Stock Market Linkages: BRIC and US

Its implications for International Portfolio Diversification

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Abstract

With the rapid growth in emerging economies especially BRIC nations, many investors would certainly consider investing in these markets rather than in the advanced or developed markets. However, the question of whether these markets are integrated so that investing will provide the benefit of diversification is a major concern for investors. This leads one to investigate whether markets are interdependent? The aim of this study is to investigate the linkages between BRIC nations and a developed economy like United States using econometric techniques.

Keywords: Stock Market Linkages, Stationary, Co-integration, Volatility Measure (GARCH Model).

INTRODUCTION

International stock market linkages have attracted increasing attention in the process of so called globalization. Seeking excess returns through international diversification is one of the strategies employed by large multinational financial institutions in an ever intensifying competitive financial environment, while national markets, considered individually, appear to have been exploited to their full so that any non trivial profitable opportunities do not remain in the context of semi-strong market efficiency.

The degree of integration of financial markets around the world increased significantly during the late 1980s and 1990s. A key factor underlying this process has been the increased globalization of investment seeking higher rates of return and the opportunity to diversify risk internationally. At the same time, many countries have encouraged inflows of capital by dismantling restrictions, deregulating domestic financial markets (financial openness), and improving their economic environment and prospects through the introduction of market-oriented reforms. This increase in the degree of

integration of world capital markets has been accompanied by a significant increase in private capital flows to developing countries.

The last decade saw the rise of the BRIC nations, Brazil, Russia, India, and China are expected to contribute twice as much to global growth in the coming decade as the G3, the traditionally top-performing developed nations of Europe, Japan, and the USA, according to Goldman Sachs research. By 2020, it expects the BRICs to account for a third of the global economy in PPP terms and to contribute about 49% of global GDP growth. What is different about this growth in the coming decade is that it is being driven by the increasing interconnectivity of the BRIC economies, which are gaining strength as they exchange commodity inputs and manufactured exports. And this economic integration looks set to fundamentally change the global economy (and balance of power) in the next ten years and beyond—with huge implications for financial analysts and economists alike. The current study thus examines the stock market linkages between the BRIC nations and the US, and its implications for international portfolio diversification for investors. The approach is to apply econometric techniques to find out the co-integration

between the markets. The results indicate that the markets under study are indeed correlated and there exists co-integration between markets pairs Russia-China, Russia-US and Brazil-India. In terms of diversification opportunities this does mean that the investors need to take care when investing in these markets as the linkages impact the benefits of diversifications and short-term gains.

The point when the correlation between the returns of the equity markets increases, the risk exposure of the portfolio (all else being constant) will start to increase and, at a certain point international diversification will no longer look beneficial. However this allows investors to spread their portfolio across markets which in return reduce risk when diversified effectively.

Numerous works studying international linkages of the equity markets have contributed an in-depth understanding of the market behavior. However, little attention has been given to the emerging equity markets of BRIC nations since their rapid economic growth early this decade. Therefore the study is designed to fill the above gap by applying various robust techniques.

LITERATURE REVIEW

Numerous studies have been carried out to investigate stock market linkages, integration or interdependence. Stock market is said to be integrated when correlation exists between markets. However the results of these studies are mixed, inconsistent and sometimes even contradict with each other (Hilliard (1997), Aggarwal et. al. (2003), Abbas and Chancharat (2008)). If evidence of stock market linkage were found, it would imply that there is a common force that brings these markets together (Choudhry et. al. (2007)) Hence, the benefit of diversification would be limited. Apart from analyzing only the interdependencies of stock markets, many researchers have also focused on the impact of major events such as market crisis, market liberalization, etc on the stock market linkages (Tan and Tse (2002), Lim and McAleer (2004), Aggarwal et. al. (2008)). Since the early 1990s, most of the research on international stock market linkages has been concentrated on the mature and emerging markets.

Studies by Hilliard (1997) and Asimakopulos et. al. (2002) investigated the interrelationship between daily returns generated by major stock exchanges. Evidence found that strong interdependence exists between the daily returns generated by United States and other selected major world indices. This was followed by the work of Aggarwal et. al. (2003) that examined the time-varying integration of European equity markets over the 1985 to 2002 period using daily data for the main EU countries. Using estimates of traditional co-integration, Haldane and Hall Kalman filter technique, and dynamic eigenvalue analysis in their study, the result shows the evidence of integration in European countries only after the establishment of EMU and the ECB during 1997-98 periods. The result also indicates that Frankfurt is the dominant market for equities in Europe.

By controlling for the exchange rate, Tan and Tse (2002) use daily data in local currencies over 1988-2000 to examine the linkages among U.S., Japan, and seven Asian stock markets including Malaysia, Philippines, Singapore, and Thailand. By truncating the data at the end of 1996 and restarting the data in mid-1998 to create a pre-crisis and post-crisis comparison, they found that markets appear to be more integrated after the crisis than before. Another interesting result is that Malaysia is less affected by the U.S. and Japan after the crisis, which can be attributed to the success of its capital and currency controls, but Singapore and Malaysia still affect each other strongly, which can be attributed to geographic proximity, economic linkages, and structural symmetry. Meanwhile Golaka et. al. (2003) examined the interdependence of the three major stock markets in South Asia. Using daily stock market indices of India (NSE-Nifty), Singapore (STI) and Taiwan (Taiaex) from January 1994 to November 2002, employed bivariate and multivariate co-integration test. The result shows that no co-integration was found for the entire period which leads one to conclude that there is no long run equilibrium between India, Singapore and Taiwan.

Similarly by working on a list of semi-strong efficient market, Lim and McAleer (2004) conducts a study to examine the dynamic interdependencies of five ASEAN stock markets i.e. Indonesia, Malaysia, Philippines, Singapore and Thailand with the US stock market over the period of April 1990 to July 1997 using daily total

market-return indices for each stock market. The result indicates higher average returns and correlations over the post crisis period. Result also indicates an increase in the integration between the ASEAN-5 markets after the financial crisis and US market returns have significant influence on the returns of all ASEAN-5 markets. Another study carried out by Click and Plummer (2005), controlling for local currency examined whether the ASEAN stock markets are integrated or segmented using co-integration technique using daily and weekly stock index quotes in local currency data from July 1998 to December 2002. The empirical result suggests that the ASEAN-5 stock markets are co-integrated. However, only one co-integrating vector is found, leaving four common trends among the five variables. Hence, the ASEAN stock markets are integrated, but the integration is still far from complete.

Later Royfaizal et. al. (2007) analyse the stock market interdependencies between the Asean and U.S. stock markets before, during and after Asian financial crisis by using weekly stock indices expressed in local currencies from July 1997 to June 1998. Employing the Granger-causality test based on VECM to test the long run relationship among the stock markets, the study shows that the long-run relationships between ASEAN stock markets occur only for during and post-crisis period. In a similar study on the Asian markets Choudhry et. al. (2007) observed the changes in the long run relationship between eight Far East countries namely Thailand, Malaysia, Indonesia, Hong Kong, Singapore, the Philippines, South Korea and Taiwan around the Asian financial crisis of 1997-98. They examined the change in the influence of the U.S. and Japanese stock markets in the Far East region before, during and after the Asian financial crisis using daily stock price indices from January 1, 1998 to January 1, 2003. Correlation coefficients, multivariate co-integration, causality test and regression were conducted. Results showed significant long-run relationship and linkages between the Far East stock markets before, during and after the crisis. It was also found larger U.S. influence in all periods and some evidence of increasing Japanese influence to the eight Far East countries.

Meanwhile Abbas and Chancharat (2008) investigated the existence of co-integration and causality between the

stock market price indices of Thailand and its major trading partners (Australia, Hong Kong, Indonesia, Japan, Korea, Malaysia, the Philippines, Singapore, Taiwan, the UK and the USA), using monthly data spanning the period from December 1987 to December 2005. They used both the Engle-Granger two-step procedure (by assuming no structural breaks) and the Gregory and Hansen test (allowing for one structural break). From the result, evidence of potential long run benefits from diversifying the investment portfolios internationally was found. Results also notice that the stock returns of Thailand and three of its neighbouring countries (Malaysia, Singapore and Taiwan) are interrelated during these periods.

Although there are continuous researches done on market integration, it has mainly focused on the developed markets. Until the late 1980s the Asian-Pacific stock markets, had grown in some importance, where a considerable amount of work was done to investigate the relationship and linkages among the markets. However, few studies concentrated on the relationship of two major emerging markets namely China and India with other major developed stock markets in the world.

In the mid twentieth century, Chi et. al. (2006) examined the bilateral relations between three pairs of stock markets, namely India-U.S., India-China and China-U.S. They used weekly stock index of Bombay Stock Exchange National Index for India, All Shares Index from Shanghai Stock Exchange for China, and the S&P 500 index for U.S. market from January 2, 1991 to December 29, 2004. Augmented Dickey-Fuller and Phillip-Perron unit root test were used to test the stationary of the series and subsequently employ the Fractionally Integrated Vector Error Correction Model (FIVECM) to detect the co-movement of the pairs of stock markets. Result shows that the three markets are fractionally co-integrated with each other. It was also found that U.S. market leads the Indian market in information spill-over and leads the Chinese market in return transmission. These results suggest that the two emerging markets appear to be more closely linked to each other relative to the U.S.

Similarly Chattopadhyay and Behera (2006) later examined if the reform in the Indian stock market had

led to the integration with the developed stock markets in the world. It was found that Indian stock market is not co-integrated with the developed market as yet although some short-term impact does exist. More recently, Janak Raj and Sarat Dhal (2008) investigated the financial integration of India's stock market with global and major regional markets. It was found that Indian market's dependence on global markets, such as U.S. and U.K., is substantially higher than on regional markets such as Singapore and Hong Kong while Japanese market has weak influence on Indian market.

One of the recent works by Singh et. al. (2009) applied the open and closed price volatility testing the interdependence of fifteen world indices including an Indian market index in terms of return and volatility spillover effect. Vector autoregressive model (VAR) was used to estimate the conditional return spillover among these indices in which all fifteen indices are considered together. It is found that there is greater regional influence among Asian markets in return and volatility than with European and US. Japanese market, which is first to open, is affected by US and European markets only and affects most of the Asian Markets. US market is influenced by both Asian and European markets.

In comparison to the work done above this research applied the intra-day readings to observe the linkages between China and India with major developed markets, this study will also focus on analysing whether the two major emerging markets decouple from major developed markets namely U.S., U.K., Japan and Hong Kong.

RESEARCH METHODOLOGY

1. Data

The data used in this study are from the major stock market indices of Brazil, Russia, India, China and United States stock market. The indices used for the various markets are shown in the figure below:

(REFER TABLE 1 HERE)

Data consists of the day end stock market index observations for each index from 1st July 2004 to 1st March 2012, amounts a total of 2,801 observations. If a value was missing, data from the previous day were used. The indices were taken from Yahoo! Finance.

All of the indices are expressed in terms of local currencies to avoid problems associated with transformation due to fluctuations in exchange rates and also to avoid the restrictive assumption the relative purchasing power parity holds. In addition, the preference for local currencies focuses on the domestic causes of stock market interdependence. According to *Leong and Felmingham (2001)*, by converting these indices to a common currency there is a possibility that the impact of local economic conditions and domestic economic policy maybe distorted. The data is then analyzed using E-View 5.1 which provided the data analysis and regression output.

2 Methodology

In order to analyse the linkages of Indian and Chinese market with other major markets, the study adopts six major methods.

2.1 The Correlation Test

The first step involves a simple correlation test to measure the strength and direction of the association between the stock indices. The significance of the correlation for each index provides a preliminary indication of the strength of association between the indices of different stock markets under study. According to *Leong and Bruce Felmingham (2001)*, correlation coefficients are known to be biased upward if the share price indices has heteroskedastic elements, thus it does not provide a sound basis for studies of interdependence.

However correlation analysis only measures the degree of linear association between two variables hence provides little insight on the dynamic linkages and causality between stock markets. Therefore, the analysis of stock market integration is extended employing Granger Causality test.

2.2 Granger Causality Test

Granger Causality test is conducted to further analyse the significance and direction of causality between Chinese and Indian market with other major stock markets. According to *Granger (1969)*, this test will answer the question of whether X causes Y. Y is said to be Granger-caused by X if X helps in the prediction of

Y, or equivalently if the coefficient on the lagged X are statistically significant. To show that X Granger cause Y, first step is to consider an autoregression for Y. Next, lagged values of X are added as the extra independent variables. Granger Causality test results are very sensitive to the number of lags used in the analysis. There are four different criteria for specifying the lag length. This study will adopt Akaike information criterion (AIC) suggested by Akaike (1974). The equation for the pairwise Granger causality tests are as follow:

$$Y_t = \alpha_0 + \alpha_1 Y_{t-1} + \dots + \alpha_p Y_{t-p} + \beta_1 X_{t-1} + \dots + \beta_p X_{t-p} + \mu_t \quad (1)$$

Where, X_t and Y_t = daily stock market index for country X and Y respectively
 μ_t = error term at time t

The F test is used to test the hypotheses of the Granger Causality as follow:

$$H_0: \beta_1 = \beta_2 = 0 \text{ (X does not Granger cause Y)} \\ H_1: \text{At least one of the } \beta_i \neq 0$$

The null hypothesis is rejected if the computed F-value exceeds the critical F value at the chosen level of significance (0.05). This implies that X does Granger cause Y. The test is performed in pair-form between China and U.S, U.K, Japan and Hong Kong. Similarly, the same method is repeated between India and U.S, U.K, Japan and Hong Kong. The causality between Indian and Chinese market is also examined.

2.3 Unit Root Test

Prior to the co-integration analysis, the univariate properties of the data series are examined whether the series are non-stationary or contain a unit root. A series is said to be stationary if the mean and variance of the series do not systematically differ over the time period. Regression in which the variables are non-stationary can lead to spurious result where variables may share the same time trend even though they are not really related.

Unit root test involves examining whether the series are stationary or not at level and subsequently finding the order in which they are integrated if the series is non-stationary. This study employs Augmented Dickey-Fuller (ADF) test to determine the unit root property of

the stock market indices which requires regressing ΔY_t on a constant, a time trend ΔY_{t-1} and several lags of dependent terms as follows:

$$\Delta Y_t = \gamma_0 + \gamma_1 Y_{t-1} + \beta_1 \Delta Y_{t-1} + \varepsilon_t \quad (2)$$

Where, Δ = first difference operator

γ_0, γ_1 and β_1 = coefficients to be estimated

Y_t = non-stationary time series

ε_t = error term at time t

The test statistics known as the tau statistics are checked against the critical values tabulated by Dickey and Fuller on the basis of Monte Carlo simulations. The null hypothesis of series contain a unit root is rejected if t-statistics is smaller (more negative) than the critical value respectively. The Durbin-Watson test values are also observed. DW test statistics value of 2 or very close to 2 will indicate that the test result is reliable i.e. indication of no autocorrelation problem. Next the presence of co-movement between the stock market indices is tested using co-integration test.

2.4 Co-integration Test

Co-integration test is among the most widely used method in examining the relationship or integration in financial market. The concept of co-integration was introduced by Granger (1981) and further developed by Engle and Granger (1987) which incorporates the presence of non-stationary, long-term relationship and short-run dynamics in the modelling process. A series is said to be integrated of order one i.e., I (1) if it becomes stationary after the first differencing. If there exists a linear combination of two or more I (1) series that its stationary, then the series are co integrated. Co-integration requires that the variables to be integrated of the same order. Thus, this study employs Augmented Dickey Fuller (ADF) tests to determine the order of integration for every stock return. When both the variables are integrated of same order, then the estimate the co-integrating regression is carried out using ordinary least square.

$$Y_t = \beta_0 + \beta_1 X_t + \mu_t \quad (3)$$

Where Y and X are non-stationary series. The residuals, denotes as μ_t are then tested to ensure that they are I (0)

by running the Augmented Dickey-Fuller (ADF) test. The time series is said to be co-integrated if the residual is itself stationary, I (0). The residual will still be non-stationary if the time series are not co-integrated. In result the non-stationary I (1) series have cancelled each other out to produce a stationary I (0) residual.

Next the test statistics against the critical values are checked. If t-statistics is smaller (more negative) than the critical value, null hypothesis of residuals contain unit root is rejected and conclude that the residuals or the error term is stationary. This would imply that the two stock indices are co-integrated.

2.5 Time-Series Regression when series are Co-integrated: Error Correction Model (ECM)

When the two stock indices are co-integrated, this also implies that there is a long-term equilibrium relationship between them. To test if there may be disequilibrium in the short run, the residual of the co-integrating regression is used to tie its short-run behaviour to its long-run value. According to the Granger Representation Theorem, if two variables are co-integrated, then the relationship between the two can be expressed as an Error Correction Model (ECM). In this model, the error term from the OLS regression, lagged once acts as the error correction term. The ECM allows the introduction of past disequilibrium as explanatory variables in the dynamic behaviour of current variable thus enables to capture both the short-run dynamic and long-run relationships between the stock indices. The basic ECM is as follows:

$$Y_{t+1} = \alpha_0 + \alpha_1 X_{t+1} + \alpha_2 \mu_{t-1} + \varepsilon_t \quad (4)$$

Where μ_{t-1} , is the lagged value of error correction term derived from the co-integration regression and ε_t is the residual or error term with the usual properties. The model relates to the changes in the dependent variable i.e., stock index Y to the change in independent variables i.e., stock index X and the “equilibrating” error in the previous period.

In the above regression, X_{t+1} captures the short-run disturbance in stock index X . The F-tests of the differenced independent stock index X_{t+1} , give a sign of

the short-term causal effects. Meanwhile, μ_{t-1} captures the adjustment toward the long-run equilibrium. The long-run relationship is indicated through the significance of the t-test of the lagged error correction term μ_{t-1} . However, the coefficient of the error correction term α_2 , is a short-term adjustment coefficient. It will explain the speed of adjustment back to equilibrium if it is statistically significant. In other words, it represents the proportion by which the long-run disequilibrium in stock index Y is being corrected in each short period.

2.6 Time-Series Regression when series are not Co-integrated

One may encounter instances where unit root tests indicate that your time series have unit roots, but the Engle-Granger test indicates that the series are not cointegrated. That is, the series may not be trending together and may not have an equilibrium relationship. In these cases, one should not run a regression of Y on X due to the spurious regression problem. The presence of such characteristics suggests that you should rethink your basic model and include other explanatory variables. Instead of working with Y and X themselves, for example, one could difference them.

$$\Delta Y_t = \alpha + \phi \Delta Y_{t-1} + \beta \Delta X_{t-1} + \varepsilon_t \quad (5)$$

RESEARCH RESULTS AND ANALYSIS

1 Descriptive Statistics

The descriptive statistics for all the five stock indices under study are given below. These include the distribution of mean, standard deviation, skewness and kurtosis. For the purpose of comparison, the daily closing price index for each stock market is transformed to its return form.

(REFER TABLE 2 HERE)

In term of absolute value, the mean of the Russian market is greater than other indices. Meanwhile, in the same observation period, the Russian market index has been the most volatile while the DJIA index is the least volatile. Table 1 also shows that the indices' skewness value is negative for China, and that all the indices have Kurtosis values larger than 3, which indicate fat-tails.

Therefore, the Jarque-Bera (JB) values of the indices imply that none of the indices is normally distributed which is consistent with prior literature.

(REFER FIGURE 1 HERE)

Figure 1 presents the movement of all the eight indices in the observed period from July 2004 to February 2012. As can be seen in Figure 2, Russia records the market capitalizations that are much higher than those of the other observed indices. Interesting observation from Figure 1 is that Sensex's market capitalization started to increase in the year 2005. All stock indices started to decline or having negative growth in the February 2008 onwards. This is contributed by the credit crisis that took on a full head stem from August 2007 where most world stock markets are falling in tandem with each other.

2 Analysis of Correlations

The correlations between the stock indices for the period of July 2004 to February 2012 are computed to measure the strength of the association between the stock indices. Table 2 presents the simple correlation coefficients among the 5 stock indices under study.

(REFER TABLE 3 HERE)

While the numerical values of correlation coefficients may range from 1.0 to -1.0, the majority of the correlation in Table 2 exceeds 0.3 and often exceeds 0.5. From the result, we can see that both India and China are highly correlated with Brazil with correlation coefficient of 0.958 and 0.713 respectively. Also, the correlation between India and China is high 0.729. This may be due to the close proximity between the markets resulting in increase money flows as investors can easily switch investments between the two markets. Thus stock price indices between India, China and Brazil tend to correlate.

Correlation between US and Russian stock indices is also on the higher side 0.795, compared to correlation of US with other stock markets. This suggests that US is more correlated with Russia as compared to say China in the period under study. The increasing economic interdependence between the US and Russia has

contributed to the high correlation or co-movement between the two markets.

China has relatively lower correlation with US as compared to the emerging economies of Brazil, Russia and India. The result indicates that the correlations between China and Russia are the highest.

There is no negative correlation found between the five markets under study for the period. Overall, the results from the correlation coefficients suggest some insight on the short-term relations between BRIC and US.

3 Analysis of Granger Causality Test

The Granger Causality test is conducted to investigate direction of causality between the BRIC nations and US. The F-statistics from the Granger Causality test results is presented in annexure 1. The results show that there is evidence of unidirectional causality from Brazil to Russia. This result supports the high correlation found between them in the analysis of correlation earlier.

The results show that BOVESPA has bidirectional causality with Sensex and China. This result supports the high correlation found between India-Brazil and China-Brazil in the analysis of correlation earlier. It is found that there is bidirectional causality between China-India and India-Russia. This can be seen in the increased amount of bilateral trade between the countries over the years.

The F values indicate that US does Granger causes all of Brazil, Russia, India and China. The results show that there is evidence of unidirectional causality from Russia to China. This result supports the high correlation found between them in the analysis of correlation earlier.

To sum up, overall results of Granger causality test suggest that the Brazil market has bidirectional causality with the both Indian and Chinese market (5% significance). This support the evidence of high correlation between the two markets in the analysis of simple correlation conducted earlier. Another interesting result is the evidence of bidirectional causality between India-Russia (5% significance) and China-India (10% significance).

4 Analysis of Unit Root Test

Augmented Dickey-Fuller (ADF) test is used to test the stationarity of the stock price indices. The result of ADF unit root test in Table 4 shows that the null hypothesis of a unit root cannot be rejected, which indicates that all stock indices are non-stationary series. However, since the t-statistics is smaller (more negative) than the critical value in the first difference form, there is no evidence to support that the presence of unit in the series. Hence, all the stock price indices are stationary, and integrated of order one, I (1) which is consistent with results in the finance literature.

(REFER TABLE 4 HERE)

5 Analysis of Eagle Granger Test

Once identifying that all stock indices are integrated of same order, then the co-integrating regression using OLS are estimated. The residuals, denoted as μ_t are tested to ensure that they are stationary by running Augmented Dickey-Fuller (ADF) test. The result of the ADF test on the residuals of the regression is presented in Table 5 below. Schwarz Info Criterion is used to determine the appropriate number of lags. The DW test statistics from each regression equations are examined to ensure that there is no autocorrelation problem.

Since the test statistics are smaller (more negative) than the critical value, null hypothesis of residuals contain unit root is rejected and conclude that the residuals or the error term is stationary. This would imply that the two stock indices are co-integrated. Hence the results indicate that Russia-US, Russia-China and Brazil-India markets are co-integrated for the period under consideration. Similarly, the results also indicate that Brazil-Russia, Brazil-China, Brazil-US, Russia-India, India-China, India-US and China-US are not co-integrated.

The findings where stock market indices are co-integrated means that there is a linear combination between the indices that forces these indices to have a long-term equilibrium relationship even though the indices may wander away from each other in the short run.

(REFER TABLE 5 HERE)

6 Analysis of Error Correction Model for Co-Integrated Series

As stated in Granger Representation theorem, the relationship between two co-integrated variables can be expressed as error correction model (ECM) which is useful to capture both the short-run dynamic and long-run relationships between the stock indices. Table 6 below summarise the F-statistics, coefficient of the lagged value of error correction term (ECT) and the t-ratio between pairs of stock market indices of Russia-US, Russia-China and Brazil-India. This bivariate co-integration, if it exist will reveal the existence of a long-run equilibrium.

The significance of the F-statistics on the lagged value of ECT, suggests that short-run causality exists between the two co-integrating indices. On the other hand, the long-run relationship is captured through the significance of the t test of the lagged error correction term.

(REFER TABLE 6 HERE)

The significance of the F stat on lagged value of independent stock index X_{t-1} , suggests that short-run causality exist between the 3 pairs above at the 5 per cent level. The significant of t stat on the lagged error correction term μ_{t-1} suggests that there is long-run relationship between the pairs too.

CONCLUSION

This study has investigated the linkages among BRIC nations and United States. Extending related empirical studies, the correlation test is used as preliminary phase of examining the linkages between the markets. Next the co-integration test is applied to comprehensively investigate the direction of relationship.

Based on the analysis of correlation, it was found that BRIC nations are highly correlated with each other than with U.S. Russia is most correlated with US followed by China and India. This is not surprising as U.S is the world's foremost stock market and has large influence on other stock markets. Beside that U.S. is also one of the main trading partners for China and India.

Both Chinese and Indian markets are found to be highly correlated. The increasing economic interdependence between the China and India has contributed to the high correlation or co-movement between the two markets. Overall, the results from the correlation coefficients suggest some insight on the short-term co-movement between China and India and suggests that the benefits of any short-term diversification, or speculative activities, are limited between them.

Several interesting observations emerge from the Granger Causality analysis. First, the findings show that there is bi-directional causality between India-Brazil, India-Russia and China-Brazil. Again, this result supports the high correlation found between these pair of markets. The F values indicate that US does Granger causes all of Brazil, Russia, India and China. The results show that there is evidence of unidirectional causality from Russia to China. This result supports the high correlation found between them in the analysis of correlation earlier.

In terms of co-integration it is seen that there is evidence of co-integration relationship across the markets under study. Russia is found to be co-integrated with United States and China. Brazil is also co-integrated with Indian market.

Subsequently the error correction model (ECM) analysis showed that there is short-run causality and long run relationship between the co-integrated markets of Russia-US, Russia-China and Brazil-India.

The results observed can be explained based on the recent macroeconomic and trade scenario in these pair of nations. The US trade in goods with Russia has been on the rise continuously. The trade deficit was around 8,900 million USD in 2004 and 26,287 million USD in 2011. Russia and China also share close relationships as far as being trading partners is concerned. Recently, China and Russia decided to renounce the US dollar and resort to using their own currencies for bilateral trade. Also, Russia's entry into the World Trade Organization (WTO) will serve as a considerable spur to China-Russia cooperation in trade and investment. Similarly, in recent years, relations between Brazil and India have grown considerably and co-operation between the two

countries has been extended to such diverse areas as science and technology, pharmaceuticals and space. The two-way trade in 2007 nearly tripled to US\$ 3.12 billion from US\$ 1.2 billion in 2004.

In conclusion, BRIC nations are correlated among each other. This result is further confirmed with the analysis of Granger causality where there is bi-directional causality between India-Brazil, India-Russia and China-Brazil. Plus the results show that there is evidence of unidirectional causality from Russia to China. The relationship can be seen in the increasing bilateral trades among these countries.

In terms of diversification opportunities this does mean that the investors need to take care when investing in these markets as the linkages impact the benefits of diversifications and short-term gains.

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Figure1. Movement of the Indices in the Observed Period

Table 1. Markets under study

Market	Index Used
Brazil	BOVESPA
Russia	RTSI
India	Bombay Stock Exchange (BSE)
China	Shanghai Composite Index
US	Dow Jones Industrial Average

Table 2. Descriptive Statistics

	BRAZIL	RUSSIA	INDIA	CHINA	US
Mean	0.00053	0.011092	0.000558	0.000296	0.000139
Median	0	0	0	0	0
Maximum	0.147	29.479	0.173	0.095	0.111
Minimum	-0.114	-0.191	-0.110	-0.088	-0.079
Std. Dev.	0.016	0.557	0.014	0.015	0.011
Skewness	0.227	52.788	0.446	-0.170	0.222
Kurtosis	13.671	2791.054	16.373	8.920	19.428
Jarque-Bera	13308	908000000	20958	4102	31510
Observations	2800	2800	2800	2800	2800

Table 3. Correlation Analysis

	BRAZIL	RUSSIA	INDIA	CHINA	US
BRAZIL	1	0.722	0.958	0.713	0.357
RUSSIA	0.722	1	0.777	0.707	0.795
INDIA	0.958	0.777	1	0.729	0.457
CHINA	0.713	0.707	0.729	1	0.514
US	0.357	0.795	0.457	0.514	1

Table 4. Augmented Dickey-Fuller test results

Stock Index	Level (with intercept and trend)	First Difference (Constant)
Brazil	-2.287172	-52.67499
Russia	-2.313837	-48.53706
India	-2.083912	-49.97032
China	-1.051237	-53.37737
US	-1.846101	-55.64543
1% Critical Value	-3.9613	-3.961321
5% Critical Value	-3.4114	-3.411412
10% Critical Value	-3.128	-3.127558

Table 5. Unit Root Test applied to the Residuals of Cointegrating Regressions

Indices	Test statistics for residuals	Indices	Test statistics for residuals	Indices	Test statistics for residuals
Russia/US	-3.736	Russia/China	-2.858	Brazil/India	-4.211
Brazil/Russia	-1.159	Brazil/China	-1.745	Brazil/US	-1.62
Russia/India	-2.461	India/China	-1.951	India/US	-1.959
China/US	-1.506				
1% Critical Value	-3.432	5% Critical Value	-2.862	10% Critical Value	-2.567

Table 6. Bivariate ECM for Co-Integrated Indices

Stock Indices	α_2	t-stat for μ_{t-1}	F	Stock Indices	α_2	t-stat for μ_{t-1}	F
Russia/US	-0.0069	-4.6*	123.08*	Russia/China	-0.0039	-2.979*	43.537*
Brazil/India	-0.0108	-3.609*	152.483*				

* indicates significance at the 5% level

Annexure 1 Granger Causality Test

Pairwise Granger Causality Tests

Date: 03/06/12 Time: 14:00

Sample: 7/01/2004 3/01/2012

Lags: 2

Null Hypothesis:	Obs	F-Statistic	Probability
RUSSIA does not Granger Cause BRAZIL	2799	1.74280	0.17522
BRAZIL does not Granger Cause RUSSIA		57.7823	2.6E-25
=====			
INDIA does not Granger Cause BRAZIL	2799	5.52854	0.00402
BRAZIL does not Granger Cause INDIA		60.3075	2.3E-26
=====			
CHINA does not Granger Cause BRAZIL	2799	3.50218	0.03026
BRAZIL does not Granger Cause CHINA		26.6911	3.3E-12
=====			
US does not Granger Cause BRAZIL	2799	4.73015	0.00890
BRAZIL does not Granger Cause US		0.02880	0.97161
=====			

INDIA does not Granger Cause RUSSIA	2799	3.95062	0.01935
RUSSIA does not Granger Cause INDIA		6.31769	0.00183
=====			
CHINA does not Granger Cause RUSSIA	2799	1.66061	0.19021
RUSSIA does not Granger Cause CHINA		8.13764	0.00030
=====			
US does not Granger Cause RUSSIA	2799	50.2189	3.7E-22
RUSSIA does not Granger Cause US		1.21213	0.29772
=====			
CHINA does not Granger Cause INDIA	2799	2.58493	0.07558
INDIA does not Granger Cause CHINA		9.14390	0.00011
=====			
US does not Granger Cause INDIA	2799	64.7684	3.2E-28
INDIA does not Granger Cause US		1.65273	0.19171
=====			
US does not Granger Cause CHINA	2799	32.3332	1.3E-14
CHINA does not Granger Cause US		0.84149	0.43118
=====			