsilon_{t-i} + \varepsilon_t \ldots\ldots\ldots (3)$$

where,

Y_t is stock market return, Y_{t-i} is lagged value of Y_t, ε_{t-i} is the lagged value of the error term, and εt is the error term or residual from the equation. In order to employ the GARCH type models, the ARCH effects or the heteroskedasticity in the residuals (variances), extracted from the equation 2, should be there. The heteroskedastic variances mean that the variances are not homoskedastic, rather they are varying with the passage of time.

Under E-GARCH, the logged conditional variance is a function of its own lagged values as well as of the error terms. The EGARCH model was developed by Nelson (1991) to capture the leverage effects in the volatility. By leveraging effects, we mean that the falling returns add to the volatility in the market in comparison to the positive returns. The decreasing returns reduces the equity value in comparison to the debt value, which further increases the volatility in the equity markets, as studied by Black (1976).

$$log \, h_t = \alpha_0 + \alpha_1 \left(\frac{|\varepsilon_{t-1}|}{h_{t-1}} - \sqrt{\frac{2}{\pi}} \right) + \delta \, \frac{\varepsilon_{t-1}}{h_{t-1}} + \beta_1 h_{t-1} + \lambda \varepsilon^2_{t-1} \ldots\ldots\ldots \quad (4)$$

where,

δ is an asymmetry coefficient and the presence of leverage effect will be there when $\delta < 0$ and is found to be significant. The α_1 and β_1 are the ARCH terms and the GARCH terms respectively, where the ARCH term exhibits the impact of the news or information on the conditional volatility and the GARCH term exhibits the persistency level in the volatility.

To study the spillover effects from the U.S., one day lagged squared residuals extracted from the mean equation of the U.S. market from eq (2) was introduced as an explanatory variable in the conditional variance equation of the BRIC countries. If the coefficient λ is found to be significant, then there is spillover of volatility from the U.S. to the BRIC countries' stock markets during the period undertaken for the study.

Data Analysis and Results

To start with, an attempt has been made to understand the behavior of the return distributions. The Figure 2 is the graphical presentation of the index returns during the year 2007-2009. All the markets were volatile during this period due to the existence of the subprime crisis. Small changes are followed by smaller changes and vice-versa for larger changes. This justifies the adoption of the EGARCH model to capture the volatile nature.

The Table 1 reports the index returns and characteristics. On an average, returns were higher in the Brazilian market, followed by the Indian market during the crisis period ; whereas, the returns were negative for the Russian

Figure 2. Graphical Presentation of Index Returns

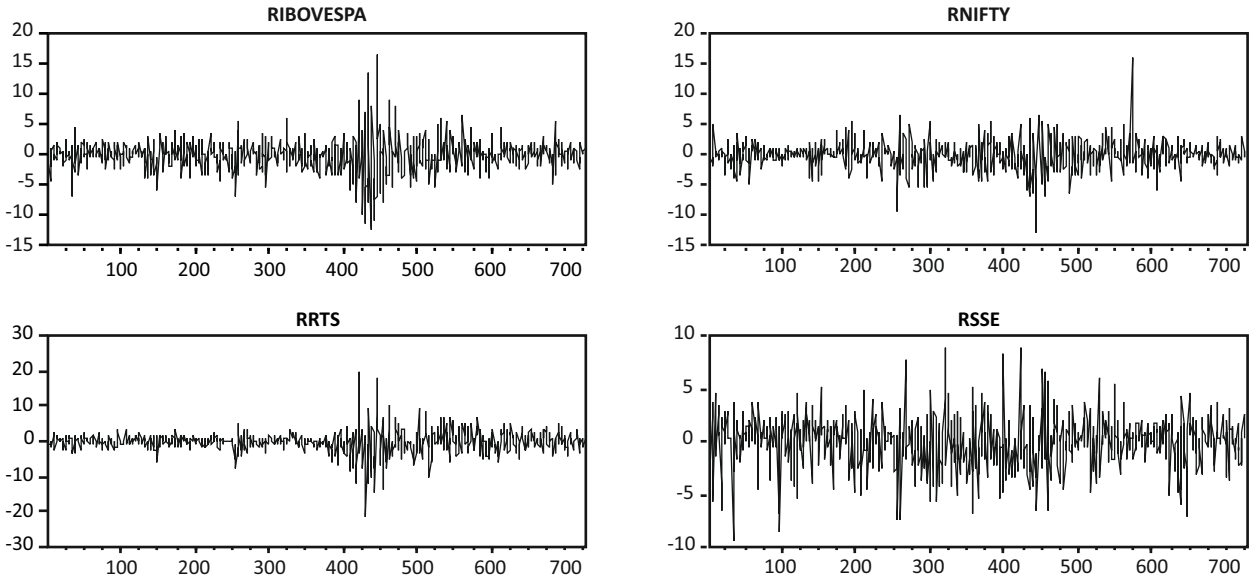


Table 1. Index Returns and Characteristics

Particulars	Brazil	India	Russia	U.S.	China
Mean	0.054093	0.033297	-0.032297	-0.030641	0.024949
Median	0.175466	0.092083	0.131980	0.079341	0.291172
Maximum	13.67661	16.33432	20.20392	10.95720	9.034251
Minimum	-12.09605	-13.01419	-21.19942	-9.469514	-9.256154
Std. Dev.	2.342952	2.136629	2.943001	1.839011	2.271668
Skewness	-0.015402	0.081726	-0.367418	-0.149880	-0.343399
Kurtosis	8.118347	9.563303	12.64316	9.551250	4.665077
Jarque-Bera	854.7235	1406.257	3051.436	1403.160	105.8411
Probability	0.000000	0.000000	0.000000	0.000000	0.000000

Figure 3. Thirty Days Rolling Correlation of BRIC Countries' Returns with the U.S. One Day Lagged Return

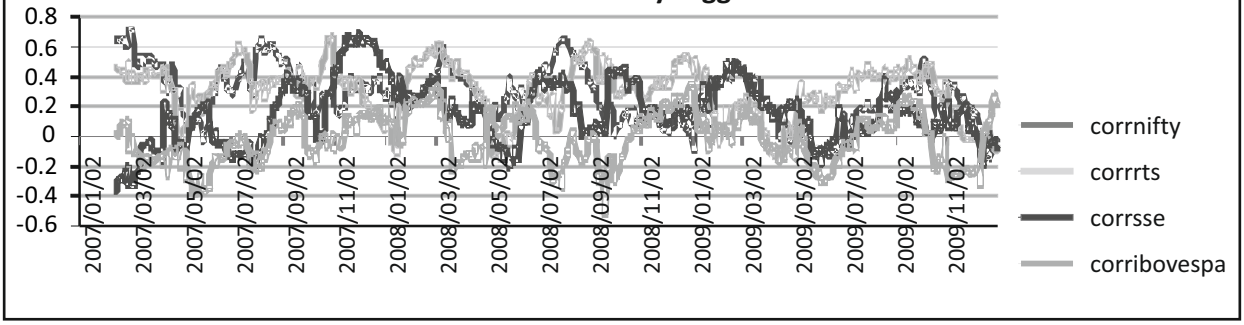


Table 2. E-GARCH (1,1) Results

	Brazil			Russia			India			China		
	Coeff	***z*-stat.**	***p*-value**	**Coeff**	***z*-stat.**	***p*-value**	**Coeff**	***z*-stat.**	***p*-value**	**Coeff**	***z*-stat.**	***p*-value**
α_1	0.121	3.599	0.000*	0.157	7.350	0.000*	0.234	7.944	0.000*	0.101	3.904	0.000*
β_1	0.937	59.555	0.000*	0.968	131.614	0.000*	0.938	80.575	0.000*	0.886	36.833	0.000*
δ	-0.141	-5.729	0.000*	-0.097	-6.279	0.000*	-0.104	-4.628	0.000*	-0.133	-5.228	0.000*
λ	0.004	2.172	0.029*	0.003	1.683	0.0924	0.003	1.634	0.102	0.002	1.283	0.199
$\alpha_1 + \beta_1$		1.059			1.125			1.172			0.987	
AIC		4.16			4.40			4.12			4.41	
Arch test (1)		0.1397**			0.226**			0.548**			0.590**	

* Reject Null Hypothesis of no relation at the 5% significance level ;
** Accept Null Hypothesis of homoskedasticity at the 5% significance level

and the U.S. markets (Table 1). The Russian economy witnessed higher standard deviation in the stock market returns as compared to the other countries. The Kurtosis values are reasonably high in all the countries, thereby highlighting the presence of clustering in the financial data. The Jarque-Bera test exhibits that the series are not normally distributed. Barring India, the skewness values are negative for other countries, which shows that the probability of negative returns is higher as compared to positive returns.

It has been observed that the financial time-series data suffers from the clustering phenomenon as well as from the leptokurtic distributions. This has also been observed in our return series during the crisis period. The *p* -values extracted from the Augmented Dickey Fuller test support the acceptance of the alternate hypothesis of stationary time series at the 5% significance level, thereby stating that the return series are stationary in nature.

The Figure 3 exhibits the 30 days rolling correlation of the BRIC countries' market returns with the U.S. one day lagged return. A rolling correlation is a better way to comprehend the behavior and the co-movement among the markets during the period, which has been taken into consideration for the purpose of the study. The fluctuations in the correlation coefficients during the period highlights the existence of a crisis during that period. The correlation coefficients are positive and comparatively very high in the context of the Russian, Indian, and Chinese stock markets during the third quarter of the year 2008 because of the Lehman Brothers crisis that took place. The correlation coefficient between the stock market returns of the U.S. and the Brazilian market remains more or less negative throughout the concerned period.

During the third quarter of the year 2008, the coefficient fell drastically, becoming negative in nature, stating that the return spillovers that took place between the Brazilian and the U.S. markets had a negative relation and correlation with each other, whereby the increased returns in one market led to decreased returns in the other market.

Volatility Spillover from the U.S. to the BRIC Countries

There are time differences in the trading hours of the concerned countries. The time difference between the U.S. (New York) and Brazil is only 1 hour in comparison to the other countries in the BRIC block, so contemporaneous volatility spillover impacts do exist (Bhar & Nikolova, 2007). However, in the present study, we are focusing only on the dynamic impact of the U.S. market on the BRIC countries, and thus, we relied only on the one day lagged U.S. market effect. Due to the increased level of integration among the markets all over the world, the crisis which started in the U.S. got spillover from the domestic market to the other foreign markets directly as well as indirectly. The indirect spillover took place in the sense that even though a country did not have a direct exposure to the U.S. market, but having linkages with the countries who further had an exposure to the U.S. market resulted in a spillover of the crisis to that country as well.

The ARCH effects have been found in the return series of the BRIC countries at the 5% significance level. The presence of the ARCH effects further exhorts the use of the E-GARCH model to capture the spillover impact as well as the leverage impact of negative returns. The E-GARCH results (Table 2) of the Brazilian, Russian, Indian, and Chinese markets are being reported as above. In case of the Brazilian stock market, both the ARCH and the GARCH terms are found to be significant. The *z*-statistic is higher in case of the GARCH effect, stating that the past volatility had a larger impact on the current conditional volatility. There is persistency in the conditional volatility. The asymmetric coefficient is also found to be significant, exhibiting that the falling returns had an increased impact on the conditional volatility. The one day lagged volatility in the U.S. stock market also had a statistically significant impact on the current conditional variance of the Brazilian market, thereby reporting the spillover of the U.S. stock market volatility to the Brazilian market. This result is compatible with the findings of Nikkinen, Saleem, and Martikainen (2013), but only with respect to the Brazilian market. The total of the ARCH and GARCH terms needs to be less than one so that the volatility gets reduced and reverts to the unconditional level over a period of time. However, in case of the Brazilian market, the total is greater than one, making the case of an explosive and infinite volatility in the Brazilian market. The results are compatible with the results obtained by other researchers. After applying the GARCH model, there are no ARCH effects left in the residuals, and the residuals derived from the conditional variance equation are idiosyncratic errors.

The one day lagged volatility in the U.S. stock market does not have a statistically significant impact on the Russian stock market (Table 2) during the period undertaken for the study. The ARCH and the GARCH terms are found to be significant. The impact of a news or any information is lesser in comparison to the past volatility. The asymmetric coefficient is found to be statistically significant, showing the leverage effects. The crisis which started in the U.S. did not have an impact on the conditional variance of the Russian market directly, yet the falling returns increased the volatility and had an impact on the Russian market indirectly. The total of the ARCH and the GARCH terms is more than one, highlighting the explosiveness in the conditional variance. The ARCH effects are not in existence after employing the GARCH model.

In case of the Indian stock market (Table 2), the results are similar to the Russian stock market, where the impact of past volatility is greater in comparison to the new impact on the conditional volatility. The coefficient of the one day lagged U.S. stock market volatility to account for the impact on the Indian stock market volatility is not found to be statistically significant, but the asymmetric coefficient is found to be significant, showing that the leverage effects are present in the Indian stock market. During a crisis period, the behavior of the investors changes due to the risks present in the emerging markets as compared to the advanced economies. This leads to the flow back of funds to the advanced economies in the event of any crisis, as observed by Frank and Hesse (2009). The flow back of funds entail to negative returns in the emerging markets. Similarly, Mishra, Das, and Pradhan (2010) observed that the increased volatility in the Indian market was a product of the U.S. financial crisis. Again, the total of the ARCH and GARCH terms is greater than one, highlighting the explosive volatility during this period. The residuals are homogenous after applying the GARCH model. The results for the Chinese market (Table 2) are similar to the ones obtained for the Indian and Russian markets. The asymmetric coefficient and the ARCH and GARCH terms are found to be statistically significant at the 5 % level. However, the coefficient of the one day lagged U.S. volatility is not statistically significant. The residuals are found to be homogenous after applying the GARCH model. In case of the Chinese market, the total of the ARCH and GARCH terms is less than one, stating that the volatility dies out over a period of time. With respect to the Chinese market, the result is compatible with the results obtained by Kishore and Singh (2014), wherein the authors could not detect a direct impact of the U.S. stock market news on the Chinese and Brazilian markets' volatility.

In case of the Brazilian, Russian, and Indian markets, the volatility is very explosive as depicted by the total of ARCH and GARCH terms, making the conditional volatility in the markets non-stationary. The non-stationarity of the conditional variance makes the model unfit for forecasting, but as the study covers the period during the subprime crisis, an explosive volatility is evident. The main motive of the study is to model the volatility during the crisis period and not to forecast the conditional volatility. Overall, the results reported by the model employed support the rejection of the null hypothesis only with regards to the Brazilian market at the 5% level of

significance. The null hypothesis states that the U.S. market volatility did not have a significant impact on the BRIC markets respectively, against the alternative of the significant impact of the U.S. market volatility on the BRIC markets respectively. With respect to the Russian, Indian, and Chinese markets, we failed to reject the null hypothesis at the 5% significance level per se. Moreover, the results reported by the model justify the volatility present in the BRIC markets during the period from 2007-2009. The leverage effect, volatility persistency, and volatility spillovers from the U.S. market put the BRIC markets in a jittery phase, as depicted in the Figure 2.

Research Implications

A change in the conditional variance requires a portfolio manager to adjust the allocations so as to maintain the portfolio values. The interaction in the conditional variances due to the increasing integration among the markets; the spillover of the variances is, furthermore, an inevitable thing that the managers should consider, especially during an adverse event. Moreover, as reported by the study, the indirect impact of volatility in one country as compared to another is also a new phenomenon requiring the understanding of the spillover(s). A proper strategy should be employed to hedge a portfolio by diversifying the portfolio and by using derivative products.

Conclusion

To model the dynamic spillover of the volatility of the U.S. market to the BRIC countries' market during the subprime crisis, the major stock market indices have been taken into consideration. The stock market indices discount the future information well in advance. So, to analyze the impact of one economy on the other during the crisis period, stock indices act as a robust instrument. The technique of ARMA E-GARCH (1,1) was employed to capture the spillover effects. The trade relations among countries come to a standstill in the event of a crisis. All this has an impact on the stock markets as well. The volatility of one market spillsover to the other market directly as well as indirectly during a crisis period.

The results from the E-GARCH (1,1) model support spillover of the U.S. stock market volatility to the Brazilian stock market only. The coefficient of the one day lagged U.S. market volatility is not found to be significant at the 5% level in the context of the Russian, Indian, and Chinese markets. The results derived from the E-GARCH model are different, considering the findings of the other researchers. However, the period which we have considered is full of adverse events that took place in the U.S. market due to the subprime crisis. The results reported by the model bring into being a new fact that the volatility in the Russian, Indian, and the Chinese markets did not get affected by the volatility in the U.S. market directly during this period, yet the indirect impact was observed in the sense that the falling returns in these markets further increased the conditional variance. The falling returns make the investors to expect a risk premium, which further discounts the stock prices and increases the volatility.

Due to latest technology, markets all over the world are integrated with each other. The increasing cross country transaction of securities has made the stock markets vulnerable to a crisis. Global investors need to understand the linkages that exist between the countries. If a crisis and the volatility of one market have an impact on the volatility of another country's market, then the diversification benefits will be reduced for an investor. A high standard deviation or a highly volatile market incorporates various risks in the portfolio of an asset class, and the problem increases further when the volatility of one market gets transferred to the other market, thereby having an impact on the portfolio returns.

Limitations of the Study and Scope for Future Research

The present study has considered only an adverse event, that is, the U.S. financial crisis period (from 2007 - 2009).

Future research can be extended to cover the period after the U.S. financial crisis, specifically to understand the impact of a developed economy like the U.S. on other emerging markets, either directly or indirectly. Moreover, the same study can be conducted with regard to other emerging markets or frontier markets, and researchers can ascertain their response to volatility from a developed economy.

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