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Full Length Research Paper

Behaviour of emerging stock markets in the global financial meltdown: Evidence from bric-a

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This paper examines the emerging market indices of Brazil, Russia, India, China, and Argentina (BRICA) and investigates the linkages among the stock markets of the BRICA countries and their relations with the US market. We employ the vector auto regression (VAR) techniques to model the interdependencies and Granger causality test to find evidence of a short-run relationship between these markets. In addition, we employ the Impulse Response test to evaluate the persistence of shocks by using daily data from 1st January, 2002 to 18th February, 2009. Our findings show that the US market has a significant effect on all BRICA countries in the same trading day. The most integrated markets to the BRICA countries are Russia and Brazil; the least integrated ones are China and Argentina. The Granger causality test supports our VAR calculations and shows that Russia influences all other countries and Brazil affects Argentina, Russia and India. However, China only affects Argentina and Russia. Impulse response test shows that all countries respond to an anticipated shock immediately and recover in nearly five or six days.

Key words: Emerging markets, global financial crisis, integration, correlation, spillover.

INTRODUCTION

Recent financial meltdown although appearing ruinously from the current viewpoint is by no means a unique event. Extraordinary events such as the US stock market crash in 1987; the breakdown of the European Monetary System in 1992; the turmoil in bond market in 1994 and the Asia-Pacific crisis beginning in 1997 were all extraordinary events. In today's fast moving finance world, there are many factors binding financial markets to each other. The existence of strong economic and trading links, the increases in liberalization activities of governments, the advancement of international trade and finance, rapid developments in telecommunication and trading systems, and the formation of common trading blocs such as NAFTA, EU and ASEAN are some factors contributing to financial integration. However, integration among world equity markets reduces the diversification benefits of investing in international markets. Therefore, it is vital for the international investors and global portfolio managers assess the dependencies among international stock markets especially whilst the economies in turmoil.

In this paper we try to examine the relationship between the behaviour of stock prices of the BRICA countries and their interactions with US market to investigate whether there is potential for diversifying risk by investing in stock markets of these countries. BRICA, referring to the combination of Brazil, Russia, India, China and Argentina, consists of the fast-growing economies that are anticipated to surpass the current rich countries in the near future. However, there is no empirical research in the finance literature addressing to the interactions among the stock markets of BRICA countries. The major aim of this paper is to test whether the BRICA countries still offer international

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investors a valuable diversification benefit despite their rapidly growing economic integration and increasing role in the world economy.

The paper is structured as follows: Section 2 briefly glances at the previous studies on market integration. In section 3 the data and the methodology are presented. The empirical results are discussed in Section 4. Section 5 concludes the paper.

Previous studies

In general, the lack of interdependence across national stock markets has been accepted as a factor supporting the benefits of international portfolio diversification. In the same vein, there are several available studies on both long-run and short-run relationships among international stock markets. The studies on co-integration provide conflicting evidence depending on the use of the different markets, different sample periods and different frequency of observations (daily, weekly or monthly) as well as different methodologies to investigate the interdependence of stock markets. The focus of the majority of early studies has been on stock markets of developed countries. So that, with increased globalization of stock markets and importance of emerging markets in the world economy, a study on the relationships among the major emerging markets and their interactions with world leader may be important. Although there are a few studies that address the integration of emerging markets on the regional basis, to our knowledge, none of them has specifically focused on the BRICA countries. This paper intends to fill this gap.

Chaudhuri (1997) used the Engle-Granger co-integration and Granger causality test to examine the relation among six Latin American countries for the period of 1985 -1993 and found a long run relationship between them. In addition, they found a significant causal relationship in both directions. Chen et al. (2002) examined the relationship between six Latin American countries including Argentina and Brazil, and employed the error correction VAR technique using daily returns from 1995 - 2000 and argued that the diversification benefit in different Latin American markets was limited. Fernandez and Sosvilla (2003) provided evidence on relationship between US and Latin American markets using daily data covering the period of 1995 - 2002 and employed co-integration techniques allowing for structural breaks. Their results suggested that when conventional cointegration techniques were applied, a long run relationship could be found only between Brazilian index with S and P500. In contrast, they concluded that if the structural breaks were introduced, a strong evidence of co-integration would exist among these markets. This implied that it was still possible in this region to derive portfolio diversification in the short run. However, the gains from international diversification for investors with long holding periods might be limited.

Chang et al. (2000) applied VAR test in stock market daily returns of five Chinese regions, Taiwan, Hong Kong, Singapore, Shanghai and Shenzhen, in addition to USA and Japan; according to their empirical finding, out of the seven stock markets, only USA and Japan were influential. Huang et al. (2000) applied co-integration techniques that allow the structural breaks to investigate the relationship among US, Japan and South China Growth Triangle (SCGT) along the sample period spanning from 2nd October, 1992 to 30th June, 1997 and found no integration among these markets except between Shanghai and Shenzhen. Their Granger causality test showed that the stock price changes in US have more impact on SCGT markets than do those of Japan. In their study Narayan et al. (2004) focused on South Asia as a region and examined the linkages between the stock markets of Bangladesh, India, Pakistan and Sri Lanka, using daily data over the period of 1995 - 2001. They tested the long-run relationships by applying the bounds test and found that in the long run, stock prices in Bangladesh, India and Sri Lanka influenced stock prices in Pakistan. In addition they employed the Granger causality analysis to examine the impulse response functions. They found that in the short run there was unidirectional Granger causality from stock prices in Pakistan to India, stock prices in Sri Lanka to India and from stock prices in Pakistan to Sri Lanka. Groenewold et al. (2004) use co-integration and VAR analysis to unfold interrelationship between stock market indexes in greater China (Shanghai and Shenzhen together as Mainland China, Hong Kong and Taiwan) in the time span of 1992 - 2001. The results show that in a large extent the mainland Chinese markets were insulated from the other two, while some linkage existed between Taiwan and Hong Kong. Chen and Glascock (2005) examined the linkages among these three greater China stock markets and two developed markets including Japan and US with weekly data covering the period from January, 1993 to August, 2004. By employing the Johansen test they found that the GCEA markets were not co-integrated with either the Japanese or the U.S. market and they were not co-integrated with each other. Cheung et al. (2006) examined the China's integration with Hong Kong and Taiwan and found a partial integration. In his study, Li (2007) estimated a four-variable GARCH for the Shanghai, Shenzhen, Hong Kong and New York markets. He allowed for time varying variance-covariance, in a period of 2000 - 2005, but failed to find any integration of the Chinese markets with that in the US, while identifying a very weak link for spillovers of volatility from Hong Kong to the two Chinese markets. Kashefi (2008) used the co-integration and causality tests to find a pair-wise relationship between the US and Pacific Rim markets. The results indicated no long run relationship between all markets. Their Granger Causality tests showed that U.S market changes led to changes in Pacific Rim markets, save China.

Meric et al. (2006) used rolling correlations and

Table 1. Statistical properties.

	BOVESP	MERVAL	RTSI	SENSEX	SHCOMP	SPX
Mean	0.000301	0.000392	0.000279	0.000539	0.000221	-0.000170
Std. Dev.	0.019577	0.021005	0.023063	0.016671	0.017742	0.011519
Skewness	-0.283012	-0.345788	-0.687530	-0.597940	-0.095566	-0.042948
Kurtosis	6.724186	7.688150	18.44461	8.253424	7.140049	15.78293
Jarque-Bera	893.3754	1413.857	15136.87	1827.592	1081.406	10288.06
Probability	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

Principal component analysis (PCA) to determine the integration of seven Latin American economies in a sample of 1995 - 2005 on weekly returns of the stock market indexes. In addition they employed the same methodology including the Latin American countries together with seven major developed stock markets and nineteen emerging stock markets. They found that China exhibited some co movement with emerging Asian markets, while Russia seemed to co move with the large emerging Europe countries. Lucey and Voronkova (2007) used dynamic conditional correlation (DCC) derived from multivariate GARCH framework to make inferences about short-term interdependence between Russian equity market and developed markets. They applied co-integration methods testing the relationship between Russian and other equity markets over the period of 1995 -2004. They obtained mixed results about the number of co-integration relationships after the 1998 Russian equity market crisis, taking into account co-integration with both single and multiple breaks.

Although the past studies pointed out mixed results on long-term and short-term linkages between the returns of BRICA stock markets in their region, majority of the studies, which included US stock market into their analysis, argued that the US market was still leading world stock market. In this study, we employ VAR analysis and Granger causality test to measure the short-term interaction within the BRICA countries and their relation with US stock market. Our results also suggest that US stock market have a significant effect on all BRICA countries.

Data and methodology

The sample consists of the daily values of the stock indices of Brazil (BOVESPA), Russia (RTSI), India (SENSEX), China (SHCOMP) and Argentina (MERVAL) provided by Is Investment Inc. As a proxy of world stock market, S and P500 Index (SPX) is used. All the indices are measured in local currency, assuming the perspective of an investor hedging the currency risk. The data set starts on 1st January, 2002 and ends on 18th February, 2009, consisting of 1511 observations. The daily returns are calculated by taking the natural logarithm of the first differences of the indices. Statistical properties of the data are given in Table 1.

The high variability of RTSI is visible in Table 1. As expected, SPX is the least risky index among these 6 indices followed by SHCOMP. The non-normality of the returns can be seen from leptokurtic distributions and the results of Jarque-Bera normality tests. The third moment reveals that the return series are not symmetric and left tailed. Another interesting finding is the negative mean value of the S and P500 Index, which reflects the negative effects of the global financial crisis.

Figure 1 plots the index values for the sample. The upward and downward trends are nearly the same for all indices. All indices reveal the sudden fall due to global financial crisis starting from the end of 2008.

The unconditional correlation matrix is reported in Table 2. The highest correlation is between Brazil and Argentina, geographically near locations, followed by S and P500 and Brazil. The lowest correlation coefficient is calculated between Argentina and China.

In this present paper, a Vector Autoregression (VAR) model is used in order to determine the spillovers between BRICA countries. A VAR model is a simultaneous-equation model, where some variables are both exogenous and endogenous. That is, some independent variables are also included in the model as dependent variables. The model also contains the lagged values of the variables. A p'th order VAR can be written as:

$$Y_t = \alpha + \sum_{j=1}^{p} Y_{t-j}\phi_j + U_t \text{ and } U_t \sim iid(0, \sum)$$

Where Y_t, a $1 \times g$ vector, denote the t'th observation on a set of g variables, U_t is a $1 \times g$ vector of error terms, α is a $1 \times g$ vector of constant terms, and the ϕ_j, for j = 1,... p, are $g \times g$ matrices of estimated coefficients.

According to this specification, the returns of indices of BRICA countries and SPX can be written as:

$$r_{it} = \alpha_i + \beta_s r_{spx} + \sum_{j=1}^{p}\sum_{k=1}^{5} r_{t-j,k}\beta_{i,k} + u_{it}$$

where r_{it} is the return of country i in time t, β_s is the coefficient of SPX, r_{spx} is the return of SPX, k denotes the BRICA countries (for k = 1, … , 5), j denotes the number of lags (for j = 1, … , p) and, $r_{t-j,k}$ is the returns of BRICA countries. As an example, the following expression is for the returns of BOVESPA for one lag:

$$r_{1t} = \alpha_i + \beta_g r_{spx} + \beta_{1,1} r_{1,t-1} + \beta_{1,2} r_{2,t-1} + \beta_{1,3} r_{3,t-1} + \beta_{1,4} r_{4,t-1} + \beta_{1,5} r_{5,t-1} + u_{it}$$

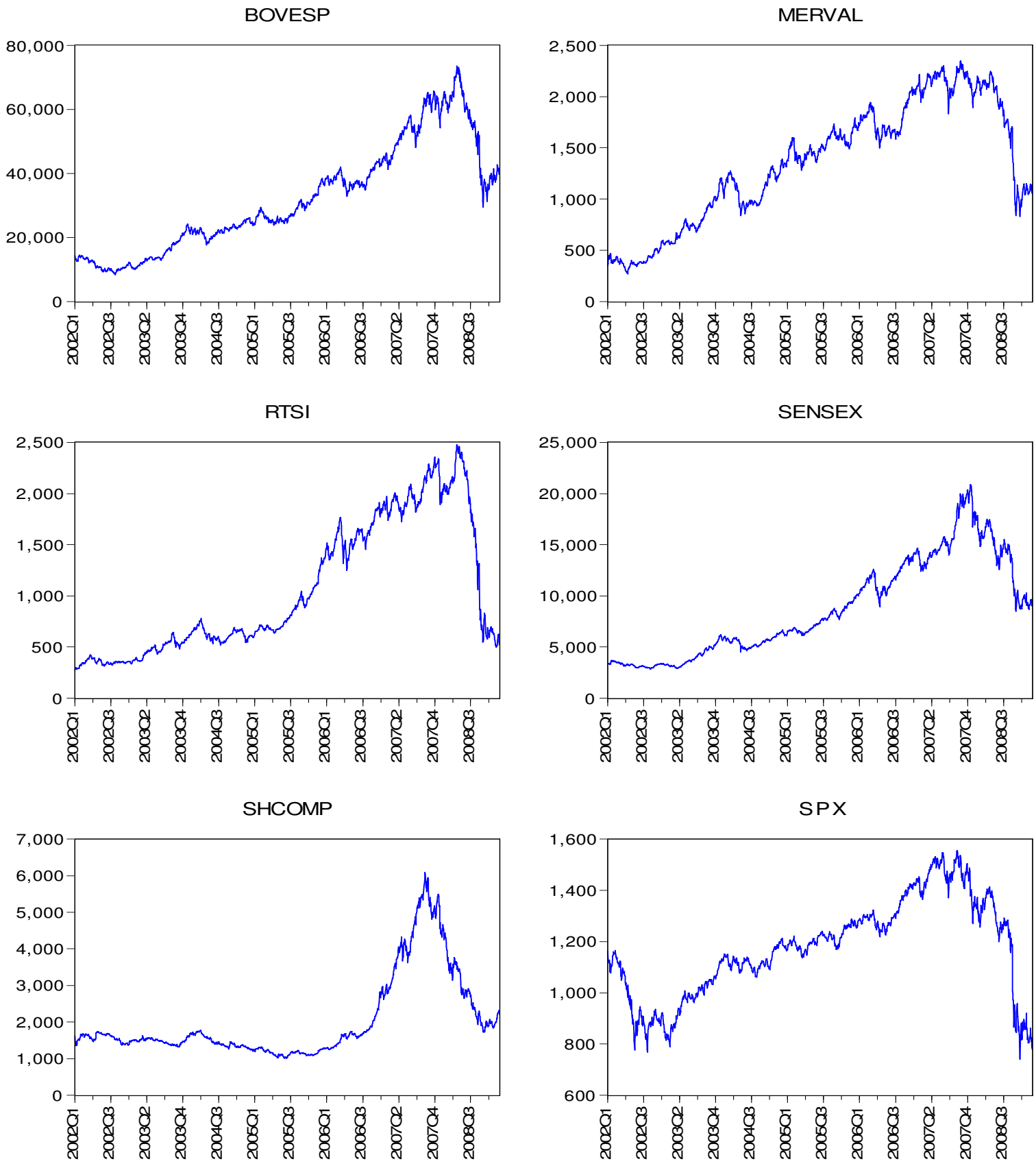

Figure 1. Stock indices.

Table 2. Unconditional correlation matrix.

	BOVESP	MERVAL	RTSI	SENSEX	SHCOMP	SPX
BOVESP	1.000000					
MERVAL	0.462478	1.000000				
RTSI	0.291891	0.271521	1.000000			
SENSEX	0.221023	0.171977	0.335369	1.000000		
SHCOMP	0.118392	0.070120	0.134888	0.179270	1.000000	
SPX	0.459142	0.374747	0.435390	0.278442	0.091313	1.000000

Table 1. The results of unit root tests*

Variable	Lag	ADF	PP
BOVESPA	0	-39.10212	-39.23893
MERVAL	0	-39.32709	-39.45838
RTSI	0	-36.46228	-37.07621
SENSEX	0	-37.65051	-37.64342
SHCOMP	0	-39.52782	-39.53595
SPX	7	-13.75246	-38.24812

*The McKinnon critical value rejecting the null hypothesis of a unit root is -2.863248 at the %5 level of significance.

Where $\beta_{1,1}$ is the autocorrelation, $\beta_{1,2}, \beta_{1,3}, \beta_{1,4}, \beta_{1,5}$ are the spillover coefficients of other countries, and β_g is for the global effects (SPX).

In this VAR specification, S and P 500 index is treated as an exogenous variable. In this model, including the SPX as an endogenous variable means that, the returns in SPX is determined by its own lagged values and the lagged values of BRICA countries. However, keeping in mind that S and P500 is one the leading stock market indices of the world, one can assume that BRICA countries' market returns have nothing to influence SPX. That's why SPX is included into the model as an endogenous variable.

Empirical results

First, we tested the data for stationarity by using Augmented Dickey and Fuller and Phillips and Perron unit root tests. The results of these two tests are summarized in Table 3.

The lag lengths of ADF unit root tests are selected according to Schwarz Information Criterion. The model used in both ADF and PP test includes a trend and intercept, as it is popular when working with index data. Excluding the trend or intercept terms do not change the results. The results are also not affected when the information criterion for optimal lag length is changed. As seen in Table 3, the results of both unit root tests reject the null hypothesis of a unit root. That is, we can clearly conclude that the return series for all these six indices are stationary. In order to determine the optimal lag length, VAR lag order selection criteria are used. The result of this test up to 8 lags is shown in Table 4. According to AIC and FPE criteria 3 lags are optimal for our model.

The results of VAR Lag Exclusion Wald Tests are given in Table 5. The results reveal that the fourth lags of endogenous variables are jointly insignificant at 5% significance level. The VAR estimation results of the model are reported in Table 6.

At first sight, the results show that SPX returns have a significant effect on all BRICA countries in the same trading day. The signs of all coefficients for this variable are positive indicating the co-movement of these emerging markets with SPX. The most integrated markets with the others are Russia and Brazil where the least integrated are China and Argentina, as there are only two significant coefficients belonging to Chinese and Argentinean stock market returns. The isolation of Chinese stock market from other markets is visible from the low adjusted R-squared value of the China model, which can be explained by the restrictions on free international movements of capital in China. However, Argentina, which is an open market economy, is only affected by Brazil and SPX. Another interesting finding of the model is that, one lagged value of Brazil, spills over all other markets except China. According to our model, Russia is the most integrated market to the BRICA countries, as all other markets affect Russian market. On the other hand, Russian market is not affected by its own lagged values, which shows that investors in Russian stock market should not care about the near past values of the returns for their investment decisions. Brazil is the second most integrated market to the BRICA countries, as nearly all other markets affect Brazil except China. Interestingly, all the significant coefficients of Brazilian market returns model except Russia and SPX is negative, revealing the opportunity of hedging for the international investors. The transmission for Brazil is as follows, the returns of Brazil are negatively affected by yesterdays Brazilian, Argentinean and three days lagged value of Indian market returns, whereas one day lagged value of Russia has a positive impact. Another interesting result is the effect of Brazilian market on Indian stock market returns. SENSEX is significantly affected by the all three lagged values of Brazilian market returns.

In order to evaluate the persistence of shocks, the impulse-response functions for a time horizon of 10

Table 4. VAR lag order selection criteria.

Lag	FPE	AIC	SC	HQ
0	2.86e - 18	-26.20702	-26.17166*	-26.19385
1	2.73e - 18	-26.25288	-26.12910	-26.20677*
2	2.70e - 18	-26.26401	-26.05183	-26.18498
3	2.69e - 18*	-26.26706*	-25.96647	-26.15509
4	2.71e - 18	-26.26041	-25.87140	-26.11550
5	2.73e - 18	-26.25341	-25.77600	-26.07558
6	2.76e - 18	-26.24153	-25.67570	-26.03076
7	2.80e - 18	-26.22635	-25.57211	-25.98265
8	2.81e - 18	-26.22515	-25.48251	-25.94852

*indicates lag order selected by the criterion.
FPE: Final prediction error.
AIC: Akaike information criterion.
SC: Schwarz information criterion.
HQ: Hannan-Quinn information criterion.

Table 5. VAR lag exclusion Wald tests.

	Joint	Joint
Lag 1	126.5499	125.7854
	(1.55e-15)	(2.11e-15)
Lag 2	67.27678	70.69786
	(9.69e-06)	(3.03e-06)
Lag 3	54.50779	56.90915
	(0.000571)	(0.000275)
Lag 4	37.04641	
	(0.057154)	

trading days are given in Figure 2. Impulse-response functions measures the impact of an unanticipated shock on time t on the future returns. Graphs show that, a one standard deviation shock on stock market returns dies out very quickly for all six indices. After nearly five or six days, the reactions to innovations are not measurable. In addition, the reactions are very small, within ± 0.004 band.

The Granger causality test is a common method to measure causality between two variables. If the lagged observations of a variable (x) do not help to predict the future values of another variable (y), we can conclude that x does not Granger-cause y (Granger, 1969; Sims, 1972). The p-values for the null hypothesis of x does not Granger-cause y for BRICA countries are shown in Table 7. The last row indicates the joint significance of all lagged endogenous variables in the model.

The Granger causality test results are in line with VAR estimates. According to the results, Brazil Granger-causes Russia and India. Russia Granger-causes all other countries, whereas China only influences Argentina. The feedback effects (x Granger-causes y and y Granger-causes x) are between Brazil - Russia, Brazil - India, and Russia - China. For all models, all other endogenous variables are jointly significant except Argentina.

Conclusion

In this paper, we investigate the relations among the emerging stock markets of BRICA countries and the US on the threshold of a global financial crisis in the highly globalized finance world for possible portfolio diversification opportunities for the investors. The VAR estimation results show that the US stock market has significant effect on all BRICA countries in the same trading day. This result supports the previous studies. We find out that Russia is the most integrated market to the BRICA countries, as all other markets affect Russian one. Brazil is the second most integrated market to the BRICA countries, and like Russia, all the other markets affect Brazil except China. Another important finding is that all the significant coefficients of Brazilian stock market model except Russia is negative, thereby indicating the opportunity of hedging for international investors. We also find that Chinese market is segmented from the aforementioned markets; hence, it carries potential for providing benefit for international diversification. This can be explained by the restrictions on international capital movements in this country. The findings are in line with the majority of the previous studies on China. However, although Argentina is an open market economy, only Brazil and the US affect it. Another interesting result is that one lagged value of Brazil spills over all other markets except China. The Granger causality tests are in line with the VAR estimates and show that Brazil affects Russia and India; Russia affects all other countries and China influence only Argentina. In addition, the impulse-response analysis indicates that if there is an unanticipated shock, all countries would react swiftly and recover

Table 6. VAR estimation results.

	BOVESP	MERVAL	RTSI	SENSEX	SHCOMP
BOVESP(-1)	-0.090564*	-0.084671*	0.142437*	0.082335*	-0.010194
	(-3.36425)	(-2.83123)	(4.47038)	(3.35443)	(-0.37282)
BOVESP(-2)	-0.009589	0.007767	-0.002020	0.086260*	-0.046179
	(-0.35425)	(0.25829)	(-0.06305)	(3.49505)	(-1.67953)
BOVESP(-3)	-0.019132	-0.017192	0.046665	0.052847*	-0.012811
	(-0.70960)	(-0.57396)	(1.46223)	(2.14961)	(-0.46776)
MERVAL(-1)	-0.054771*	-0.024313	0.039974	0.023036	0.045462
	(-2.25029)	(-0.89915)	(1.38755)	(1.03799)	(1.83877)
MERVAL(-2)	0.029202	-0.015852	0.080346*	0.064731*	0.032136
	(1.20374)	(-0.58817)	(2.79814)	(2.92639)	(1.30407)
MERVAL(-3)	0.021558	0.019575	-0.019871	0.039160	0.059422*
	(0.88484)	(0.72321)	(-0.68909)	(1.76280)	(2.40109)
RTSI(-1)	0.087030*	0.036343	0.019023	0.035119	0.043905
	(3.97661)	(1.49474)	(0.73436)	(1.75988)	(1.97492)
RTSI(-2)	-0.010172	0.033309	-0.027413	-0.004113	-0.020560
	(-0.46404)	(1.36779)	(-1.05655)	(-0.20576)	(-0.92334)
RTSI(-3)	0.017860	0.000247	-0.003645	-0.025042	0.036783
	(0.83030)	(0.01035)	(-0.14317)	(-1.27679)	(1.68340)
SENSEX(-1)	-0.048193	-0.000265	0.016551	-0.038767	0.034674
	(-1.64676)	(-0.00816)	(0.47782)	(-1.45282)	(1.16639)
SENSEX(-2)	0.026926	0.055819	0.085682*	-0.047391	-0.012986
	(0.92657)	(1.72899)	(2.49104)	(-1.78856)	(-0.43991)
SENSEX(-3)	-0.064389*	-0.013899	-0.062747	0.018153	0.042785
	(-2.22449)	(-0.43223)	(-1.83147)	(0.68780)	(1.45515)
SHCOMP(-1)	0.024584	0.003004	-0.048150	-0.022410	-0.033135
	(0.95135)	(0.10464)	(-1.57424)	(-0.95112)	(-1.26230)
SHCOMP(-2)	0.026449	0.004532	0.010617	0.001488	-0.017112
	(1.02547)	(0.15815)	(0.34777)	(0.06328)	(-0.65316)
SHCOMP(-3)	0.001259	0.024864	0.097049*	-0.006668	0.034801
	(0.04896)	(0.87012)	(3.18770)	(-0.28431)	(1.33197)
C	0.000465	0.000370	0.000264	0.000513	0.000211
	(1.04683)	(0.74862)	(0.50291)	(1.26578)	(0.46739)
SPX	0.833048*	0.723865*	0.849140*	0.391200*	0.141834*
	(20.9554)	(16.3904)	(18.0464)	(10.7926)	(3.51238)
Adj. R-squared	0.227339	0.148692	0.219013	0.113416	0.025504

*Indicates significance at 5%.

in about five or six days.

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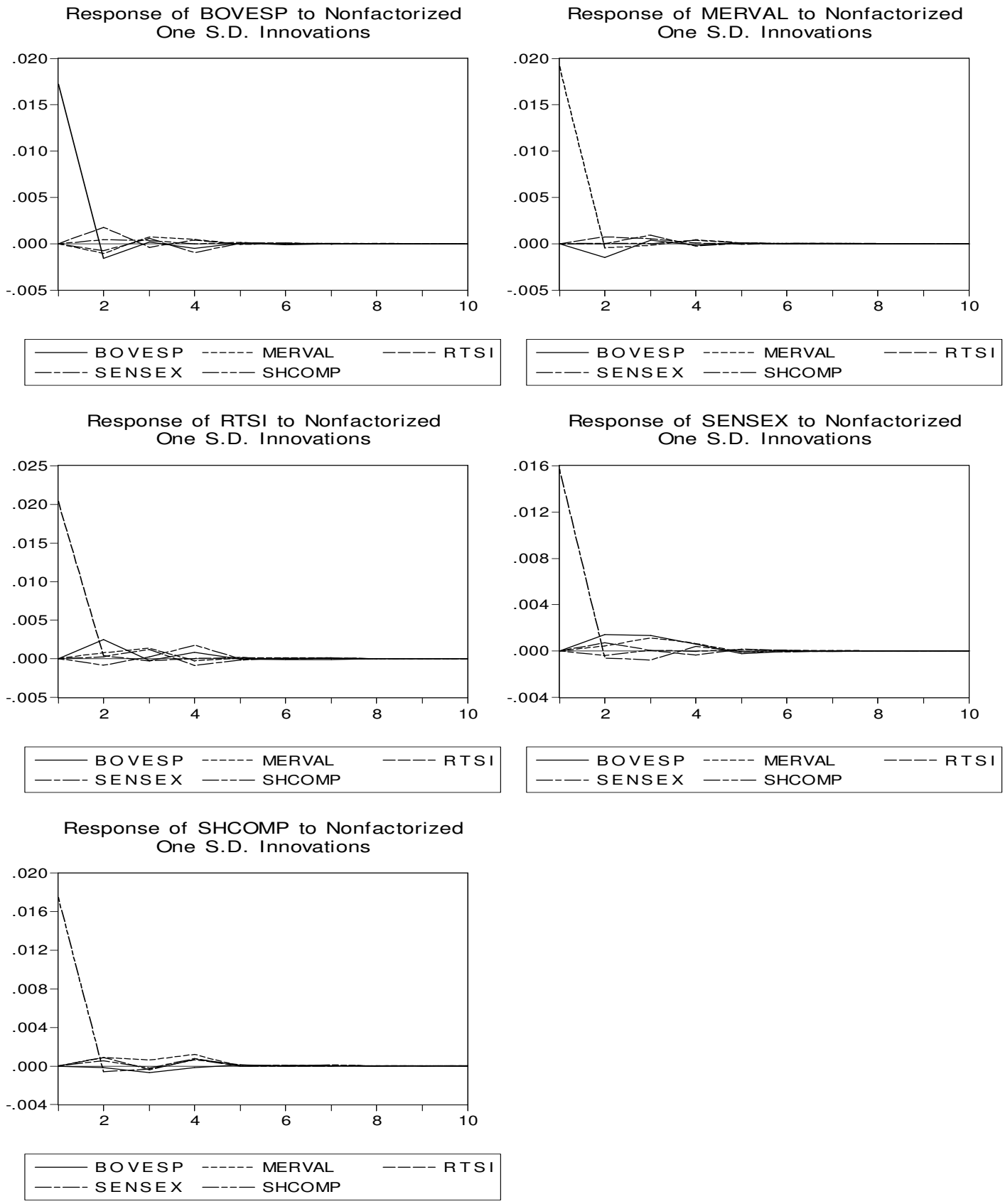

Figure 2. Impulse-response functions.

Table 7. Granger causality test for returns.

VAR Granger Causality/Block Exogeneity Wald Tests					
	BOVESP	**MERVAL**	**RTSI**	**SENSEX**	**SHCOMP**
BOVESP		0.0389	0.0001	0.0000	0.3780
MERVAL	0.0590		0.0159	0.0054	0.0144
RTSI	0.0008	0.2683		0.1789	0.0519
SENSEX	0.0410	0.3605	0.0184		0.3174
SHCOMP	0.5952	0.8538	0.0050	0.8036	
All	0.0029	0.1420	0.0000	0.0000	0.0002

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