



## Exploring dynamic causal linkages between Major Stock Exchanges of Asia and established markets of UK, USA, Germany, and Japan - A comparative analysis of Pre and Post era of Global Financial Crisis

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### Abstract

*This study explores the linkages between regional stock markets of three Asian (China, Pakistan and India) countries with well-established stock markets of Germany, United Kingdom, United States of America and Japan. Impact of global financial crisis (2008) has been analyzed on stock markets of sample countries by disaggregating the stock indices data into pre and post global financial crisis regimes. This study has employed weekly data of stock market from March 2001 to February 2008 to represent pre financial crisis performance of stock market whereas data from March 2008 to February 2016 refers to post financial crisis regime. Time-series techniques of unit-root testing, Johansen method of cointegration, Vector Error correction mechanism, variance decompositions, Impulse response function were employed. Results obtained suggest that integration and dynamic linkages among stock markets of sample countries have strengthen after financial crisis. This study advises the investors to include other markets in their portfolio as well so that their risk gets distributed to other markets as well. The policy makers may consider the fact that the degree of financial integration of regional stock markets has increased after the event of global financial crisis and the markets are no more regional markets.*

**Key Words:** Stock markets, Global and regional integrations, Panel Analysis

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## **1 Introduction**

In many ways the world is becoming one large market rather than a series of separate national markets. The same goods and services can be found in many countries throughout the world. Workers are finding it easier to move between countries and capital (finance) is also moving more freely from country to country. Increasing free trade and the rising mobility of labor and capital are having many effects on businesses all over the globe. With increasing degree of globalization, the equity markets of the world are no longer national markets.

In fact, modern research reveals that financial integration of the world has been more rapid than the real-sector integration. The most efficient channel of global financial integration is thought to be the stock market linkage among different countries and the flow of financial fluctuation transmission is normally attributed towards the stock market linkages (Baig et.al. 2020). The global financial crisis is an example of global financial integration. The financial crisis of 2007-08 in the US that was generated due to collapse in the US mortgage markets not only affected the equity markets in the US, but throughout the world equity market indices dropped vividly. The investors in different markets of Tokyo, New York and London waited for announcements from the listed companies to adjust their portfolios in line with the news from the other markets.

Initially, the Asian economies were not largely affected by the crisis, but over the passage of time, the stock markets and the exchange rates experienced strong pressure (Das, 2011).

The global financial crisis affecting different economies of the world has posed several questions for the economists. The response of financial markets as regards to financial integration is questioned Heilmann (2010) Jebran (2014) explored the linkages between Pakistan and five Asian countries including India, Indonesia, China, Malaysia and Srilanka and found causal relationship among some Asian countries but no integration between Pakistan and selected Asian countries. Our study is

different from this paper in the sense that we have investigated the long run and dynamic relationship among three Asian countries with the four stock markets of highly developed countries. Our objective is to empirically explore the extent of transmission of fluctuations in the financial markets of developed countries on financial markets of major developing countries in Asia in the pre and post 2008 crisis periods.

This study aims to determine whether the stock markets of Pakistan, India and China have any pattern or trend following movements with their international stock market counterparts i.e. USA, UK, Japan and Germany or not. The reason being that the developing markets are considered to be getting affected by the events happening in developed markets. Moreover, China and India are the most important emerging Asian economies and their linkage financial linkages with the stock markets of developed markets are important.

This paper is primarily concerned in exploring the contagion effect of the stock markets between two major Asian stock markets and Pakistan and their international counterparts because the stock markets of the developing economies are considered to be getting affected by the events happening in the developed markets. The global financial crisis experienced by the US led to the dropping of stock prices in other markets of the world. Also, the Asian financial crisis of 1997 led to the dropping of stock markets, exchange rates and prices of other assets. Pretorius, (2002).

The ‘contagion effect’ is defined as the movement of the asset prices together which are not caused by the movement of economic fundamentals just like an infectious disease which spreads to other human beings. Likewise, the happening of an event in a market affects other markets due to large capital outflows in other markets as well without any significant change in the economic fundamentals of the recipient country such as interest rates, profitability of the firms, the rate of inflation etc.

The literature review reveals that results of different studies on interlinkages of different stock markets are mixed for

example, Milionis et.al. (1998), Choudhry (1997), Masih and Masih (1997), Chen et.al. (2000), Kasa (1992), Voronkova, (2004), Wong et.al. (2007), Wahab and Waheed (2008), Modi, et.al. (2010), Hassouneh, et.al. (2017) found string or visible linkages between different stock markets. Similarly, Richards (1995), Elyasiani et.al. (1998), Kasa (1992) in case of Canada only, Yang et.al. (2003), Yang and Hu (2000), Fernandez and Rivero (2001) concluded that there is no long run or short relationship among different stock markets. Moreover, Yang et.al. (2014) found that cointegration relationship amplified after the Lehman Brothers collapse. Fall in degree of liquidity barriers and capital mobility and investment friendly environment have been mentioned as main factors behind interlinkages between stock markets of different regions and markets. To the best of our knowledge, there is no study exploring the interlinkages between developing and developed countries dividing the sample between pre and post 2008 crisis periods. According to our finding, there is a greater extent of financial integration among markets selected Asian and developed countries markets in the post financial 2008 crisis against pre-crisis linkage.

## **2 Literature Review**

The stock market interdependencies has been a major preoccupation for financial analysts and economic researchers since early seventies. The short-run linkages between the stock market were investigated and explored by economic researchers.

The theory relevant to stock market or financial integration may be attributed towards contagion effect. The ‘contagion effect’ is defined as the movement of the asset prices together which are not caused by the movement of economic fundamentals just like an infectious disease which spreads to other human beings. Likewise, the happening of an event in a market affects other markets due to large capital outflows in other markets as well without any significant change in the economic fundamentals of the recipient country such as interest rates, profitability of the firms, the rate of inflation etc.

Hence, this thesis intends to investigate the dynamic linkages (lead – lag relationships) between the stock markets as

specified above by applying Johansen cointegration framework on weekly data of stock market indices of the selected countries.

To the best of my knowledge, the specific group of countries has not been explored in the previous studies. The Pakistan stock market has not received consideration from the researchers as far as the co-movements and cointegration is concerned. This study will fill this gap.

Kasa (1992) investigated the stock markets of Japan, Germany, England, the USA and Canada by applying Johansen tests for collective movements of the selected stock markets. The presence of a collective style and trend was observed and the results of factor loading highlighted that this trend was strong in degree for the Japanese stock exchange and was the weakest for the Canadian share market.

Richards (1995). The markets of Australia, Canada, Austria, Germany, France, Denmark, USA, Switzerland, Holland, Spain, Norway, Sweden, Hong Kong, Italy and Japan were tested for cointegration for the period 1970 – 1994. The results suggest that there is no relationship among the markets under study. However, the paper suggested that the relative returns are predictable across sixteen national stock markets. The author employs the Johansen (1988) methodology and Engle – Granger (1987) method for testing of cointegration.

Milionis et.al. (1998), employ AR model on a set of the markets of Britain, USA and Greece for the period 1990 – 1992 and found that the US stock exchange significantly contributed to movement in the Athens stock Exchange whereas there was weak correlation with the UK stock exchange although statistically significant. The notion of weak-form market efficient hypothesis was rejected although Athens Stock exchange was informationally efficient in terms of assimilation of the information from foreign markets.

The markets of Argentina, Chile, Mexico, USA, Venezuela, Colombia and Brazil were studied by Choudhry (1997) for the period 1989 – 1993. The author applied Johansen

method for cointegration test and found that the markets were interrelated.

The markets of Taiwan, Singapore, South Korea and Hong Kong are investigated by Masih and Masih (1997) along with the established markets of the USA, the UK, Japan and Germany. He employs Johansen method of cointegration in four alternate models each containing one established market and four regional markets. He finds long run relationship evidence in each of the four models.

The markets of emerging Sri Lankan equity market and the stock markets of her trading associates (Hong Kong, the US, India, Singapore, Taiwan, Japan and South Korea) were examined using VAR. The authors found no significant relationships between the capital markets of Sri Lankan Island, the equity markets of Asia and the US. The authors suggest that less liquidity different barriers on national investors were the probable explanations for these results Elyasiani et.al. (1998).

Huang, Yang and Hu (2000) used bi-variate cointegration test proposed by Engle –Granger and Granger causality test on a system of six stock markets including USA, China, Taiwan, Hong Kong, South China and Japan. The author found no long run relationship between the stock exchanges under investigation.

Chen et.al. (2000) find cointegrating relationship between the markets of Brazil, Argentina, Chile, Mexico, Venezuela and Colombia in the long run till 1999; the period of study was from 1995 – 2000. The methodology employed was correlation and Johansen method.

Fernandez and Rivero (2001) studied the linkages between the stock markets of Asia over the time period 1977 – 1999 by using Cointegration techniques developed by Johansen which allow to include a structural break. The authors find no long run relationship if the possibility of structural breaks is excluded. If the possibility of structural break is allowed then evidence of significant relationships were found.

Similarly unnoticed linkages of Central European markets with their established counterparts in Europe and the United States were detected using the developed methodology. Voronkova, (2004).

The post era of Asian financial crisis of 1997 has received attention from different researchers as far as the stock market linkages are concerned. The researchers found that market association between different Asian markets enhanced in magnitude after the crisis. Yang et.al. (2003).

The ASEAN-5 countries namely Indonesia, the Philippines, Malaysia, Thailand and Singapore along with the US market given its global impact and significance were investigated. The authors find that the financial crisis of Thailand Bhat increased the cointegration between the stock markets of the region. Wong et.al. (2007).

Wahab and Waheed (2008) used graphical models and correlation analysis on nine stock markets of the world. They observe conditional relationship based on a structure between the financial returns of international stock markets.

Modi, et.al. (2010) found that the relationship of India with Brazil, Mexico, UK and the US is low. It is concluded therefore that these combinations provide an attractive combination for the diversification of the portfolio for the Indian investors. It is revealed that DOWJONES, MXX and NASDAQ are minimum reliant on other markets. The DJIA was found to be the influential market of the study. They used Granger – causality tests.

The transition process of stock exchanges of CEE-4 stock markets namely Czech Republic, Slovakia, Poland and Hungary from different national markets to integrated markets of the world was studied by Baumöhl (2013). The developed markets of G7 countries were selected namely stock exchanges of the USA, Canada, Germany, France, Italy, Japan and the UK. The correlation between the markets was found to be around 0.60. The Slovakian stock Exchange appears to be the most segmented market of the study and isolated from rest of the others. The

relationship between the stock markets strengthened over the period of time.

Yang et.al. (2014) studied the cointegration relationships among 26 worldwide stock market indices over the periods of sub-prime and European debt crisis and their influence rank are investigated by developing and analyzing directed and weighted cointegration linkages. The methodology used is Engle – Granger methodology for testing of cointegration. The obtained results are shown as follows: the crises have altered cointegration relationships among stock market indices, their cointegration relationship amplified after the Lehman Brothers collapse, while the degree of cointegration progressively lessened from the sub-prime to European debt crisis.

Hassouneh, et.al. (2017) built a violence index and used it as an exogenous variable in a VECM-MGARCH model on the Palestinian Stock exchange, the Israeli Stock exchange and the Jordanian Stock Exchange. Their findings suggest the existence of an equilibrium relationship between the three markets, which is essentially kept through Palestinian and Jordanian stock market adjustments and that equilibrium does not respond to increases in violence. An increase in violence has short-run direct negative impacts on the Palestinian stock exchange but does not directly influence the Israeli and Jordanian stock markets. The violence index is built by considering the number of daily casualties and fatalities that occurred in Palestine during the sample period.

Hence, considering above discussion, it is significant to explore the financial linkage among important emerging Asian economies with developed countries stock market.

### **3 Empirical Methodology**

This paper intends to investigate the dynamic linkages in terms of co-movements between stock markets by applying the cointegration framework proposed by Johansen on weekly data in four alternative models of three Asian Stock Exchanges namely Pakistan Stock Exchange Index, Chinese stock exchange, Indian stock exchange and one established market out of four markets of Japan, USA, UK and Germany. Hussain et.al. (2009), Khan



(2011), Harper et.al (2013), Sadia et.al (2020), Baig (2014), Lal et. al. (2016) and Ali et.al (2018) used The Johansen method for cointegration Granger causality and VECM for short and long-run adjustment. The cointegration framework proposed by Engle-Granger is not applied on the group of stock markets rather the cointegration framework proposed by Johansen is applied. The Johansen method allows to detect more than one cointegrating relationship in the model. The Engle-Granger method provides a foundation for the Johansen method of cointegration. After confirming the presence of cointegration, next step will be to formulate VECM to investigate short-run and long-run dynamic relationships followed by Granger causality tests, Variance decomposition analysis and impulse response functions of the four models.

#### **4 Data and empirical results**

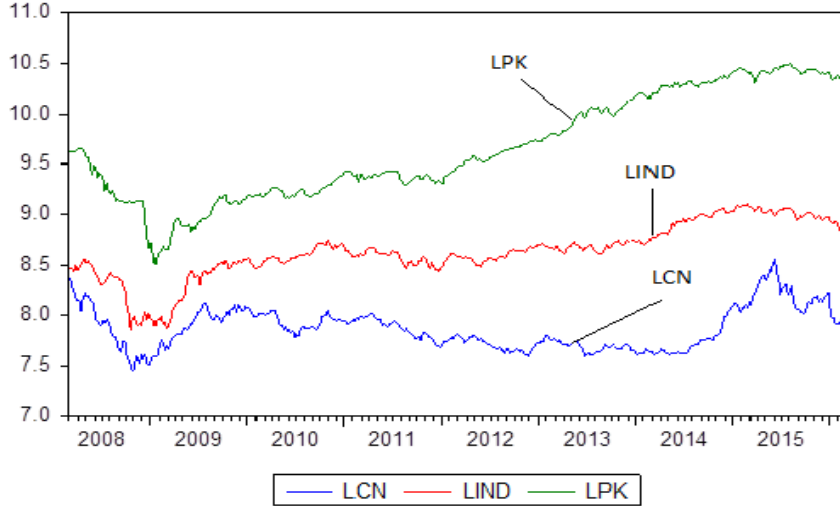
The markets included in the study are the USA (S&P 500), Germany (DAX 30), UK (FTSE – 100), Japan (NIKKEI – 225), Pakistan (PSX – 100), China (SSEC) and India (NIFTY – 50). The data comprises end-of-the week values of selected stock market indices. The markets of Pakistan, China and India are included as regional markets and four established markets of Germany (GER), United kingdom (UK), United States (US) and Japan (JN). The time period selected is around a significant event of the financial crisis that initiated due to the defaults of buyers in the mortgage market and culminated when Lehman Brothers Holding Inc. filed for the bankruptcy of the investment bank in 2008.

The data include eight years before March 2008 and eight years after March 2008. The sample size of eight years (416 observations) is chosen to include ample period before and after the financial crisis. This will allow us to investigate that whether the event has changed the dynamics of the stock market or not. The estimation is done separately on the two data sets to allow us to infer that whether the stock market integration has been affected after the period of crisis or not. All the data has been sourced from yahoo finance, except for the nifty and the respective websites of the stock exchanges included in the study. The website of yahoo finance has been used by researchers Khan (2011) and Harper, Jin,

& Gleghorn (2013). The stock price indices of the Asian markets are graphically presented in Figure 1.

**Figure 1**

*Stock price indices of Asian countries from the period (March 2008 to 2016)*



Whereas Fig.2 show the stock price indices of the established markets. The indices are of the post era of global financial crisis.

**Figure 2**

*Stock price indices of established countries (March 2008 to 2016)*

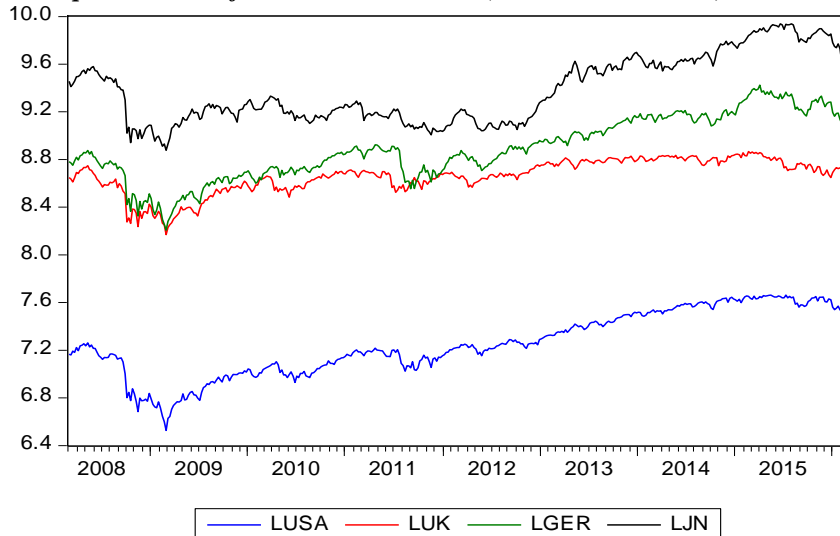
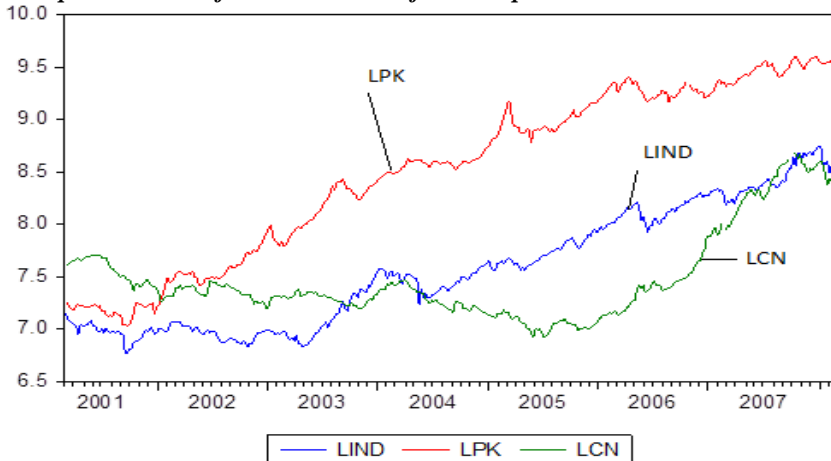
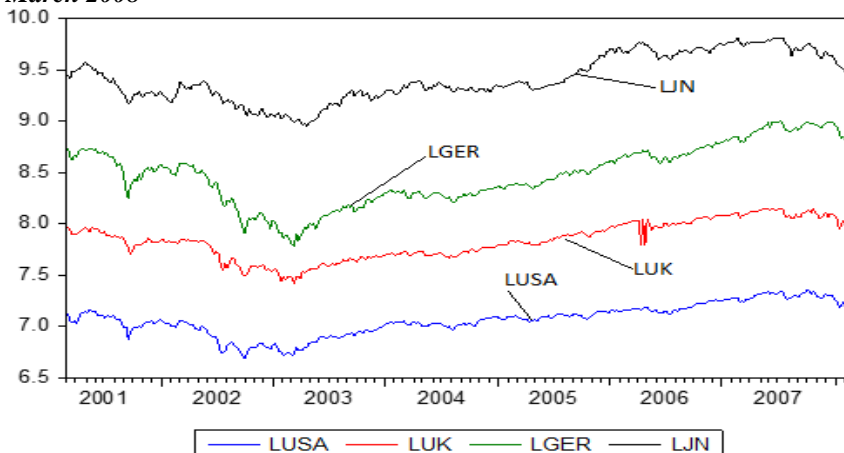


Figure 3 and 4 show the graphical representation of the Asian markets and the established markets for the period ranging from March 2001 to February 2008. The period shows the era of the pre global financial crisis. The data has been applied natural logarithm for several reasons as it allows the coefficients to be interpreted as percentages.

**Figure 3**  
*Stock price indices of Asian countries from the period March 2001 to 2008*



**Figure 4**  
*Stock price indices of established countries from the period March 2001 to March 2008*



#### **4.1 Tests for Univariate Integration: Tests of the Unit Root Hypothesis**

A prerequisite for performing cointegration test is to make sure that each individual series of the data is non-stationary. To determine that whether each series is stationary or not, Augmented Dickey Fuller test has performed with intercept on all seven series for pre and post data. The results of the ADF Tests are reported in the table 4.1.

**Table 4.1**  
*Tests for Stationary*

Augmented Dickey Fuller test		
Levels		
	PRE	POST
	$t_a$	$t_a$
US	-1.1963	-0.8873
UK	-0.9411	-1.6860
JN	-1.0917	-0.9450
GER	-0.8984	-0.9201
PK	-0.6099	-0.2023
IND	0.5269	-1.1298
CN	0.7040	-2.5355
First-difference		
	$t_a$	$t_a$
US	-19.9264	-4.4180
UK	-31.7306	-4.4310
JN	-18.8563	-11.8157
GER	-18.4775	-7.4513
PK	-16.4124	-7.9958
IND	-22.8179	-8.0111
CN	-16.9134	-18.8639
Critical values for significance level		
1% level		-3.448161
5% level		-2.869285
10% level		-2.570963

*Source:* Authors' estimation. Significant at 5% significance level

#### **4.2 Cointegration Test in a Multivariate Setting**

Having confirmed that each stock price index is  $I(1)$ , The Johansen and Juselius approach will be applied as it allows to test for cointegration relationship in a multivariate environment as opposed to two-step cointegration test proposed by Engle-Granger method.

Results of Johansen test by applying it to each of the four model for the two data sets are shown in table 4.2.

The optimal length structure for VAR is based on Schwarz info and Akaike Information Criterion (AIC), Interestingly each of the four models show no cointegration relationship in the period before the financial crisis and at most one cointegrating relationship after the period of financial crisis. Interestingly, both maximum Eigen statistic and trace test suggest at most one cointegrating vector for the vectors including the Japanese market, the German market and the US market for the period of post financial crisis.

In case of the vector including the UK market the trace test suggests that there is no cointegrating relationship present whereas the maximum Eigen statistic suggests the presence of one cointegrating relationship. As the two tests are efficient, we conclude the presence of one cointegrating relationship in the vector including the UK market.

These results depict that the event of global financial crisis has increased the linkages between the stock markets of the world. This also suggests that efficient market hypothesis is violated after the global financial crisis and diversification across the markets is of no use as one market contains the information of other. Also, the event of global financial crisis acted like a contagion which spread the effects of itself to different economies of the world.

The presence of one cointegrating relationship suggests that there are three common trends in the model stated above. Moreover, the presence of cointegration in the four models rules out that the relationship between the SPIs is spurious and will lead to a meaningful result of the relationship.

Secondly, there will be granger causality either unidirectional or bidirectional running between the markets in the short run.

Thirdly, the number of cointegrating relationships found in the system will produce error correction term which will be used as in the vector error correction mechanism of the systems.

Fourthly, the presence of cointegration rules out the specification of structural VAR as it does not impose the constraint of cointegrating relationships.

**Table 4.2a**  
*Cointegration test proposed by Johansen and Juselius for multivariate environment for the Post Global financial crisis data*

Hypotheses		Test Statistic	
Vector: [US, PK, IND, CN]			
Null	Alternate	Trace Statistic	Max-Eigen Statistic
$r=0$	$r>0$	62.08639 <sup>a</sup>	34.78801 <sup>a</sup>
$r\leq 1$	$r>1$	27.29839	19.72203
$r\leq 2$	$r>2$	7.576352	7.325672
$r\leq 3$	$r>3$	0.25068	0.250680
Vector: [UK,PK, IND, CN]			
Null	Alternate	Trace Statistic	Max-Eigen Statistic
$r=0$	$r>0$	44.67286	27.93853 <sup>a</sup>
$r\leq 1$	$r>1$	16.73433	11.45762
$r\leq 2$	$r>2$	5.27671	5.141664
$r\leq 3$	$r>3$	0.135046	0.135046
Vector: [JN, PK, IND, CN]			
Null	Alternate	Trace Statistic	Max-Eigen Statistic
$r=0$	$r>0$	48.66066 <sup>a</sup>	29.25467 <sup>a</sup>
$r\leq 1$	$r>1$	19.406	13.03735
$r\leq 2$	$r>2$	6.368651	5.637163
$r\leq 3$	$r>3$	0.731488	0.731488
Vector: [GER, PK, IND, CN]			
Null	Alternate	Trace Statistic	Max-Eigen Statistic
$r=0$	$r>0$	55.17942 <sup>a</sup>	29.06021 <sup>a</sup>
$r\leq 1$	$r>1$	26.11921	19.79515
$r\leq 2$	$r>2$	6.324062	6.024385

$r \leq 3$	$r > 3$	0.299677	0.299677
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Source: Authors' estimation

**Table 4.2b**

*Cointegration test proposed by Johansen and Juselius for multivariate environment for data before the global financial crisis*

Hypotheses		Test Statistic	
Vector: [US, PK, IND, CN]			
Null	Alternate	Trace Statistic	Max-Eigen Statistic
$r=0$	$r>0$	38.17459	20.80944
$r \leq 1$	$r > 1$	17.36515	11.97568
$r \leq 2$	$r > 2$	5.38947	4.92162
$r \leq 3$	$r > 3$	0.46785	0.46785
Vector: [UK, PK, IND, CN]			
Null	Alternate	Trace Statistic	Max-Eigen Statistic
$r=0$	$r>0$	39.10466	20.41765
$r \leq 1$	$r > 1$	18.687	11.62064
$r \leq 2$	$r > 2$	7.066367	6.901955
$r \leq 3$	$r > 3$	0.164412	0.164412
Vector: [GER, PK, IND, CN]			
Null	Alternate	Trace Statistic	Max-Eigen Statistic
$r=0$	$r>0$	39.59399	21.46176
$r \leq 1$	$r > 1$	18.13223	11.88965
$r \leq 2$	$r > 2$	6.24258	6.119456
$r \leq 3$	$r > 3$	0.123124	0.123124
Vector: [JN, PK, IND, CN]			
Null	Alternate	Trace Statistic	Max-Eigen Statistic
$r=0$	$r>0$	39.53074	21.07577
$r \leq 1$	$r > 1$	18.45497	10.31529
$r \leq 2$	$r > 2$	8.139673	7.898456
$r \leq 3$	$r > 3$	0.241218	0.241218
Critical values			
Significance Level 5%		Trace Statistic	Max-Eigen Statistic
$r = 0$	$r > 0$	47.85613	27.58434
$r \leq 1$	$r > 1$	29.79707	21.13162
$r \leq 2$	$r > 2$	15.49471	14.2646

$r \leq 3$	$r > 3$	3.841466	3.841466
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Source: Authors' estimation, <sup>a</sup> denotes rejection at 95% critical level

Having concluded that the stock markets before the event of global financial crisis were not cointegrated and that the stock markets after the event of global financial crisis to be cointegrated, I formally analyse the data post the global financial crisis. The presence of cointegration allows to produce VECMs exploring short run and long run dynamics, testing the imposition of restrictions on the coefficients of the long-run cointegrating vector, constructing variance decomposition and generating impulse response functions.

### 4.3 Testing the Imposition of Restrictions on the Coefficients of the Long-Run Cointegrating Vector Computed Through JJ Methodology

After estimating a cointegrating relationship in each of the four models is to test the exogeneity of the variables in each of the long-run cointegrating vector. The Johansen method allows us to impose restrictions on the coefficients of the long-run cointegrating vector and then testing the significance of the test statistic result. These test statistics are chi-square distributed and are distributed asymptotically. Analyzing the cointegration vector allows us to determine the most important component in the vector. The results are reported in Table 4.3.

**Table 4.3**  
*Results of testing the imposition of restrictions on the coefficients of the long-run cointegrating vector computed through JJ methodology*

Test	The Model involving (SPI)			
	USA	UK	GER	JN
SPI=0	14.78856 <sup>a</sup>	8.214179 <sup>a</sup>	9.250138 <sup>a</sup>	9.721542 <sup>a</sup>
PK=0	11.31936 <sup>a</sup>	2.58601	7.322696 <sup>a</sup>	15.83847 <sup>a</sup>
IND=0	5.105858 <sup>a</sup>	15.74179 <sup>a</sup>	2.217291	10.81879 <sup>a</sup>
CN=0	1.961495	12.99804 <sup>a</sup>	0.249986	16.19055 <sup>a</sup>

Note: The null hypothesis of the test statistic is that it is chi-square distributed. <sup>a</sup> denotes significance at 1% level. Source: Authors' estimation



One result which is consistent in all of the four models is that each established market enters its model significantly and the null hypothesis of  $US=0$ ,  $UK=0$ ,  $GER=0$  and  $JN=0$  is rejected thereby implying that each of the market explains its respective model significantly and influences the other markets in the model in the long run.

It is interesting to note that in the US model, China does not play role in explaining the US market indicated by the acceptance of the null hypothesis i.e., CN is equal to zero whereas the Pakistani market along with the Indian market exert long-run impact on the US market.

In the UK model, the results are opposite to that of the US market where Pakistani do not enter in the long run relationship significantly whereas the Chinese market and the Indian market enter in the long run relationship with the UK market.

It is interesting to note that in the GER model, China and India do not play role in explaining the GER market indicated by the acceptance of the null hypothesis i.e., CN and IND both are equal to zero whereas the Pakistani market exerts long-run impact on the GER market.

Interestingly, in the Japan model all the markets enter in the long run relationship significantly.

#### **4.4 VECMs (Vector Error correction Model) and Short Run Causality**

The next step, after confirming the presence of cointegrating relationship among the variables, is to compute short run causalities by running the restricted VAR wherein the long run error correction term appears as the exogenous variable. This process is known as Vector Error correction mechanism. As per our conclusion before, there is one cointegrating relationship in each of our model, so there will be one error correction term in each of the system and the coefficient of which will determine the speed of adjustment of the linkage of the model to the long-run equilibrium.

It is worth noting that each error correction term of the cointegrating vector is obtained by normalizing the vector of cointegration on the established market stock price index (SPI) and is checked for its significance by the way of t-statistic. The significance of the coefficient of the error correction implies that there is a long run relationship between the regional markets and the established market. The coefficient of the error correction term depicts the speed of adjustment through which the markets will adjust themselves in the long run.

The corresponding error terms were checked for stationarity through the routine ADF tests and four of the error correction terms were found to be stationary further confirming the cointegration between the markets in the model.

In all, there were 16 equations that were estimated, each model having four VECMs equation. As these equations were estimated through OLS, therefore the model was subject to inconsistencies such as the deviation of the error term from homoscedastic variance and the presence of serial correlation in the error terms and the departure of the error terms from normal distributions. Also, the equations suffered from the error terms having heteroskedastic variance. This problem imposes the issue that with heteroscedasticity present in the error terms, the value of t-statistics and the standard errors of the do not remain robust. Among different methods advised in the literature, I have used Newey West's heteroscedasticity and autocorrelation consistent (HAC) standard errors method which is now routinely incorporated in EViews 8. This method makes the standard error of the coefficients more robust and makes inference made on the basis of it reliable. This method also accounts for addressing the presence of serial correlation between the error terms making the t-statistic of the coefficients to be more reliable. The precaution which is to be exercised is to have a large sample. Our data set contains 418 observations which is large enough to use this (Newey West) method.

Also the Jarques-Bera rejects the null hypothesis of the error terms being normally distributed in all the sixteen equations,

but this condition of the error terms being normally distributed is relaxed in large samples Gujarati (2011).

Then, we move to check the weak exogeneity of the variables included in the model to check whether there is a short run relationship between the variables or not. we have used the Wald's test which allows to impose restrictions on the coefficients of the model and after that generates the results of the F-statistic. (Also known as Granger causality test) If the value is greater than the critical value then the null hypothesis of the test is rejected. The restriction was imposed on all of the lags of a particular market one by one that the coefficients of the lags of the market do not explain the movement of the dependent market. This method was done with four equations in each of the model containing the established market by making the first difference of the market as the dependent variable. The comments on each of the four models are as under. The results are reported in table 4.

#### **4.4.1 Stock Price Index – USA VECM**

The market of the USA is found to be exogenous markets in the model in the short run meaning that the market is not affected by the movements of other markets i.e., India, Pakistan and China in the short run. The Pakistani market is only affected by the movements in the US market in the short run. The coefficient of the error term in this equation is not significant implying that the Pakistani market does not correct itself in the short run to restore the long-run equilibrium. In case of the USA, the long term channel is active implying that the US market bears the burden of short-run adjustment to the long run. Interestingly, the Indian market and the Chinese market both are affected by the movements in the US market in the short run and the coefficient of the ECT is also significant meaning that the deviations from cointegration in the relationship is primarily caused in the Indian and the Chinese market in the short run to restore long-run equilibrium pattern. To conclude we can say that the markets of China, Pakistan and India are affected by fluctuations in the US market in the short run thereby indicating that the each of the regional market included in the study is affected in the short run by fluctuations in the stock market. The markets of US, China and

India correct themselves in the short run to retain the long-run equilibrium between the markets.

#### **4.4.2 Stock Price Index – UK VECM**

When the established market is UK in the model instead of the US, the Pakistani market continues to be exogenous in the short run and the longrun. The markets of China and India continue to be influenced by the established market of the UK in the short run. In this model, the UK is the stock price along with the Chinese market index in which the ECTs is significant implying that the UK market and the Chinese market change themselves in the short run to retain long-run equilibrium between the markets.

#### **4.4.3 Stock Price Index – Germany VECM:**

The ECT of the German market in this system is active along with the Indian market implying that these two markets bear the brunt of short-run adjustment to the long run. Again in this model the Chinese, the Pakistani and the Indian market continue to be led by the changes in the established market of Germany in the short run results consistent to the US model.

#### **4.4.4 Stock Price Index – Japan VECM:**

In this model, the Pakistani market continues be the exogenous market. However, interestingly changes in the Pakistani market and the Chinese market in the short run causes influences in the Japanese markets. The Japanese market continues to bear the burden of the adjustment by changes in the short run to retain the long run along with the Indian market and the Chinese market. Interestingly, the Indian market is significant in explaining short term linkages in the Chinese model.

**Table 4.4**  
**VECM results based on four models including USA, UK, Germany and Japan**

F Statistic				
$\Delta$ SPI	$\Delta$ PK	$\Delta$ IND	$\Delta$ CN	t - statistic, ECT(-1)
SPI = USA				
$\Delta$ SPI	0.285746	0.05559	0.670495	-4.09547 <sup>a</sup>
$\Delta$ PK	4.123832 <sup>a</sup>	0.01874	0.444792	0.055207
$\Delta$ IND	4.668358 <sup>a</sup>	0.082108	0.739483	-2.92681 <sup>a</sup>
$\Delta$ CN	12.43397 <sup>a</sup>	0.002388	0.107059	-2.6525 <sup>a</sup>
F Statistic				
$\Delta$ SPI	$\Delta$ PK	$\Delta$ IND	$\Delta$ CN	t - statistic, ECT(-1)
SPI = UK				
$\Delta$ SPI	0.109002	1.451157	1.343961	-2.48233 <sup>a</sup>
$\Delta$ PK	0.939687	0.752175	0.667111	-1.93553
$\Delta$ IND	11.96001 <sup>a</sup>	0.001586	0.525371	1.249084
$\Delta$ CN	11.70982 <sup>a</sup>	0.094387	1.467547	-2.38691
F Statistic				
$\Delta$ SPI	$\Delta$ PK	$\Delta$ IND	$\Delta$ CN	t - statistic, ECT(-1)
SPI = GER				
$\Delta$ SPI	0.306296	0.089827	0.478748	-4.99105 <sup>a</sup>
$\Delta$ PK	3.00838 <sup>a</sup>	0.17014	0.518316	-0.31487
$\Delta$ IND	2.83599 <sup>a</sup>	0.036644	1.058938	-3.53708 <sup>a</sup>
$\Delta$ CN	7.576126 <sup>a</sup>	0.26114	0.305323	-0.46881
F Statistic				
$\Delta$ SPI	$\Delta$ PK	$\Delta$ IND	$\Delta$ CN	t - statistic, ECT(-1)
SPI = JN				
$\Delta$ SPI	3.616564 <sup>c</sup>	3.48462 <sup>c</sup>	0.247434	-3.05215 <sup>a</sup>
$\Delta$ PK	0.007133	0.647378	0.547836	1.785692
$\Delta$ IND	0.007231	0.022277	0.175786	-2.61679 <sup>a</sup>
$\Delta$ CN	0.001645	0.416928	3.02856 <sup>c</sup>	2.153517 <sup>a</sup>

<sup>a</sup> denotes significance at 5% level <sup>b</sup> denotes significance at 10% level. Source: Authors' estimation

#### 4.5 Variance Decomposition

Having conducted the short run analysis through the model provided by the Vector Error Correction Mechanism, I

proceed to the dynamic analysis of the impact of one market on to the other markets. The VECM analysis is strictly within sample analysis whereas the variance decomposition analysis allows us to predict the future course of the markets. The system is given a shock and the forecast error variance is calculated to gauge how shock to a given market translates to other markets. The error variance thus forecasted and calculated is decomposed into different components. The innovations in different stock markets is depicted by each of the different components.

Theoretically, if a market is explained mostly by its own forecasted error variance, then that market is relatively exogenous. The variance decomposition is reported for one week, 4 weeks (month forecast), 12 weeks (quarterly forecast), 21 weeks (semi-annual), 52 weeks (annual forecast).

The results discussed are only discussed for the 4 week period (short run) 52 weeks period (long run). The results are reported from table 5.5 to 5.8. In the short run i.e., 4 weeks a month, table 5.5, the US market is the exogenous market with only 3% of the US market being explained by innovations in other markets. However, in the long run (52 weeks), 75% of the US market is explained by innovations in the Pakistan and the Indian market. In the short run, the Pakistani market is relatively exogenous where only 6% of its value is explained by the US market. The result is somewhat different from the short run analysis and as such this result is not consistent with our Granger temporal causality in which the US market does influence the Pakistani market in the short run. But as stated earlier, that the VECMs analyses the past data based on the lags of the variables thereby only providing a model for causal analysis and the variance decomposition is in effect a test for exogeneity (Brooks, 2014). Also, it is possible that the US market did not have a contemporaneous rather than had a lagged impact on the Pakistani market.

**Table 4.5**  
**Variance decomposition for the system including the US market**

Variance Decomposition of LUSA:					Variance Decomposition of LIND:				
% of forecasted variance which is described by changes in					% of forecasted variance which is described by changes in				
Period	LUS	LPK	LIN	LC	Period	LUS	LPK	LIN	LCN
	A		D	N		A		D	
Week					Week				
1	100	0	0	0	1	31.7	0.40	9	0.00
	97.5			0.5		32.8		65.7	
4	7	1.46	0.38	8	4	4	1.38	6	0.01
	76.2	18.0		1.3		19.0		73.8	
12	4	5	4.33	8	12	4	7.11	4	0.01
	52.2	37.1		1.8		11.6	12.0	76.2	
21	7	4	8.78	1	21	8	7	3	0.02
	22.4	61.0	14.3	2.1			18.3	76.8	
52	9	8	1	1	52	4.81	2	4	0.03

Variance Decomposition of LPK:					Variance Decomposition of LCN:				
% of forecasted variance which is described by changes in					% of forecasted variance which is described by changes in				
Period	LUS	LPK	LIN	LC	Period	LUS	LPK	LIN	LCN
	A		D	N		A		D	
Week					Week				
1	1.86	4	0.00	0	1	2.56	0.60	0.25	9
		98.1		0.0					96.5
4	6.01	2	0.01	5	4	5.81	2.03	0.90	6
		93.9		0.0					91.2
12	4.98	9	0.08	4	12	2.29	8.44	2.77	0
		94.8		0.0			13.7		86.5
21	4.04	8	0.14	4	21	1.80	7	4.18	6
		95.7		0.0					80.2
52	2.93	1	0.24	3	52	2.64	0	5.86	9
		96.8		0.0			20.4		71.0

Cholesky ordering: LUSA LPK LIND LCN

Source: Authors' estimation

The results for variance decomposition analysis of the Indian market are in line with the VECM results generated above where 32% of the Indian market variance is described by fluctuations in the US market. In the 52 week period horizon, the

Indian market is relatively exogenous, where around only 23% of its variance is explained by fluctuations in the Pakistani market and the Indian market and only 0.02% being explained by innovations in the Chinese market.

The results for the variance decomposition of the Chinese market in the system is: around 65 of its variance is explained by the US market in the short run and the Chinese market explains around 91% of its own variance. In the year period. The Chinese market is forecasted to be relatively 20% of its variance is explained by the Pakistani market innovations.

**Table 4.6**

***Variance decomposition for the system including the UK market***

Variance Decomposition of LUK:					Variance Decomposition of LIND:				
% of forecasted variance which is described by changes in					% of forecasted variance which is described by changes in				
Period	LUK	LPK	LIND	LCN	Period	LUK	LPK	LIND	LCN
Week					Week				
1	100	0	0	0	1	9.46	2.05	88.50	0.00
4	98.78	0.01	0.16	1.04	4	15.80	2.60	81.33	0.27
12	96.23	0.04	0.82	2.91	12	18.09	2.84	78.67	0.40
21	92.49	0.08	2.72	4.71	21	19.19	2.95	77.37	0.49
52	83.87	0.16	7.83	8.14	52	20.75	3.08	75.52	0.64
Variance Decomposition of LPK:					Variance Decomposition of LCN:				
% of forecasted variance which is described by changes in					% of forecasted variance which is described by changes in				
Period	LUK	LPK	LIND	LCN	Period	LUK	LPK	LIND	LCN
Week					Week				
1	0.15	99.85	0.00	0.00	1	0.07	0.89	2.82	96.22
4	0.36	98.35	1.28	0.02	4	0.78	1.32	7.94	89.97
12	0.20	94.14	5.38	0.28	12	0.40	1.21	19.78	78.60
21	0.53	89.14	9.53	0.80	21	0.95	1.03	30.27	67.74
52	1.55	80.02	16.55	1.88	52	2.75	0.72	46.15	50.38

Cholesky ordering: LUK, LPK, LIND, LCN.

Source: Authors' estimation



The UK market is the exogenous market both in the short run and in the 52 weeks period. In the 52 weeks period 84% of its error variance is explained by its own innovations. The Indian market and the Chinese markets contribute in explaining the error variance of around 8% and 7% respectively. These results are in line with our previous findings. The Pakistani market continues to be the exogenous market in the short run (4 weeks period) where in less than 2% of its variance is described by other markets. Even in the 52 weeks period only 20% of its value is explained by other markets.

The Indian market is explained 16% by innovations in the UK market which is consistent with our VECM results and in the larger period it accounts for the explanation of 20% value. The Chinese market variance decomposition is somewhat different from the VECM analysis where around 8% of the variance is explained by the Indian market and the UK market does not explain the future course of the Chinese market possibly due to reasons outlined previously. (Brooks, 2014).

The German market is the exogenous market in the 4 weeks period whereas in the 52 week period the Pakistani market explains 55% of forecast error variance of the German market. The results are consistent with our VECM results. The Pakistani market continues to be exogenous market in the short run (4 weeks period) with 95 percent of its variance explained by itself. The degree of exogeneity increases in the 52 week period where in 98 percent of its variance is explained by its own shocks.

**Table 4.7**  
***Variance Decomposition for the System Including the Germany Market***

Variance Decomposition of LGER:					Variance Decomposition of LIND:				
% of forecasted variance which is described by changes in					% of forecasted variance which is described by changes in				
Period	LGE	LPK	LIN	LC	Period	LGE	LPK	LIN	LCN
	R		D	N		R		D	
Week					Week				
1	100	0	0	0	1	36.23	0.37	63.40	0.00

*Dynamic Causal Linkages Between Major Stock Exchanges*

4	98.53	0.88	0.56	0.03	4	34.47	1.16	64.16	0.21
		13.1							
12	81.92	7	4.56	0.35	12	20.65	5.23	73.48	0.64
		30.3							
21	59.20	0	9.44	1.06	21	13.00	8.93	77.09	0.99
		55.7					13.9		
52	25.70	2	16.26	2.31	52	5.45	0	79.22	1.43
<b>Variance Decomposition of LPK:</b>					<b>Variance Decomposition of LCN:</b>				
% of forecasted variance which is described by changes in					% of forecasted variance which is described by changes in				
Period Weeks	LGER	LPK	LIND	LCN	Period Weeks	LGER	LPK	LIND	LCN
1	1.95	98.05	0.00	0.00	1	4.35	0.56	0.14	94.96
4	4.91	94.92	0.07	0.10	4	10.17	1.15	0.43	88.24
12	3.65	95.99	0.18	0.17	12	7.68	2.47	0.85	89.01
21	2.71	96.79	0.27	0.22	21	5.78	3.52	1.14	89.56
52	1.65	97.68	0.39	0.28	52	3.54	4.99	1.54	89.93
Cholesky ordering: LGER LPK LIND LCN									

*Source:* Authors' estimation

The Indian market in the short run is dependent on the German market (around 34% of its variance value is explained by the German market) whereas in the 52 weeks the Indian market becomes endogenous explaining 79 percent of its own value. 10 percent of the value of the variance of the Chinese market is explained by the fluctuations in the German market in the 4 weeks period and in the 52 weeks period, China retains its exogeneity by explaining 90 percent of its own value through its own fluctuations.

**Table 4.8**  
**Variance decomposition for the system including the Japanese market**

Variance Decomposition of LJN:					Variance Decomposition of LIND:				
% of forecasted variance which is described by changes in					% of forecasted variance which is described by changes in				
Period	LJ N	LPK	LIN D	LCN	Period	LJN	LP K	LIN D	LCN
Week					Week				
1	100	0	0	0	1	31.3	0.37	68.30	0.00
	99.					28.7			
4	39	0.05	0.25	0.30	4	8	1.31	69.20	0.70
	95.					25.2			
12	23	1.42	0.34	3.01	12	8	3.81	68.33	2.58
	89.					22.9			
21	50	3.56	0.92	6.06	21	2	5.89	66.99	4.20
	80.			10.7		19.8			
52	00	7.17	2.06	7	52	3	8.86	64.76	6.55
Variance Decomposition of LPK:					Variance Decomposition of LCN:				
% of forecasted variance which is described by changes in					% of forecasted variance which is described by changes in				
Period	LJ N	LPK	LIN D	LCN	Period	LJN	LP K	LIN D	LCN
Week					Week				
1	3.5	96.4			1	6.96	0.26	0.19	92.5
	4	6	0.00	0.00		13.4			9
4	7.5	91.7			4	6	0.28	2.48	83.7
	5	0	0.74	0.01		21.1			8
12	12.	84.4			12	9	0.33	5.36	73.1
	86	4	2.20	0.50		25.8			3
21	16.	79.1			21	7	0.84	7.24	66.0
	35	5	3.31	1.19		31.4			4
52	20.	72.1			52	5	1.79	9.57	57.1
	77	2	4.80	2.31					9

Cholesky Ordering: LJN LPK LIND LCN

Source: Authors' estimation

The Japanese market is the exogenous market in the four weeks period and in the 52 weeks period 7% of its value is explained by innovations in the Pakistani market and 11% of its

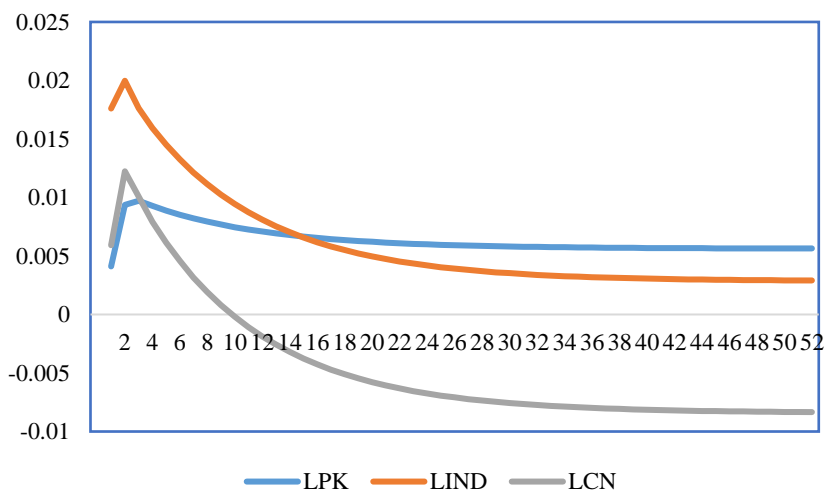
value is explained by the Chinese market and the Japanese market itself accounts for 80 percent of its own value. In the four weeks period, the Pakistani market is exogenous whereas in the 52 weeks period, 20 percent of the value of the Pakistani market is explained by innovations in the Japanese market whereas the Pakistani market itself accounts for 72% of its own value.

The Indian market is influenced by the Japanese market where in 29% of its value is explained by the fluctuations in the Japanese market and the Indian market itself accounts for 70% of its value of forecast error variance in the short run. The 52 week period is somewhat also gets affected by the Pakistani market (9 percent), the Chinese market (6 percent), and the Japanese market 20 percent.

#### **4.6 Impulse Response Functions**

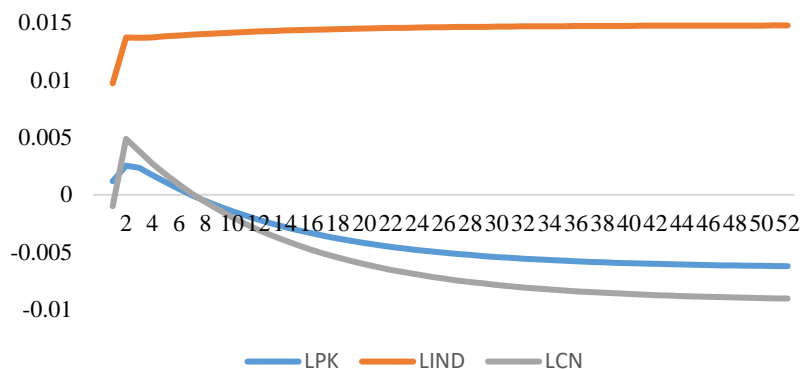
**Figure 5**

*Response of regional markets to Cholesky one standard deviation shock to USA market*



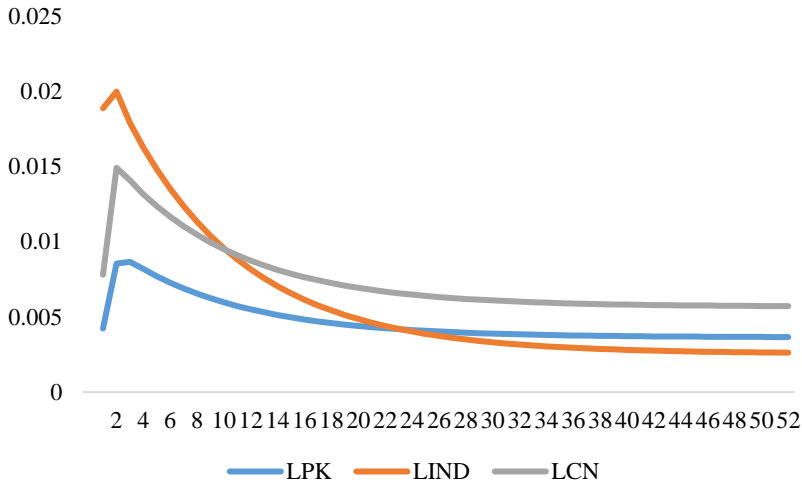
All the three markets respond to a shock in the US market in the initial weeks of the reception of the shock. The Pakistani market and the Indian market seem to have a positive effect of that shock persistently whereas the Chinese market after initial positive effect seems to have persistent negative effect after eight to nine months. Interestingly all the regional markets seem to have positive effects initially after the reception of shock.

**Figure 6**  
*Response of regional markets to Cholesky one standard deviation shock to UK market*



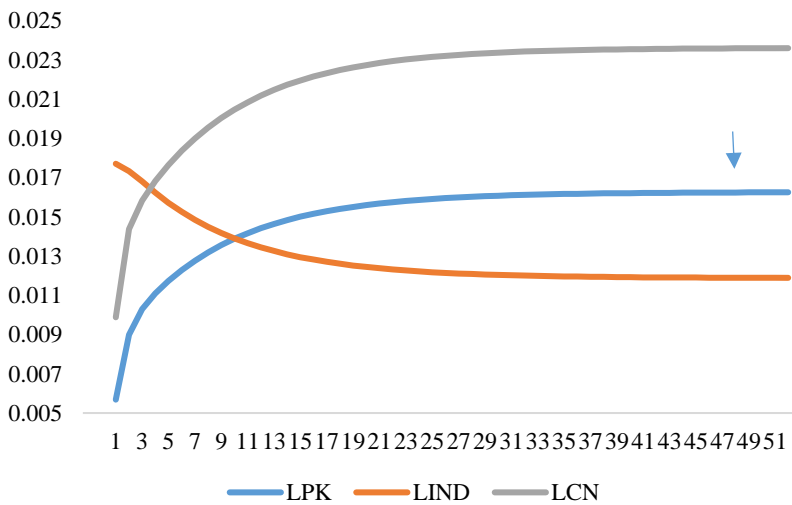
The Chinese market continue to exhibit the same trend here if an unanticipated shock is given to the UK market as is the case where shock was given to the US market. Interestingly, the Pakistani market joins the rally with the Chinese market although the level of readiness to the reception of the shock is somewhat less than the Chinese market.

**Figure 7**  
*Response of regional markets to one standard deviation shock to GER market*



The regional market of India exhibits a positive effect throughout the period under study. All the three markets responded positively to a shock generated to the Germany market and all the three markets retained the positive effect of the shock throughout the period under study with India initially being the largest responder but gradually the effect of that shock somewhat declined.

**Figure 8**  
*Response of regional markets to one S.D. shock to Japan market*



The Indian market showed a declining trend till 24 weeks but the effect remained positive throughout the period. However, the Chinese market and the Pakistani markets showed upward trends with the Chinese market showing a greater degree of reception of the shock.

To conclude, we can say that all the regional market showed the signs of reception of the shock given to all the established markets of the USA, UK, Germany and Japan. The result is consistent with the presence of cointegrating relationship present in each of the four models that these markets have long run equilibrium relationship.

## **5 Summary and Policy Implications**

The stock markets of the region viz. China, India, and Pakistan were studied and analyzed along with one established stock markets of the USA, UK, Germany and Japan in four separate models for the time period around a global event of global financial crisis that primarily hit the mortgage markets of the USA. The data starting from the period March 2001 to March 2008 and another data set starting from March 2008 to March 2016 was analyzed using Johansen method of cointegration. The summary of the results is that there was no cointegration relationship in any of the models of the four established markets before the period of global financial crisis. Interestingly, in the data set starting from March 2008 to March 2016 which depicts the period of post global financial crisis there is evidence of one cointegrating relationship in each of the four models suggesting that the interdependence among the stock markets of the world increased after the global financial crisis.

The period depicting the post financial crisis was analyzed through imposing long run restrictions on the long-run cointegrating vector, Granger causality test for exploring short run dynamics, forecasting through variance decomposition and impulse response functions.

Interestingly, each of the four established markets exerted long run impact on the regional markets in each of the four models. The market of India influenced each of the established

market except Germany whereas the Pakistani market exerted a long run impact on each of the four established markets except the UK. The Chinese market was the least influential of the three regional market that impacted only two of the established markets of the UK and Japan. The Japanese market resulted in to be the most open market of the study in the long run.

The residuals from each of the four cointegrating vectors obtained from the four models were embedded in the VECMs. The most influential market was the US whose short run fluctuations impacted each of the regional markets in the short run and the least influential was Japan whose fluctuations in the short run did not affect any of the regional markets. The most endogenous market was the Indian which was affected by three of the established markets of USA, UK and Germany. These results were broadly in line with the variance decomposition results with a few exceptions, the reasons of which had been discussed previously.

The presence of cointegrating relationship between the variable led to persistent effect due to impulse in one of the established markets which is depicted by the impulse response function of the four markets.

Secondly, there exists long relationship between the regional markets and the established market of the US, the UK, Germany and Japan in the post era of the global financial crisis whereas there is no long run relationship between the regional markets and any of the established market of the US, the UK, Germany and Japan before the event of global financial crisis.

Thirdly, the presence of cointegration in each of the four models eliminates the possibility of spurious relationship between the markets. This violates the efficient market hypothesis as one of the market contains information for the other markets.

Fourthly, the investors who seek to minimize their risk by diversifying their portfolio should be aware that the regional markets of Pakistan, India and China share long run equilibrium relationship with the established markets of the USA, UK, Germany and Japan.



The inference for the policy makers and the investors are clear.

Firstly, the investors are advised to include some other markets in their investment portfolio to incorporate the benefit from diversification.

Secondly, an important implication in each of the four models is that the regional markets are driven by the fluctuations in the established markets with the exception of the Japanese market. The regional markets' fluctuations do not create fluctuations in other stock markets of the region depicting independence of the regional markets from each other in each of the four models with the exception of the Japanese model in which fluctuations in Indian market leads to the changes in the Chinese market. Moreover, the evidence of significance of the Indian market in explaining the Chinese market is rejected at 5% level of significance but accepted at 10% level of significance also confirms our claim that the regional markets are independent of the fluctuations happening in the regional markets at 5% level of significance.

Thirdly, based on our variance decomposition analysis, the most exogenous market in the future will be the UK followed by the Japanese market where the greatest % of their variances is explained by their own shocks.

Fourthly, keeping in view the increasing economic integration of Pakistan and China it is interesting to note that the financial markets of the two countries are still not integrated. The increasing economic integration between the two countries through China Pakistan Economic Corridor (CPEC) could be a starting point of financial integration of the stock markets in the future.

Fifthly, the policy makers of the regional markets are advised to keep in view the fact the markets of Pakistan, India and China are no longer regional markets.

Most importantly this study finds a greater extent of financial integration among markets selected Asian and developed countries markets in the post financial 2008 crisis against pre-crisis linkage.

The type of the study has several motivations for future research. With cointegration present in the four models it may be of strong interest to investigate the driving factors which tie these markets. Moreover, the inclusion of more established markets in the study will also improve our understanding of the cointegration of the regional markets with the established markets of the world. The economic growth of the Asian region which includes world's future largest economies of China and India along with Pakistan may attract the interests of researchers in understanding the driving factors behind these relationships.

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