

Are Stock Markets Interdependent? An Empirical Study of Selected Market Indices

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Abstract

It has been acclaimed by various researchers that international diversification has reduced its charm as return-risk of the world markets are highly correlated due to information spillover effect and globalisation. This study examines inter linkages and interactions, if any, among the selected twelve indices of developed and emerging economies. The study applies descriptive statistics, correlation coefficients and Granger Causality test to check basic characteristics of each indices and their correlation and impact on each other. Granger Causality test for some indices shows that return of one market index had causal influence on return in other market index. The finding of this paper gives good insights to the international investors who are looking to reduce risk for a given level of return.

Keywords: Market Indices, Integration, Diversification

Theoretical Stands

As per recent empirical findings and evidences, the world markets are integrated with each other as the information flowing from one market affects the other markets as well. Investors of the developed market are considering developing markets because developing countries are transforming themselves in to emerging economies by growing at the extra ordinary pace due to globalisation, new technological innovations and financial integration (Stiglitz, 2006). The liberalisation of financial markets has resulted in regional economic integration, greater co-movement in the stock prices, and foreign investments. The global financial crisis has focused more attention on the linkages among the stock markets of world economies. The main factors behind the market integration is mainly free flow of capital, increased flow of information and reduction in transaction costs. Liberalisation has removed or at least reduced the barriers for foreign inflows to domestic country. Also, deregulation and trade liberalisation has opened the opportunities for foreign and domestic investors. In a similar way, common stock markets have been opened for foreign

investors. Naturally, this helped the investors to reduce their risk by diversifying their portfolio worldwide by investing in to developed and developing markets. Gradually, the huge flow of investment in the capital markets caused the international markets to lead and follow one another. Liberalisation and globalisation opened opportunities for investors to invest in foreign markets but these also caused the foreign markets to lead and lag each other and this to some extent and in some counties resulted in to limited or negligible benefits of diversification. The reason behind this is the increased correlation among different indices of the world. This has made many researchers to explore the linkages between the foreign markets to get some insights on the same (Jebran, 2014). This is also important for policy makers to investigate that if stock markets appear to be closely related, so any uncertainty in one market may be spread to other markets. This is because as per the portfolio management theories, the investors should hold a well-diversified portfolio of various securities that are negatively correlated with each other (Markowitz, 1987, 1991).

Review of Literature

Interdependency among global stock markets is studied primarily through correlation of returns, co-integration, and the granger causality. Lamba (2003) studied large sample analysis for the dynamic relationship between the south Asian markets of India, Pakistan and Sri Lanka and the major developed markets. The research found that the Indian market is influenced by the large developed equity markets such as US, UK, and Japan. Further, it has been noted that the extent of influence has increased for the recent period of the study i.e. January 2000 to February 2003. The research came with the interesting findings that the Indian market do not exert any significant influence on Pakistan and Sri Lanka market and Pakistan and Sri Lanka markets are relatively isolated from the major developed market. Durai and Bhaduri (2006) attempted to study 10 indices of the world and compared it with India's two representative indexes S&P CNX Nifty and

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BSE 100 as representative and checked for its robustness for a period of 1st July 1997 to 18th August 2006. The research came with interesting findings that there is a poor correlation across the markets mainly between Nifty index and Asian markets and with other four developed markets. Further, the average correlation among these markets is below 30 percent and only four developed markets showed high correlation among them. In a similar path paved by Durai and Bhaduri (2006); Siddiqui (2009) divided the study period in to two parts namely, period I (02/06/2004 to 01/06/2009) and period II (01/06/1999 to 01/06/2004) and studied 13 stock indices of India, US, China, Hong Kong, Malaysia, Japan, Singapore, South Korea, Israel, Taiwan, and Indonesia. The study found that volatility has gone down in period II and change in correlation is widespread in period II. Further, it was realised that the interdependencies among the indices increased in period II. In addition, it was found that both US indices are unable to cause impacts on various Asian markets. Singh and Singh (2011) found that Chinese and Indian markets are correlated with each other and so US and UK market. As both these markets have causality with developed market of the world, the benefits of diversification or speculative activities are limited between them. An empirical finding for BRIC nations by Singh and Sharma (2012) contradicted with Singh and Singh (2011) and concluded that there are visible effects of stock exchanges on each other and found that Russian, Indian, and Brazilian stock exchanges affect each other; but none of these affect Chinese stock exchanges and they all get affected by Chinese stock exchanges. Subhani *et al.* (2011) considered for the study Karachi Stock Exchange, Bombay Stock Exchange, Dhaka Stock Exchange and Nepal Stock Exchange. Research found linkages of stock prices of Karachi stock exchange with the stock prices of Dhaka Stock Exchange; and KSE is not cointegrated with rest of the equity market considered for the study. Tahir, Sabir, Ali, Ali, and Ismail (2013) considered for their study four indices of south Asia and four indices of developed market and found that correlation result is not significant between south Asian and developed market and only equity market of US and India found correlated with each other individually. Research found out bidirectional causal relationship between CSE and KSE. Further, the findings by the authors recommended that international portfolio managers should include Karachi Stock Exchange in their portfolio as it is not linked with developed market which confirms with the findings and conclusion of Lamba (2003) and Subhani *et al.* (2011).

Research by Bhunia and Das (2012) showed both long run and short run association among the selected markets; however investors can reap the benefits during short term rather than long run. It concluded that Indian investors should broaden their investment horizon by considering not only Indian markets but also the selected south Asian market to reap the benefits of such diversification with risk reduction. Results by Subha and Nambi (2010) say that Indian stock market shows no dependence with the NASDAQ and S&P 500 and confirmed the absence of co integration between Indian and American stock market that contradicts with the findings of Lamba (2003). This also contradicts with the findings of Tahir *et al.* (2013). Birau and Trivedi (2013) have studied Greek, Romanian, Athens, German, and France Stock market for the period of January 2003 to December 2007 and January 2008 to December 2012. The study found that in the first period, there is no causality between Greek and Romania, Germany and Romania, and French and Romania stock market; while in the second period, causality was found between only Greek and Romania but not in the other way and for other markets. Mukherjee (2007) has correlated Indian stock market with rest of the world and found that Indian markets have become highly co integrated with its global counterparts; thus contradicts with the outcome of Durai and Bhaduri (2006).

Jebran (2014) found that stock market of Sri Lanka is granger caused by India, Indonesia and Malaysia stock market; but there is unidirectional causality from India, Indonesia and Malaysia to Sri Lanka stock market. The study came with the findings that there is no long run relationship of Pakistan stock market with any other stock market. This confirms with the findings of Lamba (2003) and Tahir *et al.* (2013). Nath and Verma (2003) in their study found no cointegration between India, Singapore and Taiwan stock market for the study period of January 1994 to November 2002. The dynamic relationship between returns and trading volumes helps to understand market clearing process and frictions in the market. Kumar and Singh (2006) worked in this direction and their findings suggest evidence of positive contemporaneous correlations between absolute price changes and trading volume and returns. However, the empirical analysis resulted in to the mixed results on asymmetric relationship between trading volumes and returns. Results by Yang, Hsiao, Li, and Wang (2006) showed that both the long run price relationship and the dynamic price transmission were strengthened among the

studied markets after the crisis. Further, it was found that the influence of Germany became noticeable on all the Eastern European markets only after the crisis but not before the crisis. Research by Daly (2003) says that in the pre and post crisis period, there is no evidence in support of co-integrating relationship between the stock markets of Australia, Germany and United States with the market of south East Asia. Even if there is a definite information leadership from the US market Mukherjee and Bose (2008) found that the US indexes do not influence the integration of Asian markets and Japan is found to play a unique role in the integration of Asian markets. The most striking evidence found is that the US market is not only seemed to influence, but also to be influenced by information from most of the major Asian markets. Further, the study found that the Indian stock return is definitely led by major stock index returns in the United States, Japan as well as other Asian markets such as Hong Kong, South Korea, and Singapore. Findings by Yuce and Mugan-Simga (2000) indicated that Eastern European economies have become more independent from the Russian economy and there is no significant effect from Russian stock exchange on the returns of the Prague, Warsaw and Budapest stock exchanges. Zabiulla (2014) has examined the cross auto correlation structures on the basis of market capitalisation of stocks in the Indian stock market by considering six indices and found that large cap portfolios provided better returns for higher risk while the small cap portfolios failed to provide better results for the risk that the portfolio was attached with. Empirical findings by Bodla and Yadav (2014) showed lack of uniformity between the results provided by various models as the result of this study showed that returns in these stock markets are not interlinked and there is no long run equilibrium; even if in few cases the return series in one stock market had causal influence on return in other stock market. By applying gravity model Flavin, Hurley, and Fabrice (2001) found that variables such as stock market proximity as well as sharing a common border are important factors for stock market linkages. Further, they found that the number of overlapping opening hours and sharing a common border tends to increase cross country stock market correlation. By moving ahead of the earlier work done by Flavin *et al.* (2001), Philipp and Louberge (2007) attempted to find out the reasons behind the stock market correlation and concluded that correlation among different markets is linked to the sectors of the market or stock market comprised of different sectors. The research came out

with the interesting findings that market level correlations are higher on average than sectoral correlations as well as that sectoral correlation between countries tends to be more stable over time than market level correlations and sectoral correlations within countries.

Data and Methodology

Rationale for the Study and Research Questions

Understanding relationship between portfolio returns based on their market capitalisation and economic stage is important for portfolio formation and diversification of risk. It is also required to know the information spillover effect and the efficiency of the market in assimilating the information on various indices (Zabiulla, 2014). In investment analysis literature, equity market integration has enough supportive notions. As per Markowitz (1952, 1991) and others, markets are said to be highly integrated only if their assets with similar risk have identical expected return (Durai & Bhaduri, 2006). Albeit this, earlier such studies have remained confined in terms of developed markets, regions etc. to understand copycat theory, market cap similarly etc. In such a scenario, understanding correlation matrix and dynamic linkages of the Indian market with other equity markets is the first step in getting the macro picture of Indian market's conduct with that of other and vis-a-vis. On one hand Yuce and Mugan-Simga (2000), Durai and Bhaduri (2006), Singh and Sharma (2012), Birau and Trivedi (2013), and Bodla and Yadav (2014) suggested that international investors can achieve long term gains by investing in the stock markets as the market are generally independent meaning opportunities for diversification do exists in these countries, while on the other hand Nath and Verma (2003), Lamba (2003), and Singh and Singh (2011) showed that benefits of diversification or speculative activities are limited due to high causality among majority of them. Further, in current parlance it is required to study the linkages of one market with varied markets that are in different stages of the economic development. Based on the extant literature review, it was realised that there is a need to throw light on the following areas. In this current scenario, it is much more essential to study the short run and long run relationships between each of the equity markets of developed and developing type. It is also required to study whether Indian equity market exert any significance influence on the other market and vis-à-vis for a long

term period as well as during crisis. In the continuation of the above two research questions, it is much needed to seek how and to what extent economic crisis of 2007 has changed the equation.

Objectives of Study

To examine the short and long run relationship between the Indian stock markets and selected south Asian & the other equity markets for the period of 1st January 2004 to 31st December 2013.

To examine whether all these markets have causal effect on each other during the whole and crisis period.

Sample Selection and Period of study

The study is based on the secondary data related to the daily closing prices of 12 indices. The indices considered in study are BSE Sensex, NSE Nifty, CSE, FTSE, Heng Seng, JKSE, KSE, Nikkie, S&P 500, Shanghai Stock Exchange, STI, and Taiwan Weighted Index. In this study, daily closing stock prices of all above mentioned indices are considered for the period from 1st January 2004 to 31st December 2013. Further, to address the research question mentioned earlier, it was decided to study the whole process first for the whole period (1st January 2004 to 31st December 2013) and then for the economic crisis period (1st September 2008 to 31st December 2010). Data were collected from their respective websites and yahoofinance.com. SPSS 17 and STATA 10 were used for data analysis. For the normality test, descriptive statistics and Kolmogorov Smirnov test (Table 2) was applied to check whether data are normally distributed or not. The null hypothesis for the normality test is that data are normally distributed and alternate hypothesis is that data are not normally distributed. If the p-value is less than or equal to 0.05, null hypothesis is rejected. Measures namely risk, return, coefficient of variation, Jarque-Beratest etc are used as a descriptive statistics. Further correlation coefficient was also applied to know to what extent different indices are correlated with each other. To check the stationarity of the data, unit root test is applied and to know which indices affect to which one; granger causality test are used for the purpose of the study. Table 1 provides snapshot of the indices considered for the study.

Table 1: Names of the Countries and Indices

Country	Index	Country	Index
INDIA	BSE 30 (sensex)	PAKISTAN	KSE
INDIA	S&P CNXNifty 50 (nifty)	JAPAN	Nikkei225
SRI LANKA	CSE	USA	S&P 500
UK	FTSE 100 (FTSE)	CHINA	Shanghai Composite (SSEC)
HONG KONG	Hang Sang (HIS)	SINGAPORE	STI
INDONESIA	JKSE	TAIWAN WEIGHTED INDEX	TWII

Research Instrument

Under Descriptive Statistics, the Average Daily Returns (mean), Skewness, Kurtosis, Jarque-Bera test are computed. The details are as follows. The logarithmic method to calculate return is as follows:

$$R_t = \ln(I_t / I_{t-1}) * 100$$

Where R_t stands for return of the index and I_t indicate index value at time 't'. Standard Deviation is known as the root mean square deviation for the reason that it is the square root of the mean of the squared deviation from the arithmetic mean. It measures the absolute dispersion.

$$s = \sqrt{\frac{\sum (x - \bar{x})^2}{n - 1}}$$

Mean is the average value of the series, obtained by adding up the series and dividing by the number of observations. It is the most common Measure of Central Tendency.

$$\bar{x} = \frac{\sum X}{n}$$

Skewness is a measure of symmetry, or more precisely, the lack of symmetry. A distribution of a data set is symmetric if it looks the same to the left and right of the centre point. The Skewness for a normal distribution is zero, and any symmetric data should have skewness near zero. Negative values for the skewness indicate that data that are skewed left and positive values for the skewness indicate that data are skewed right. Kurtosis is more commonly defined as the fourth cumulated divided by the square of the variance of the probability distribution.

$$\text{Skew} = \frac{n}{(n-1)(n-2)} \sum \left(\frac{x_i - \bar{x}}{s} \right)^2$$

$$\text{Kurtosis} = \left\{ \frac{n(n+1)}{(n-1)(n-2)(n-3)} \sum \left(\frac{x_i - \bar{x}}{s} \right)^4 \right\} - \frac{3(n-1)^2}{(n-2)(n-3)}$$

Jarque-Bera test is a goodness-of-fit test of whether sample data have the skewness and kurtosis matching a normal distribution. The test statistics Jarque-Bera is defined as

$$JB = \frac{n}{6} \left(S^2 + \frac{1}{4}(K - 3)^2 \right)$$

where n is the number of observations, S is the sample skewness and K is the kurtosis. The JB test is an indication of given distributions deviations of zero. Coefficient of Variations is a standardised measure of dispersion of a probability distribution or a frequency distribution. It is defined as a ratio of standard deviation to mean. It allows one to determine how much volatility one is measuring in comparison of amount of return one can expect from the investment. In other words, the lower the ratio of standard deviation to mean return; better is the risk-return trade off. Correlation coefficient is a normalised measurement of how the two variables (here indices) are linearly related. The correlation coefficient is calculated as:

$$\rho_{xy} = \frac{\text{Cov}(r_x, r_y)}{\sigma_x \sigma_y}$$

When the correlation coefficient is close to 1, it indicates that variables are linearly positively correlated. In a similar way, value near to -1 show that variables are linearly negatively related. For a zero value, it shows weak linear relationship between the variables.

Data Analysis and Discussion

A summary of descriptive statistics for daily market returns during 1st January 2004 – 31st December 2013 is shown in table 3. It can be noted that mean return of the developing country’s stock market are high as SENSEX, CSE, JKSE and KSE show good return over other stock markets. However, standard deviation of daily returns was found high for SENSEX, NIFTY, SSEC and HIS as compared to other. The Chinese stock market shows low return and high standard deviation and coefficient of variation. Skewness measures the asymmetry of the distribution of the return series around its mean. Almost

all the indices showed negative skewness, implying the fact that the returns had long left tail. Kurtosis measures peakedness or flatness of the distribution of the return series. The value of the kurtosis is more than 3 for all the indices except KSE indicating that the distribution is peaked (leptokurtic) relative to the normal. Thus, from the below values of skewness, kurtosis and JB test, it can be concluded that the null hypothesis of normally distributed daily returns is rejected by the normality test result.

Table 2: Test of Normality

Kolmogorov-Smirnova			
	Statistic	Df	Sig.
BSE 30 (sensex)	0.073	2742	.000
S&P CNXNifty 50 (nifty)	0.096	2768	.000
CSE	0.063	2665	.000
FTSE 100 (FTSE)	0.064	2726	.000
Hang Sang (HIS)	0.077	2914	.000
JKSE	0.065	2836	.000
KSE	0.082	2861	.000
Nikkei225	0.007	2873	.000
S&P 500	0.089	2960	.000
Shanghai Composite (SSEC)	0.064	2930	.000
STI	0.078	2867	.000
TWII	0.056	2930	.000

Source: Author’s calculation

Here from the K-S test, it can be realised that the p value is less than 0.05 for all the indices meaning null hypothesis rejected. Thus, it shows that data are not normally distributed.

As Table 3 shows, both of the Indian stock exchanges’ (SENSEX and NIFTY) returns have relatively higher correlations with the returns of the major developed markets. However, KSE, SSEC and HIS are poorly correlated with the developed equity markets. The JKSE and CSE are relatively better correlated with the developed equity markets. It is good to note that neighbouring countries’ stock markets are negatively correlated with Indian stock markets. However, due to growing international trade, investment flows, deregulation of the financial systems and growth in international capital flows; national economies have become more closely linked. The correlation study was further conducted for

crisis period (1 September 2008 to 31 December 2010) to know whether any notable change has taken place and if it is there in which direction and to what extent. This is presented in Table 4. The correlations need to be further verified for the direction of influence by the Granger

causality test and for long-term movements among the returns of stock markets. All these tests provide more robust results if the underlying are stationary over time and therefore, there is a need of a stationarity test for the time series.

Table 3: Descriptive Statistics

Stock Exchanges	Time Period	Mean	Std. Deviation	Coeff. of Variation	Skewness	Kurtosis	Jarque Berra
SENSEX	2004-2013	0.050786	1.63401994	32.1748643	-0.0593056	7.9865476	6576.614737
CSE	2004-2013	0.071203	1.14229362	16.04277155	-0.7598608	12.4367064	15671.95855
FTSE	2004-2013	0.015733	1.19281729	75.81546114	-0.1571024	9.04090506	8896.330067
HIS	2004-2013	0.023852	1.59289382	66.78189451	0.0407428	9.48641917	9419.873207
JKSE	2004-2013	0.073737	1.48972803	20.20338032	-0.6670707	6.3711366	4316.577706
KSE	2004-2013	0.070053	1.36434247	19.47596871	-0.4104814	2.79686589	874.779153
NIKKIE	2004-2013	0.01665	1.56687449	94.10649348	-0.5836342	8.51493481	7555.940725
NIFTY	2004-2013	0.04785	1.64562317	34.39119392	-0.2363976	9.10997334	8643.97366
S & P 500	2004-2013	0.020314	1.28783022	63.39548741	-0.3274904	11.0617004	12877.62393
SSEC	2004-2013	0.013718	1.68991341	123.1907397	-0.2712955	3.39435208	1193.911469
STI	2004-2013	0.022466	1.1789283	52.47716122	-0.233972	6.32822194	4256.384572
TWII	2004-2013	0.014332	1.31199396	91.54115332	-0.4105927	3.32945566	1211.73091

Source: Author's calculation

Table 4: Correlation Coefficients among Daily Market Returns for the Period from the 1st January 2004 to 31st December 2013. (Whole Period)

	SENSEX	CSE	FTSE	HIS	JKSE	KSE	NIKKIE	NIFTY	S&P	SSEC	STI	TWII
SENSEX	1	0.006253	0.034645	0.056549	0.025732	-0.00649	0.029833	-0.02726	0.056697	-0.00173	0.032846	0.092891822
CSE		1	0.040821	0.00695	0.034024	-0.00337	0.030922	-0.05033	0.017744	0.04669	0.012674	0.006847345
FTSE			1	0.002129	0.027186	0.011635	-0.02249	0.035423	0.019178	0.008289	-0.01048	6.47765E-05
HIS				1	0.007037	0.019737	-0.01791	0.006412	0.029091	-0.00201	0.027909	0.063076721
JKSE					1	0.019062	0.098087	0.025408	0.043508	0.000774	0.012111	0.035037343
KSE						1	0.032441	-0.02742	-0.00315	-0.01292	0.003261	0.027036426
NIKKIE							1	0.000126	0.025328	-0.00475	0.023442	-0.011544078
NIFTY								1	0.070926	-0.01577	0.075359	0.031152803
S&P									1	0.002025	-0.03033	-0.03158438
SSEC										1	0.035031	-0.007362579
STI											1	0.035595033
TWII												1

Source: Author's calculation

It is surprised to note that S&P is negatively correlated with only KSE, STI and TWII, while NIKKIE is negatively correlated with developed economies like FTSE, HIS, SSEC and TWII. This shows good diversification opportunity for Japanese investors. SSEC is having highest number of negative correlations with SENSEX,

HIS, KSE, NIKKIE, NIFTY and TWII. From the above table, it can be noted that SENSEX is negatively correlated with KSE and SSEC only while NIFTY is with only two emerging economies namely CSE and KSE only. It seems that Taiwan has benefited in terms of diversification as TWII is negatively correlated with all four developed market like FTSE, NIKKIE, S&P and SSEC.

Table 5: Correlation Coefficients between Daily Market Returns for the Period from the 1st September 2008 to 31st December 2010 (Economic Crisis Period)

	SENSEX	CSE	FTSE	HIS	JKSE	KSE	NIKKIE	NIFTY	S&P	SSEC	STI	TWII
SENSEX	1											
CSE	0.001527	1										
FTSE	0.032582	0.062493	1									
HIS	0.087435	-0.00941	-0.02631	1								
JKSE	0.044295	0.070464	0.04044	-0.02114	1							
KSE	-0.02485	0.063023	0.058589	0.008707	-0.0101365	1						
NIKKIE	0.027886	0.06805	-0.03588	-0.03757	0.06360783	0.030773	1					
NIFTY	-0.02623	-0.12315	0.04023	0.020725	0.02672574	-0.03924	-0.031189821	1				
S&P	0.074117	0.019745	0.024487	0.015298	0.09001702	-0.02228	0.017062724	0.112318	1			
SSEC	-0.03961	0.056455	0.035961	-0.05844	-0.0078873	-0.00464	0.044237179	-0.00974	-0.06694	1		
STI	-0.00067	-0.04541	0.02773	0.034956	0.00020068	-0.00248	0.021761693	0.103108	-0.08451	0.01757	1	
TWII	0.088216	-0.01119	-0.04457	0.161096	0.03162035	0.085887	-0.099556479	0.099541	-0.03236	-0.05559	0.067697	1

Source: Author's calculation

From Table 4, it can be observed that like whole period pairs for negative correlation, S&P is also correlated with SSEC along with KSE, STI and TWII. During crisis period, NIKKIE is still negatively correlated with FTSE, HIS and TWII; but not with SSEC. However, it has formed a new pair with NIFTY. SENSEX which was earlier correlated with SSEC and KSE only, is now correlated with STI also along with former pairs. It is good to note that NIFTY is now negatively correlated with SSEC and NIKKIE along with previous pairs KSE and CSE. TWII has added one more pair with CSE along with previous four pairs.

Further, it is worth to note that the negative correlation has increased in number during the crisis. During the whole period there were 19 negative correlations out of 66 combinations; which has increased to 27 out of 66 during the crisis period. During the crisis SENSEX has showed tremendous change in it. During whole period, SENSEX was positively related to CSE, HIS, and JKSE. This has changed to reverse by negative correlation to CSE, HIS, and JKSE after crisis period. SENSEX has remained positively correlated to developed equity markets i.e. S&P and FTSE in all three period considered for the study. Nifty has negatively correlated with the neighbouring stock markets. For the whole period considered for the study, Nifty was positively correlated with Nikkies and S&P; and negatively correlated with SSEC. While in the emerging economies, it showed negative correlation CSE and KSE. During crisis period, Nifty's correlation has remained negative with SSEC, but the negative correlation

has been weaker than the earlier phase. Further, during second phase i.e. crisis period, Nifty's correlation with S&P and JKSE has remained positive but turned negative with Nikkie and KSE.

Unit Root Test

A unit root test is used to test a stationarity of a time series data. The most appropriate and widely used test is the Augmented Dickey-Fuller (ADF), which uses the existence of a unit root as the null hypothesis. The null hypothesis for the ADF test is that the data needs to be differenced to make it stationary and the alternate hypothesis is that the data is stationary and does not need to be differenced. Integration among different indices is examined by using econometrics tools. To perform econometric test on time series data it is required that the data should be stationary in nature. To check whether data are stationary or not, Augmented Dickey Fuller Test under the unit root test was performed. Equation 1 helps to understand about unit root test,

$$Y_t = \rho Y_{t-1} + X_t \delta + \varepsilon_t \quad (1)$$

Where X_t are optional exogenous regressors with constant or constant as well as trend. ρ and δ are parameters to be estimated and ε_t is known as a white noise. Equation 2 shows the Dickey Fuller Test by subtracting Y_{t-1} from both the sides of the equation.

$$\Delta Y_t = \alpha Y_{t-1} + X_t \delta + \varepsilon_t \quad (2)$$

Where $\alpha = \rho - 1$. The null and alternate hypothesis may be written as,

$$H_0: \alpha = 0$$

$$H_1: \alpha < 0$$

Table 6: Unit Root Test in First Differences (on first Difference with Trend and Intercept Assumption)

Number	Index	ADF statistic	P- value
1	SENSEX	-46.432*	0.0000
2	CSE	-40.086*	0.0000
3	FTSE	-53.630*	0.0000
4	HANG SENG	-51.714*	0.0000
5	JKSE	-44.171*	0.0000
6	KSE	-43.197*	0.0000
7	NIKKEI	-51.635*	0.0000
8	S & P Nifty	-46.927*	0.0000
9	S & P 500	-56.050*	0.0000
10	SSE COMPOSITE	-48.979*	0.0000
11	STI	-49.738*	0.0000
12	TWII	-46.958*	0.0000

Source: Author's calculation
*significance at 1% level

From The ADF test results it was found that the ADF statistic or t- statistics are less than the critical value at 1%, 5% and 10% level of significance. The p- value of all the indices comes to zero i.e. less than 0.05. This has

rejected the null hypothesis and confirmed that all the return series do not have unit root and are stationary.

Pair-wise Granger Causality Tests

In order to examine the causal relations in between the returns of selected stock markets, granger causality test is employed. The Granger Causality Test is a statistical hypothesis for determining whether one time series is useful in forecasting another. Testing of Causality as per Granger Causality test involves using F test to study whether lagged information on another variable provides any statistically significant information about the given variable in the presence of lagged variable. If not, then other variable does not Granger causes the given variable.

If Y and X are considered to be stationary time series. To test the null hypothesis that X does not granger cause Y, is required to find the proper lagged values of Y to include in a univariate autoregression of Y. In Granger Causality test, there are bivariate regression of the below mentioned equation,

$$Y_t = \alpha_0 + \alpha_1 Y_{t-1} + \dots + \alpha_m Y_{t-m} + \epsilon_t$$

When the autoregression is augmented by including lagged values of X, it becomes

$$Y_t = \alpha_0 + \alpha_1 Y_{t-1} + \dots + \alpha_m Y_{t-m} + b_p X_{t-p} + \dots + b_q X_{t-q} + \epsilon_t$$

It can be noted that all the lagged values of X are retained in the equation that are individually significant according to their t-statistics, meaning collectively they add explanatory power to the regression according to an F test.

Table 7: Pair-wise Granger Causality Test for the Period from 1 January 2004 to 31 December 2013. (Whole Period)

	SENSEX	CSE	FTSE	HIS	JKSE	KSE	NIKKIE	NIFTY	S&P	SSEC	STI	TWII
SENSEX	-											
CSE	>>	-										
FTSE	<<	0	-									
HIS	>>	0	0	-								
JKSE	<<	0	0	<<	-							
KSE	<<	0	0	0	0	-						
NIKKIE	0	0	0	0	<<>>		-					
NIFTY	>>	0	0	<<>>	<<	<<	0	-				
S&P	>>	0	0	>>	0	0	>>	<<>>	-			
SSEC	0	>>	0	0	0	0	0	0	0	-		
STI	0	<<	>>	0	>>	>>	<<	0	>>	0	-	
TWII	<<	0	0	<<	>>	0	>>	0	0	0	0	-

Source: Author's calculation

To conduct it, 2-lag length in each pair was used. A summary of the granger causality test with direction of granger causality between each pair is shown in Table 7. The test involves examining whether lagged values of one series have significant explanatory power for another series. The null hypothesis is of no granger causality. The test is done at 5% significance level and therefore when p value is found less than 0.05, null hypothesis is

rejected meaning there is granger causality between the two exchanges.

Tables 7 and 8 contain result of the granger causality test. Here << denotes granger causality running from one direction to another, >> denotes granger causality, running from one direction to another, whereas <<>> means causality from both side and 0 is put for no causality for neither of direction.

Table 8: Pair-wise Granger Causality Test for the Period from the 1st September 2008 to 31st December 2010 (Economic Crisis Period)

	SENSEX	CSE	FTSE	HIS	JKSE	KSE	NIKKIE	NIFTY	S&P	SSEC	STI	TWII
SENSEX	-											
CSE	0	-										
FTSE	0	0	-									
HIS	0	0	0	-								
JKSE	<<	0	<<	0	-							
KSE	0	0	0	0	0	-						
NIKKIE	0	0	>>	0	>>	0	-					
NIFTY	0	0	0	<<	0	0	0	-				
S&P	>>	0	<<	0	0	0	0	0	-			
SSEC	0	0	0	0	<<	0	0	0	0	-		
STI	0	0	0	0	0	0	0	0	<<	0	-	
TWII	0	0	0	0	0	0	0	0	0	0	0	-

Source: Author's calculation

From Tables 7 and 8 it can be revealed that both ways causality (<<>>) has decreased tremendously during the crisis period compared to whole period. For the whole period; NIKKIE and JKSE, NIFTY and HIS and NIFTY and S&P showed both way causality, which has completely disappeared during the crisis period. It is noted that two way causality as well as one side causality has also reduced during the crisis period. CSE, HIS, NIFTY and S&P were granger causing the SENSEX. SENSEX was granger causing the FTSE, JKSE, KSE, TWII for the whole period, which was limited to JKSE and S&P during the crisis period. Further, KSE, JKSE, were granger causing the nifty and nifty granger caused the SENSEX during whole period; while during the crisis only HIS granger caused the NIFTY. It is further observed that Granger causality among the developed market has also reduced during the crisis period.

Conclusion

This study attempted to analyse 12 stock exchanges of both developed and developing economies to examine existence of any interlinkages between them. Previous empirical studies have given the mixed view about the inter linkages of the exchanges in terms of time, type of the market and so on. The present study found that level of correlation has increased during crisis period compared to whole period. In addition, during crisis period more pairs of negative correlation between developed and developing economies have been observed. Further, the positive correlation has become more diluted among the indices during the crisis period compared to whole period. This confirms with the findings of Durai and Bhaduri (2006) and Siddiqui (2009), but contradicts with Nath and Verma (2003), Lamba (2003), and Singh and Singh

(2011). The present empirical test gives green signal for the international investors to diversify their portfolio. Interdependency among global stock markets is studied primarily through correlation of returns and the granger causality. Results and the interpretation through Granger causality test and correlation matrix confirms each other and reinforces about the increased independency among the stock indices considered for the study.

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