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Stock Market Integration using VECM: Evidence from Largest Economies

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Abstract: *Globalization has resulted in increased co-movement of financial markets across the globe presenting profit making opportunities galore for international investors through global diversification. This study is an empirical application of daily data of Stock Exchange Indices of top ten largest economies of the world namely United States, China, Japan, Germany, United Kingdom, France, India, Italy, Brazil and Canada (in nominal GDP terms) over a period of more than ten years ranging from Sep 15th, 2008 to Dec 31st 2018.This paper attempts to unearth the issue of stock market integration focusing on the top ten largest economies of the world based on the data released by International Monetary Fund (IMF) World Economic Outlook (April 2018). A considerable research has been done to establish the co-integration amongst the member countries of ASEAN, BRIC and SAARC but the originality value of the present study lies in checking cross country cointegration (if any) among the largest economies of the world. Various financial econometric models such as Augmented Dickey-Fuller Unit Root, Correlation, Johansen Cointegration, Wald Test, VECM and Variance Decomposition have been used to analyse the possible cointegration among the sample stock markets. The empirical results suggested that there exists weak long run dynamics among the selected stock markets.*

Keywords: *Stock market Linkages, Augmented Dickey-Fuller Unit Root, Johansen Cointegration, VECM and Variance Decomposition*
JEL Classification: C 22, G10, G 15 and F30.

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Economic cross-linkages and the increased co-movement of asset prices across international markets are important outcomes as the result of globalization **(Swee-Ling Oh et al, 2010).**Stock markets across the globe, on one hand present profit making opportunities galore for international investors through global diversification and on the other hand limit the scope for international arbitrage due to cross country linkages. **(Gallo & Otrando, 2007)** Globalization and Information Technology Revolution through quick diffusion, substantial deregulation and harmonization, all fostered integration and created tremendous impact on Financial Market Structure

I. Overview of Largest Economies of the World

World GDP (nominal) is estimated at $79.87 trillion (2017) as compared to $75.49 trillion in 2016. International Monetary Fund (IMF) World Economic Outlook (April 2018) ranked the Top ten countries in nominal GDP terms as United States, China, Japan, Germany, United Kingdom, France, India, Italy, Brazil and Canada respectively. The U.S. has retained its position of being the world's largest economy with an expectancy to grow to about $34.1 billion by 2050. US Economy accounts for one-quarter of the world's economy (World Economic Forum Reports)

At second rank currently China's economy will grow to nearly $58.5 trillion in 2050, the largest in the world **(PwC World 2050 report, 2017**). After Economic reforms of 35 years (beginning 1978) China escalated its rank from 9th to 2nd position with a nominal GDP of USD 9.2 trillion and registered $14 trillion mark in 2018 as compared to $2 trillion from 2017, to $14 trillion. Next, Japanese economy did not exhibited an impressive growth as it recorded GDP of $4.87 trillion in 2017 which increased to $5.1 trillion in 2018. Currently standing at third rank, Japan is expected to drop to eighth in the world by 2050.

The German economy which plummeted 5.2% in 2009 in the wake of the financial crisis has bounced back and ranks fourth on the list of largest economies with a nominal GDP of USD $4.2 trillion and expected to reach only $6.1 trillion by 2050.

With Brexit negotiations between the UK and the EU are yet to be finalized**, United Kingdom stands fifth** with a nominal GDP of USD 3.2 trillion. The future economy of the country is only $5.3 trillion by 2050.

France takes sixth rank and has a $2.93 trillion economy, but the report indicates a slow growth ahead, to about $4.7 trillion in 2050.

India is currently having a nominal GDP of USD $2.85 trillion, but PwC expects it to grow to $44.1 trillion and surpass the U.S. economy by 2050. India's economy recently surpassed China's to become the world's fastest growing large economy with growth rate projected at 7.4% FY 2019. China and India are projected to be the two largest economies by 2050**(PwC World 2050 report, 2017**).In nominal GDP ranking, the gap between United Kingdom, France and India is not much, therefore India with its current growth rate will soon overtake them.

Italy is crippled from political instability, economic stagnation and lack of structural reforms. The European country hits the list in the eighth spot with an economy of $2.18 trillion. The South American country, Brazil has an economy of more than $2.14 trillion putting it at ninth position in top ten largest economies in the world. It is estimated that the Brazilian economy will increase to about $7.5 trillion by 2050. North American Canadian economy ranks 10th largest economy in the world with a $1.8 trillion economy. Canada with its robust pre crisis fiscal policy, a secured financial system, and a strong external sector and its resource rich western province recovered quickly from the impact of the crisis.

Research Gap:

Numerous researches are conducted to establish the co-integration amongst the member countries of ASEAN, BRIC and SAARC. This paper attempts to unearth the issue of interdependence of stock market integration focusing on the top ten largest economies of the world economies in 2018 based on the data released by International Monetary Fund. As per International Monetary Fund (IMF) World Economic Outlook (April 2018) the Top ten countries in nominal GDP terms are United States, China, Japan, Germany, United Kingdom, France, India, Italy, Brazil and Canada respectively. Even differing economically, culturally and politically, they still may offer portfolio diversification and arbitrage opportunities to the global investor. Hence the present study conforms to the originality value as it attempts to check cross country co-integration (if any) among the largest economies of the world.

Review of Literature

Evanor and Palac (1997) tested ASEAN stock markets cointegration applying unit root and co integration tests and all ASEAN market cointegrated except Indonesia. Majid et al. (2008) and Oh et al. (2010) revealed greater integration among ASEAN stock markets post-1997 financial crisis. Later Swee-Ling Oh (2010), Karim and Karim (2012) additionally applied Granger causality tests studied volatility co-movement of ASEAN-5 and found partial market integration for the pre-crisis; whereas in the post-crisis, complete integration prevails. Jakpar et al. (2013) examined the long run relationship of volatility between China and ASEAN-5 countries stock markets (Malaysia, Singapore, Thailand, Indonesia and Philippines) by using co integration test, granger causality techniques and found that China and ASEAN countries have relationship in the stock market volatility.

Walid et a l. (2014) studied BRICS countries (Brazil, Russia, India, China and South Africa) and major global factors using the quantile regression approach (1997-2013) and observed dependence of these markets with global factors. Bansal R.et al (2015) tested co-integration and positive co-relation among the stock markets of SAARC countries and thus being highly cointegated thus reducing the possibility of ample opportunities of portfolio diversification for investors in these markets. Chittedi, K.R.(2010) used the Granger causality, Johansen co-integration and Error Correction Mechanism methodology to show co-integration relationship between BRIC countries and developed countries namely USA, UK and Japan. Hammoudeh, S. et al(2014) reveal the presence of important changes in the time-varying linkages of the BRICS stock markets with the US and European ones.

Shachmurove (2006) applied VAR Models to test the dynamic interrelationships among US stock exchanges and four Emerging Tigers of the 21st Century, Brazil, China, India, and Russia proving that the Brazilian and Russian stock market returns are affected to a large extent by other stock markets with less effect on Chinese and Indian markets. Dasgupta, R. (2014) investigated BRIC and US markets across different time-horizon and validated long term integration and dynamic linkages of international stock markets using Jarque-Bera test, ADF test, Z-Test, VAR test, Engle-Granger test. Yang et al. (2003) focused on Emerging Asian Stock Markets, Japan & US focusing on Asian Financial Crisis 1997-98 tested causal relationship examining long-run and short-run dynamic linkages and found dynamic integration among countries over time, especially around periods marked by financial crises. Contrary Bora et al. (2009) applied VAR to model interdependencies, granger causality to test short term relationship between US & BRICA (Brazil, Russia, India, China, and Argentina) indices and the results exhibited same trading day significant impact of US on BRICA countries.

An and Brown (2010) examined co movements of US, Brazil, Russia, India, and China stock markets found some cointegration between the US and China, while no cointegration between the US and other emerging markets. Therefore, all of the BRIC stock markets offer portfolio diversification opportunities for global investors with an exception of Chinese stock market. Gupta (2011) proved that India, Russia, and China Economy Granger causes the Brazil economy but the reverse is not true. Unidirectional Causality is observed between India impacting Russia while China exhibited bidirectional causality with India and Russia.

Narayan, P. et al (2004) used Granger causality and impulse response function to examine the dynamic linkages between Bangladesh, India, Pakistan and Sri Lanka stock markets and found in long run stock prices of Pakistan is granger caused by Bangladesh, India and Sri Lanka. While unidirectional Granger causality running from stock prices in Pakistan to India, Sri Lanka and stock prices in Sri Lanka to India. Wang (2014) used co-integration, Granger causality and impulse response analysis to study the integration and causality among six East Asian stock markets (China, Hong Kong, Taiwan, Singapore, South Korea and Japan). Sheng, H. and Tu, A. (2000) studied 12 Asia–Pacific stock markets using a co-integration and variance decomposition analysis, before and during the period of the Asian financial crisis. **Johnson, R and Soenen, L.(2002)** found that the equity markets of Australia, China, Hong Kong, Malaysia, New Zealand, and Singapore are highly integrated with the stock market in Japan. **Mayasami R.C and Koh, T.S.(2000)** concluded that the Singapore stock market is significantly and positively co-integrated with stock markets of Japan and the United States. Arouri et al(2008) found short and long term linkages between the Latin American markets and the world market by using multivariate co-integration and VECM. **Tirkkonen (2008)** argued that the Russian Stock market through the study (VAR & cointegration) identified as an isolated market from the major global markets of US, UK, Germany and even by its neighbours of Poland and the Czech Republic.

Gohar, R et al(2018) demonstrates statistically significant and high percentage of contemporaneous association between the 21 economies of the world and Pakistan. **Mwaanga C. and Njebele, N.(2017)** investigated the relationship between the exchange rate and the stock market price in Zambia by employing the Auto Regression distribution lag (ARDL) bound tests, co-integration and Error Correction Model (ECM). The results indicated the existence of long-run co-integration. **Wong et al. (2005)** investigated developed markets of USA, UK and Japan and India (1991-2003) and suggested long run integration between India and these developed markets and in short run both USA and Japan granger causes Indian stock market. **Raj, J. and Dhal, S.(2008)**used simplest correlation technique to sophisticated VECM and cointegration model to gauge the integration of US, UK India & Japan with major regional markets of Singapore and Hong Kong. **Zheng, Y and Swee L. T. (2009)** focusing on Malaysia & Singapore studied the impact of financial sector liberalization on integration of the two markets with global markets using GARCH (1, 1). Abas (2009) examined the linkages of the Chinese and Indian markets with those of US, UK, Japan and Hong Kong. Strong correlation found between four developed markets and Indian & Chinese market.

Sheu and Liao (2011) investigated among US and developing BRIC stock markets and their evolving pattern of integration and Granger causality relationships pointed out non-linear co-integration is time varying. They highlighted international risk diversification may have gradually diminish between these markets. Sharma et al. (2013) BRICS stock markets were influenced by each other, but not to a great extent. It implies that there exists opportunities for diversification of the investors among the stock exchanges of BRICS. Jain, N,(2016) also shows there is no long run association between Indian Nifty and rest of the BRICS Stock exchanges.

Using the correlation test, Granger causality and the co- integration test applying error correction model. It was found that Chinese and Indian markets are both correlated with United States, United Kingdom, Japan and Hong Kong markets with at least one unidirectional causality. The study suggested that there are limited benefits of any short-term diversification, or speculative activities between them (Singh, G and Singh,P.,2010). Hosseini, S.M.et al. (2011) focused on China's macroeconomics variables of money supply (M2), industrial production (IP) and inflation rate (IR) and Crude oil Prices and the stock market of China and India by using VECM and multivariate co integration. They indicated that there are both long and short run linkages between macroeconomic variable and stock market index in each of these two countries.

II. Research Methodology

This study is an empirical application of daily data of Stock exchanges Indices of top ten largest economies of the world over a period of more than ten years ranging from Sep 15th, 2008 to Dec 31st 2018. The objective of the present study is to test cointegration among them, one of the way to test cointegration among them is through their stock markets. Tracking of the stock markets was done through the cointegration among the stock markets which was tracked through their Chief Indices. The analysis has obtained 2689 data points and the analysis was conducted using Eviews 8 and Microsoft Excel 2010. Data cleaning was done and the readings were matched using Daily dates. Due to inoperative period of study within some markets on few dates, all the dates do not match, as a result the data need to be matched using a suitable technique, and the paper used the moving average method to fill the missing values. All the Stock Indices series are log transformed as the technique is a widely used for making skewed distributions less skewed.

Nomenclature of the series is done on the basis of the primary stock market index of the respective country. Representation of different markets by Index Series is given in Table 1:

Table 1:

Country	India	Brazil	France	Germany	UK	US	Japan	China	Canada
Index	Nifty50	BOVESPA	CAC40	DAX30	LSE	NASDAQ	NIKKEI	SSE	S&P/TSX
Series	LNNIFTY	LNBOV	LNCAC	LNDAX	LNLSE	LNNASDAQ	LNNIKKEI	LNSSE	LNTSX

Descriptive Statistics:

One of the primary ways of understanding the properties of a series is though analyzing their descriptive statistical values (Table 2). The descriptive statistics indicate that the all the markets indicated different degree of variation or volatility with London stock market exhibiting highest degree of volatility while the Canadian stock market exhibited lowest degree of variation. Rejection of the JarqueBera statistics indicates all the series to be not normal. All the series does not follow the Normal Distribution resulting in asymmetric distribution. Measuring the symmetry of the series through Skewness depicted all the series to be asymmetric and the measure of kurtosis indicates the inclination of the tail, under perfect normal distribution the kurtosis values attain a zero value. Leptokurtic kurtosis is observed though the values are not large.

Table 2: Descriptive Statistics of all the series during study period

	LNBOV	LNCAC	LNDAX	LNLSE	LNNASDAQ	LNNIFTY	LNNIKKEI	LNSSE	LNTSX
Mean	10.97216	8.323741	9.026367	7.304569	8.213874	8.789532	9.516869	7.901069	9.486440
Median	10.96717	8.327025	9.102684	7.308047	8.279788	8.723679	9.579316	7.926002	9.502278
Maximum	11.40556	9.892107	9.514850	8.475120	9.000815	9.370629	10.09702	8.549922	9.715193
Minimum	8.488501	7.831732	8.206968	5.831366	7.145701	7.833679	8.861489	7.442319	8.931544
Std. Dev.	0.199860	0.182341	0.315757	0.**69**7342	0.446816	0.331933	0.344264	0.195324	0.**15**1958
Skewness	-1.037268	0.220003	-0.326613	0.021987	-0.166996	-0.454356	-0.006821	0.150892	-0.949771
Kurtosis	13.18762	5.173056	2.017953	1.631860	2.088417	2.970044	1.508263	2.626401	3.942554
Jarque-Bera	12110.72	550.7720	155.8635	209.9371	105.6030	92.61966	249.3450	25.84237	503.8142
Probability	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000002	0.000000
Sum	29504.13	22382.54	24271.90	19641.99	22087.11	23635.05	25590.86	21245.97	25509.04
Sum Sq. Dev.	107.3695	89.37157	267.9994	1307.135	536.6445	296.1633	318.5757	102.5517	62.06902
Observations	2689	2689	2689	2689	2689	2689	2689	2689	2689

Correlation:

Simplest technique to study co movement between the series is through testing correlation. Table 3 indicates the correlation coefficients observed among the stock markets of the largest economies.

Table 3: Correlation Matrix

	LNNIFTY	LNBOV	LNCAC	LNDAX	LNLSE	LNNASDAQ	LNNIKKEI	LNSSE	LNTSX
LNNIFTY	1.000000								
LNBOV	0.489972	1.000000							
LNCAC	0.889890	0.393841	1.000000						
LNDAX	0.953709	0.332441	0.920613	1.000000					
LNLSE	0.935994	0.296532	0.887767	0.963022	1.000000				
LNNASDAQ	0.964685	0.384514	0.885850	0.979486	0.980575	1.000000			
LNNIKKEI	0.906840	0.262198	0.927927	0.944151	0.961181	0.938377	1.000000		
LNSSE	0.534549	0.317406	0.564719	0.466289	0.462731	0.429211	0.524426	1.000000	
LNTSX	0.936186	0.500677	0.854248	0.918878	0.848232	0.907593	0.820772	0.447494	1.000000

All the markets and their indices indicated a positive correlation across the study period. Defining the correlation with our primary target Indian Stock Market exhibited strong correlation with Germany, US, Japan, Canada and France while Chinese and Brazil market France market indicated high degree of nearing 1 with all the others markets except chinese market. Brazilian market exhibited weak correlation with all the other economies. Highest correlation percentage was observed within US & UK stock market.

Testing Coinetgration:

Testing cointegration after correlation testing is applying sophisticated econometric technique after simple statistical analysis. An attempt is done to test integration among largest economies of the world, one of the way to test the cointegration among the economies is through studying their stock market. The study observed daily movement of the major indices of the largest economies.

Goodwin & Schroeder (1991) discussed the method of testing cointegration among two time series variable, and observed that the two series must be non-stationary at level while first differencing must make the series stationary and linear combination of the series will produce an error term which must be stationary.

$$y_t - \propto - \beta x_t = \in_t$$

The above mentioned equation proves error term obtained is stationary thus proving long term cointegration among the variables.

All the series were tested for stationarity at level applying the Augmented Dickey Fuller test (ADF) test using SIC criteria with intercept tested at 5% level of significance. Original series were converted to log by taking log returns of the original series and then the series were introduced for the ADF test at level and at first difference in order to prove the suitability of the series for testing cointegration. Table 4 depicts the results of ADF test.

Table 4: Stationarity Testing (ADF test)

Series	Intercept	Trend & Intercept	None
LNNIFTY	-0.970963 (0.7654)	-2.920016 (0.1562)	1.398687 (0.9600)
LNBOV	-1.951891 (.3086)	-2.262488 (0.4539)	0.569112 (0.8392)
LNCAC	-1.942026 (0.3131)	-4.315724 (0.0030)	0.121177 (0.7208)
LNDAX	-1.239944 (0.6592)	-3.491509 (0.0404)	0.722761 (0.8710)
LNLSE	-0.503113 (0.8882)	-4.512866 (0.0014)	1.618799 (0.9747)
LNNASDAQ	-0.663636 (0.8537)	-4.598152 (0.0010)	1.576579 (0.9723)
LNNIKKEI	-0.917486 (0.7832)	-3.555724 (0.0339)	0.655379 (0.8576)
LNSSE	-2.236919 (0.1933)	-2.054347 (0.5705)	0.244902 (0.7572)
LNTSX	-1.763972 (0.3988)	-3.560476 (0.0335)	0.201082 (0.7447)
LNFTSEMIB	-3.306355 (0.0147)		

T- Values & p-values (in parenthesis)

*MacKinnon (1996) one-sided p-values at 5% level of Significance: For Trend: -2.865030, For Trend & Intercept: -3.415588 &None: 1.941230

All the ten series were tested for cointegration, out of ten series, 9 proved non-stationary at level but 1 series of FTSE_MIB came to be stationary at level so the series was dropped out of the analysis. Dropping the series has not created much impact as the series FTSE_MIB represented official index of the market of BorsaItaliana, which is now owned by London Stock Exchange Group, the effect of LSE (representative official index of London Stock Exchange) are including the effect of FTSE_MIB.

If the nonstationary data become stationary at the first differencing, then there is a high probability that they have a cointegration relationship (long term relationship) among the variables. (Usman et al, 2017) and upon satisfying this condition of stationarity, the series are valid to be tested for cointegration after application of a judicious lag length criteria. The results of long-run relationship are sensitive to lag-length selected in the model (Bahmani-Oskooee and Bohal, 2000).

Optimal Lag Length:

There are multiple methods of identifying suitable lag length criteria Akaike's Information Criteria (AIC, 1973), Schwartz Information Criteria (SIC,1978), Hannan- Quinn Criterion(HQC,1979), Final Prediction Error (FPE, Akaike, 1969) were devised. The study followed the Schwartz Information Criteria (SIC,1978) following the principle of parsimony and thus selected "3" as the optimal lag length.

Johansen Cointegration

H_0: No Cointegrating relationship exist between the stock markets of the largest economies

H_1: H_0 is not true

For testing coinetgration all the series need to be stationary at same level and non-stationary at level. All the series are taken at level using the log transformation of the variables. Cointegration is tested at two levels Trace and Max Statistics at 5% level of significance(table 5). The test specification for cointegration applied to test the linear deterministic trend with Intercept (no trend). In particular, the trace test are advantageous if there are at least two or more cointegrating relations in the process.(Lutkepohl et al, 2000)

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.045021	289.6383	197.3709	0.0000
At most 1 *	0.020575	165.9982	159.5297	0.0211
At most 2	0.015237	110.1995	125.6154	0.2939

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level

Normalized cointegrating coefficients (standard error in parentheses)

LNNIFTY	LNBOV	LNCAC40	LNDAX	LNGLSE	LNNASDAQ	LNNIKKEI	LNSSE	LNSPTAX
1.00000	-2.02	6.720051	-4.41	-0.81	3.907444	-2.75	0.057972	-1.44
	(0.19287)	(0.53406)	(0.5320)	(0.23280)	(0.51956)	(0.32206)	(0.14176)	(0.47997)
T stat	-10.47338	12.58295	-8.28885	-3.479381	7.520679	-8.53878	0.408945	-3.000187

The table indicated the normalized coinetgrating coefficients, following the normalization process, the t stat for the indices LNBOV, LNDAX, LNGLSE, LNNIKKEI LNSPTAX with response to LNNIFTY are statistically significant and thus the signs are reversed. While for the remaining indices LNCAC40, LNNASDAQ LNSSE the t-stat is insignificant and thus the signs of the coefficient are taken as appeared.

The cointegrated equation and the value of t-stats enable the research to identify the direction and degree of impact created by other stock exchanges on the Indian stock market.

Upon reversing the signs of statistically significant coefficients including LNBOVESPA, LNDAX LNGLSE LNNIKKEI LNSPTAX thus create a positive impact on the LNNIFTY while LNCAC40, LNNASDAQ LNSSE have negative relationship with the LNNIFTY.
A 1% increase in LNBOV (Brazil), leads to an increase of 2.02% LNNIFTY in the long run.
A 1% increase in LNDAX (Germany), leads to an increase of 4.41% LNNIFTY in the long run.
A 1% increase in LNLSE (Europe), leads to an increase of .81% LNNIFTY in the long run.
A 1% increase in LNNIKKEI (Japan), leads to an increase of 2.75% LNNIFTY in the long run.
A 1% increase in LNTSX, leads to an increase of 1.44% LNNIFTY in the long run.
While LNCAC40, LNNASDAQ LNSSE have a negative impact on LNNIFTY

While the t-stat value for the LNCAC40 & LNNASDAQ are significant at 5% level of significanceExistence of stable equilibrium relationship is observed by obtaining cointegrated equation among the stock market indices of the largest economies. Indian market is observed to be positively cointegrated with Brazil, Germany, Canada, Japan& Europe.

VECM

Since the variables are found to have one or more cointegrating vectors, VECM (Vector Error Correction Model) is found to be suitable estimation technique. VECM (restricted Var) is very useful time series modeling technique which can be tested to examine both the short run and long run dynamics of the series if the non-stationary time series are integrated of first order , I(1) and found to be cointegrated. VECM uses no exogenous variable as all variables to be tested are endogenous. VECM can be used to directly estimate the level to which a variable can be brought back to equilibrium condition after a shock on other variables.

VECM Model:

VECM:-

$$\Delta y_t = \beta_0 + \sum_{i=0}^{n} \beta_i \Delta y_{t-1} + \sum_{i=0}^{n} \delta\, \Delta\, x_{t-1} + \varphi\, z_{t-1} + \varepsilon_t$$

Error Correction Term

$$ECT_{t-1} = y_{t-1} - \beta_0 - \beta_1 x_{t-1}$$

Here, VECM approach is used on the selected economies to investigate the possibility of an increasing market co-integration and LNIFTY is taken as the target variable.

ECT is the variable of lagged OLS residuals from the long run cointegrating equation andmeasures the rate of convergence to the long run equilibrium. ECT relates to the fact that last period deviation from equilibrium influences the short run dynamics of the dependent variable. (Engle, R.F. & Granger, O.W.J.(1987). The coefficient of ECT is the speed of adjustment because it measures the speed at which dependent variable returns to equilibrium after a change in explanatory variable. The error coefficient in the VECM model should be negative and less than one but the other coefficients are not limited to any sign or quantity.

In present study VECM approach is used on the selected economies to investigate the possibility of an increasing market co-integration and LNIFTY as target variable.

Estimated VECM

$$\begin{aligned}\Delta LNNIFTY_t = & -0.0018\, ECT_{t-1} - 0.0048\, \Delta\, LNNIFTY_{(-1)} - 0.0778\, \Delta\, LNNIFTY_{(-2)} \\ & + 0.0015\, \Delta\, LNBOV_{(-1)} + 0.0025\, \Delta\, LNBOV_{(-2)} + 0.0066\, \Delta\, LNCAC_{(-1)} \\ & + 0.0082\, \Delta\, LNCAC_{(-2)} - 0.0109\, \Delta\, LNLSE_{(-1)} + 0.0395\, \Delta\, LNLSE_{(-2)} \\ & + 0.2069 \Delta\, LNNASDAQ_{(-1)} + 0.0953\, \Delta\, LNNASDAQ_{(-2)} - 0.06\, \Delta\, NIKKEI_{(-1)} \\ & - 0.0286\, \Delta\, NIKKEI_{(-2)} - 0.0619\, \Delta\, LNSSE_{(-1)} + 0.0034\, \Delta\, LNSSE_{(-2)} \\ & - 0.0032\, \Delta\, LNTSX_{(-1)} + 0.0047\, \Delta\, LNTSX_{(-2)} + 0.0002\end{aligned}$$

$$\begin{aligned}\mathrm{ECT}_{t-1} = & \ 1.0000 LNNIFTY_{(-1)} - 1.9733\, \mathrm{LNBOV}_{(-1)} + 6.5642 \mathrm{LNCAC}_{(-1)} - 4.3080 \mathrm{LNDAX}_{(-1)} \\ & - 0.7718 LNLSE_{(-1)} + 3.7495 LNNASDAQ_{(-1)} - 2.6608 LNNIKKEI_{(-1)} \\ & + 0.0442 LNSSE_{(-1)} - 1.3601 LNTSX_{(-1)} + 9.8259\end{aligned}$$

The error coefficient is 0.18% which means the previous period deviation from long run equilibrium is corrected in the current period at an adjustment speed of 0.18% , is negative and less than one and statistically significant at 4.27% p-value(Table). It means explanatory variables granger cause LNNIFTY.

In the short run first lagged value of NASDAQ and SSE whereas second lagged values of Nifty, LSE, NASDAQ and NIKKEI have significant t-values which indicate short run influence of these variables on NIFTY.

Variance Decomposition:

VECM is interpreted through Variance decomposition. Variance decomposition is a technique to establish link between quantum of variability in target variable and its dependency on its own lagged variance and which of the independent variables is stronger in explaining the variability in the target variables over time. The Forecast Error Variance Decomposition (FEVD) examines how much of the future uncertainty of one time series is due to future shocks into the other time series in the system.

Variance decomposition of stock indices for first and tenth day in future is shown in **Table 6.** In the period 1 in short run 100% of forecast error variance in all indices is explained by itself and the contribution by other variable is zero. As we move into the period 10 in long run NIFTY itself is exhibiting strong endogenous influence with 94%, 2% and 2% of variance decomposition being explained by own shocks, NASDAQ and DAX past shocks respectively. For BOV, 92% is explained by its own shocks in the long run while CAC explains 6% of the total variance decomposition. It is evident that 76% of the forecast error variance of the CAC can be attributed to its own shocks in the long run while BOV and DAX contribute 8% and 13% respectively. In long run, DAX stock market also explains 94% of its own shocks while NASDAQ explains 4% of its total variance. In case of LSE, 94% can be attributed to its own shocks while NASDAQ contribute 5%. In US market, NASDAQ explains 97% of its own innovative shocks while NIFTY explains just 1%. In long run Japanese stock market NIKKEI, explains only 66% of its own innovative shocks where significant contribution made by DAX is 19% and NASDAQ is 11%. Indian stock market explains just a less than 2% of NIKKEI. For SSE, 96% of the contribution in long run forecast error variance is due to its own shocks and combined 3% by DAX and NASDAQ. Lastly, results of TSX depict that 90% of the total variance can be attributed to its own past shocks while a positive shock in DAX and NASDAQ affect 5% and 3% variances respectively. The Hence the results of the test are in line with VECM and Wald Test.

Table 6: Variance Decomposition Analysis

Variance Decomposition of LNNIFTY:										
Period	S.E.	LNNIFTY	LNBOV	LNCAC	LNDAX	LNLSE	LNNASDAQ	LNNIKKEI	LNSSE	LNTSX
1	0.01	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.04	94.43	0.53	0.10	1.83	0.15	2.31	0.26	0.38	0.00

Variance Decomposition of LNBOV:										
Period	S.E.	LNBOV	LNCAC	LNDAX	LNLSE	LNNASDAQ	LNNIFTY	LNNIKKEI	LNSSE	LNTSX
1	0.08	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.13	91.59	6.37	0.55	0.11	0.91	0.26	0.16	0.01	0.04

Variance Decomposition of LNCAC:										
Period	S.E.	LNCAC	LNBOV	LNDAX	LNLSE	LNNASDAQ	LNNIFTY	LNNIKKEI	LNSSE	LNTSX
1	0.04	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.07	76.27	8.26	13.39	0.25	0.79	0.21	0.46	0.24	0.13

Variance Decomposition of LNDAX:										
Period	S.E.	LNDAX	LNBOV	LNCAC	LNLSE	LNNASDAQ	LNNIFTY	LNNIKKEI	LNSSE	LNTSX
1	0.013	100.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
10	0.042	94.441	0.080	0.241	0.012	4.008	0.634	0.082	0.449	0.053

Variance Decomposition of LNLSE:										
Period	S.E.	LNLSE	LNBOV	LNCAC	LNDAX	LNNASDAQ	LNNIFTY	LNNIKKEI	LNSSE	LNTSX
1	0.020	100.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
10	0.065	93.555	0.080	0.133	0.630	4.726	0.507	0.058	0.304	0.006

Variance Decomposition of LNNASDAQ:										
Period	S.E.	LNNASDAQ	LNBOV	LNCAC	LNDAX	LNLSE	LNNIFTY	LNNIKKEI	LNSSE	LNTSX
1	0.013	100.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
10	0.039	97.040	0.019	0.933	0.198	0.013	1.253	0.039	0.098	0.408

Variance Decomposition of LNNIKKEI:										
Period	S.E.	LNNIKKEI	LNBOV	LNCAC	LNDAX	LNLSE	LNNASDAQ	LNNIFTY	LNSSE	LNTSX
1	0.012	100.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
10	0.045	65.912	0.617	1.326	19.296	0.159	10.523	1.490	0.633	0.044

Variance Decomposition of LNSSE:										
Period	S.E.	LNSSE	LNBOV	LNCAC	LNDAX	LNLSE	LNNASDAQ	LNNIFTY	LNNIKKEI	LNTSX
1	0.014	100.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
10	0.047	95.967	0.332	0.100	1.628	0.075	1.428	0.165	0.301	0.003

Variance Decomposition of LNTSX:										
Period	S.E.	LNTSX	LNBOV	LNCAC	LNDAX	LNLSE	LNNASDAQ	LNNIFTY	LNNIKKEI	LNSSE
1	0.020	100.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
10	0.043	90.561	0.206	0.321	4.535	0.056	3.425	0.695	0.029	0.170

Wald Test

The **Wald test** also known as Wald Chi-Squared Test tests if explanatory variables in a model are significant. It is conducted to see if short run coefficients of explanatory variables granger cause LNNIFTY. The results are displayed in **Table 7**

H_0: Other Stock indices do not Granger cause NIFTY.

H_1: H_0 is not true

Table 7: Wald Test

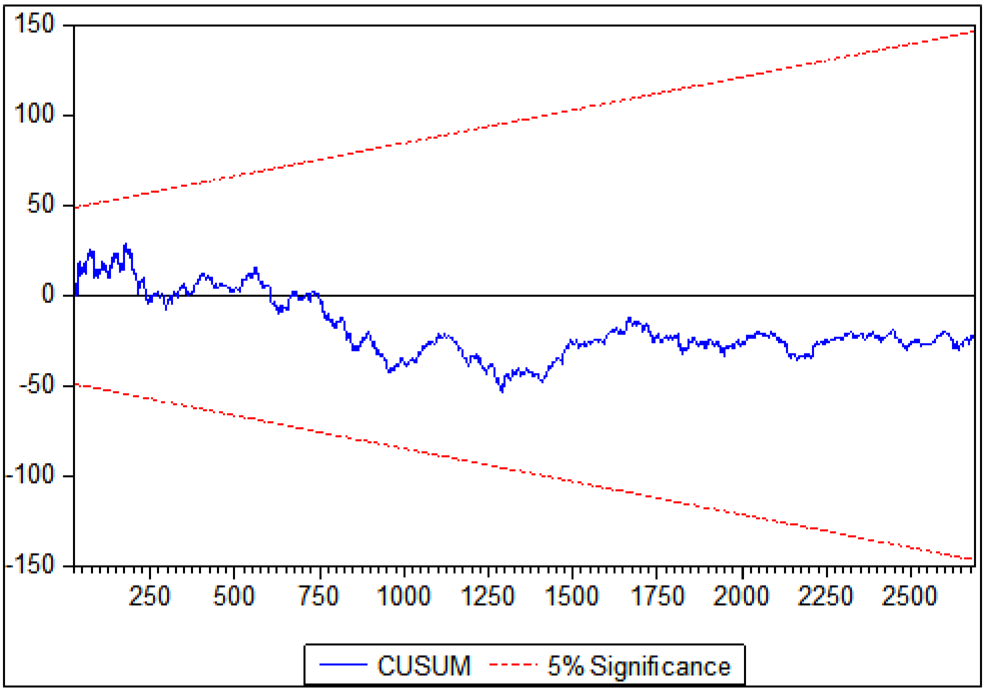
H_0	Test Statistic	Value	Probability	Decision
LNBOV does not Granger Cause LNNIFTY	Chi-square	0.720692	0.6974	Accept
LNCAC does not Granger Cause LNNIFTY	Chi-square	1.963458	0.3747	Accept
LNDAX doesnot Granger Cause LNNIFTY	Chi-square	4.832659	0.0892	Accept
LNLSE doesnot Granger Cause LNNIFTY	Chi-square	8.529753	0.0141	Reject
LNNASDAQ doesnot Granger Cause LNNIFTY	Chi-square	74.682	0.0000	Reject
LNNIKKEI doesnot Granger Cause LNNIFTY	Chi-square	10.47281	0.0053	Reject
LNSSE doesnot Granger Cause LNNIFTY	Chi-square	13.25702	0.0013	Reject
LNTSX doesnot Granger Cause LNNIFTY	Chi-square	0.379093	0.8273	Accept

Diagnostic Tests:
Following residual and stability diagnostic test are also conducted to establish the validity of the model.
Residual Diagnostic Test
Serial Correlation
Breusch-Godfrey Serial Correlation LM test is done to check whether the tested model is free from serial correlation and the results are displayed in table

H_0	F-statistic	0.976989	Prob. F(3,2663)	0.4026
No Serial Correlation in Residuals	Obs*R-squared	2.953031	Prob. Chi-Square(3)	0.3989

The p-value of 39.89% which is more than 5% shows that there is no evidence of serial correlation.

Stability Diagnostic Test
Cumulative Sum (CUSUM) of recursive residuals stability testing technique suggested by Brown et al (1975)which checks whether regression coefficients of the tested model are changing systematically. The results of CUSUM plot have been in Figure 1. Since the blue trend line located within red bounds (critical bounds at 5% level of significance) it can be concluded that model is dynamically stable and there are no structural breaks. (Iliyas, M. et al, 2010)



III. Discussion

The study is a modest attempt to establish dynamic linkages amongst the largest economies of the world. Upon testing cointegration among the economies, it is found that very few sample stock markets depict long run relationship. In the absence of cointegration, the markets would have exhibited only weak short term association but existence of cointegrating equations, markets seems to have long run association which was found to be very weak after using VECM. Variance decomposition also validate the results of weak long run dynamics.

The results of Wald Test establish that the short run causality predominantly runs from American, London, Chinese and Japanese stock market to Indian stock market, thus making it difficult for the international investors to diversity and earn short run abnormal returns in these markets. The US market impacts Indian, German, London, Japanese, Chinese, and Canadian stock markets where as German stock market also casts an impact on Indian, French , Japanese, Chinese, and Canadian stock markets. Indian stock market exercises quite insignificant impact on US market.

A quick perusal of the findings of study highlight clearcut investment and portfolio diversification opportunities for international investors. The results may guide regulators to formulate better policies regarding price discovery mechanism.

The present study may be extended to incorporate issues of volatility spillover between the sample countries. High frequency data may be used for further research. Another avenue of research is to study each country's policy responses with the objective of extracting recommendations for more efficient capital transfers.

Among the limitations of the study -The series were not tested for any structural breaks and seasonality issues. Also, scanty literature is available to study integration of largest economies.

References

[1]. **Abas, M. (2009)**: "Analysis of stock market linkages: Chinese, Indian and major markets". University of Malaya Report. pp: 1-94. https://docplayer.net/24734123-Analysis-of-stock-market-linkages-chinese-indian-and-major-markets.html

[2]. **An, L. and D. Brown, (2010**): "Equity market integration between the US and BRIC countries: Evidence from unit root and cointegration test". Research Journal of International Studies 1(16): 15-24.

[3]. **Angela Ng (2000): "**Volatility spillover effects from Japan and the US to the Pacific-Basin". Journal of International Money and Finance, vol. 19, issue 2, 207-233.

[4]. **Arouri et al(2008): "**International Stock Return Linkages : Evidence from Latin American Markets". https://economics.ca//2008/papers/0764.pdf (accessed on 9th December,2018)

[5]. **Bahmani-Oskooee, Mohsen, and Martin T. Bohl. (2000):** "German monetary unification and the stability of the German M3 money demand function." Economics Letters 66.2 203-208

[6]. **Bansal R.et al(2015):** "Co-integration of stock markets of SAARC countries - A study, International Journal of Applied Business and Economic Research13(0972-7302),1417-1430. https://www.researchgate.net/publication/316153878_Co-integration_of_stock_markets_of_SAARC_countries_-_A_study

[7]. **Bora, A. et al (2009)**. Behaviour of emerging stock markets in the global financial meltdown: Evidence from brica. Afr. J. Bus. Manage, 3(7): 396-404.

[8]. **Brown, R., J. Durbin and J. Evans (1975):** Techniques for testing the constancy of regression relations over time. Journal of the Royal Statistical Society, Volume 37, pp. 149-163.

[9]. **Chittedi, K.R.(2010):** "Global Stock Markets Development and Integration: with Special Reference to BRIC Countries". International Review of Applied Financial Issues and Economics, Issue No: 1, : 018-036

[10]. **Dasgupta, R. (2014)**:"Integration And Dynamic Linkages Of The Indian Stock Market With Bric – An Empirical Study". Asian Economic and Financial Review, 2014, 4(6): 715-731

[11]. **Dhanaraj, S. and Gopalaswamy, A.K.(2017):** "Trade, Financial Flows and Stock Market Interdependence: Evidence from Asian Markets".Empirical Economics Review 7(1),15-34.

[12]. **Engle, R.F. & Granger, O.W.J.(1987):** Co-integration and error correction: Representation, estimation and testing. Econometrica, 55(2), 251-276. JSTOR1913236.

[13]. **Gohar, R et al(2018):** "Economic Integration and Stock Market Comovement: An Empirical Study Pairing Pakistan's Stock Exchange with 21 other Markets". Journal of Reviews on Global Economics, 2018, 7, 28-36.

[14]. **Gallo, G. M. & Otranto, E. (2007)**. "Volatility transmission across markets: a Multichain Markov **Switching** model," Applied Financial Economics, Taylor & Francis Journals, vol. 17(8), pages 659-670.

[15]. **Goodwin, B. K., & Schroeder, T. C. (1991).** Cointegration tests and spatial price linkages in regional cattle markets. *American Journal of Agricultural Economics*, *73*(2), 452-464.

[16]. **Gupta, S.(2011)**. Study of BRIC countries in the financial turmoil. International Affairs and Global Strategy, 1(1): 1-15.

[17]. **Hassan, M.K. and Naka, A. (1996)** Short-Run and Long-Run Dynamic Linkages among International Stock Markets. International Review of Economics and Finance, 5, 387-405. http://dx.doi.org/10.1016/S1059-0560(96)90025-8

[18]. **Hosseini, S.M et al. (2011)**The Role of Macroeconomic Variables on Stock Market Index in China and India. International Journal of Economics and Finance, Vol. 3(6), 233-243.

[19]. **Hammoudeh, S. et al(2014):** "Dynamic global linkages of the BRICS stock markets with the U.S. and Europe under external crisis shocks: Implications for portfolio risk forecasting". https://mpra.ub.uni-muenchen.de/73400/1/MPRA_paper_73400.pdf

[20]. **Iliyas,M. et al(2010):**DETERMINANTS OF MANUFACTURING VALUE ADDED IN PAKISTAN: AN APPLICATION OF BOUNDS TESTING APPROACH TO COINTEGRATION, Pakistan Economic and Social Review Volume 48, No. 2 (Winter 2010), pp. 209-223.

[21]. **Jain, N.(2016):** The Interdependence Between Stock Markets –An Econometric study of BRICS Nations". International Journal of Research in Economics and Social Sciences (IJRESS). http://euroasiapub.org/current.php?title=IJRESS Vol. 6 Issue 8, pp. 120-132

[22]. **Jakpar et al. (2013):** "An Econometric Analysis on the Co-Movement of Stock Market Volatility between China and ASEAN-5".International Journal of Business and Social Science, Vol. 4 No. 14,181-197.

[23]. **Jebran et al (2017)** :" Does volatility spillover among stock markets varies from normal to turbulent periods? Evidence from emerging markets of Asia". https://ac.els-cdn.com/S2405918816300460/1-s2.0-S2405918816300460-main.pdf?_tid=4fe448b8-bc42-4999-9505-6c4258286631&acdnat=1544523821_f8aaad557dd5a5d0457f5fff0a575c88 (accessed on 9th December,2018.

[24]. **Johnson,R. and Soenen, L.(2002)** Asian Economic Integration and Stock Market Comovement. Vol 25(1), pages 141-157.

[25]. **Karim and Karim(2012)**INTEGRATION OF ASEAN-5 STOCK MARKETS: A REVISIT". ASIAN ACADEMY of MANAGEMENT JOURNAL of ACCOUNTING and FINANCE, Vol. 8, No. 2, 21–41.

[26]. **Kaur, G et al(2016) :** "Analysis of Intraregional Trade and Investment among India and BIMSTEC: Prospects and Challenges". https://www.researchgate.net/publication/306351361_Prospects_and_Challenges_of_Intraregional_Trade_and_Investment_among_India_and_BIMSTEC (accessed on 9th December, 2018)

[27]. **Kumar,K.K. and Mukhopadhyay,C.(2007)** Volatility Spillovers from the US to Indian Stock Market: A Comparison of GARCH Models.The IUP Journal of Financial Economics, Vol. V, No. 4,7-30.

[28]. Lutkepohl et al (2000): Maximum Eigen values Trace Tests for the Cointegrating Rank of a VAR Process. https://www.econstor.eu/bitstream/10419/62268/1/723857962.pdf (accessed as on 12th January, 2012)

[29]. **Mayasami R.C and Koh, T.S.(2000):** "A vector error correction model of the Singapore stock market" International Review of Economics and Finance, 9, 79–96.

[30]. **Mukherjee, K.N. and Mishra,R.K.(2010):**Stock market integration and volatility spillover: India and its major Asian counterparts".Vol24(2) Pages 235-251.

[31]. **Mwaanga C. and Njebele, N.(2017):**The Long-Run and Short-Run Relationship between the Exchange Rates and Stock Market Prices. Journal of Financial Risk Management, Vol.06 (04). https://file.scirp.org/pdf/JFRM_2017110115080704.pdf

[32]. **Narayan, P. et al (2004).** Interdependence and dynamic linkages between the emerging stock markets of South Asia. Journal of Accounting and Finance, 44, pp. 419–439.

[33]. **Oh, S. L., Lau, E., Chin Hong, P., & Abu Mansor, S. (2010).** Volatility co-movement of Asean-5 equity markets. Journal of Advanced Studies in Finance, 1(1), 23–30.

[34]. **Palac-McMiken, E. D. (1997): "**An examination of ASEAN stock markets: a cointegration approach". ASEAN economic bulletin. - Singapore, ISSN 0217-4472, ZDB-ID 8569551. - Vol. 13(3), pp. 299-311.

[35]. **PWCWorld 2050 report** (2017): https://www.pwc.com/gx/en/world-2050/assets/pwc-the-world-in-2050-full-report-feb-2017.pdf

[36]. **Rahman M.M and Kim, C. (2015):** "BIMSTEC Regional Integration: Prospects and Challenges". https://www.researchgate.net/publication/315030746_BIMSTEC_Regional_Integration_Prospects_and_Challenges.

[37]. **Raj, J. and Dhal, S.(2008):** "Integration of India's stock market with global and major regional markets"

[38]. file:///D:/Paper/Integration%20of%20India's%20stock%20market%20with%20global%20and%20major%20regional%20markets.pdf (accessed on 9th December,2018)

[39]. **Sengupta, J.(2017):** "BIMSTEC-FTA: A new hope for enhanced regional trade". ORF ISSUE BRIEF No. 198,pp1-8. https://www.orfonline.org/research/bimstec-fta-new-hope-enhanced-regional-trade/

[40]. **Sharma, G.D. et al (2013)**: "Are the stock exchanges of emerging economies interlinked? Evidence from BRICS. Indian Journal of Finance, 7(1): 26-37.

[41]. **Shachmurove, Y.(2006):** "Dynamic linkages among the stock exchanges of the emerging tigers of the twenty first century". International Journal of Business, 11(3): 319-344.

[42]. **Sheng, H. and Tu, A. (2000):** "A study of cointegration and variance decomposition among national equity indices before and during the period of the Asian financial crisis". Journal of Multinational Financial Management, 10, 345-365. https://pdfs.semanticscholar.org/da5a/e444f23d50329d9b0738371f2e1999b18eb6.pdf

[43]. **Sheu, H.J. and Liao, C.H.(2011):** "Dynamics of stock market integration between the US and the BRIC". African Journal of Business Management, 5(9): 3674-3689.

[44]. **Singh and Singh (2010): "**Chinese and Indian Stock Market Linkages with Developed Stock Markets". Asian Journal of Finance & Accounting ISSN 1946-052X 2010, Vol. 2, No. 2: E2

[45]. **Stoll, H. and Whaley, R. (1990):** "Stock Market Structure and Volatility". The Review of Financial Studies, Vol. 3,Issue 1, pp. 37-71.

[46]. **Swee-Ling Oh et al (2010):** "Volatility Co-movement of ASEAN-5 Equity Markets". https://mpra.ub.uni-muenchen.de/22244/1/MPRA_paper_22244.pdf (accessed on 9th December,2018)

[47]. **Tripathi V. and Sethi, S.(2012):** "Inter linkages of Indian Stock Market with Advanced Emerging Markets". Asia-Pacific Finance and Accounting Review Vol. I, No. 1, pp. 34-51.

[48]. Usman et al (2017): Application of Vector Error Correction Model (VECM) and Impulse Response Function for Analysis Data Index of Farmers' Terms of Trade. Indian Journal of Science and Technology, Vol 10(19), DOI: 10.17485/ijst/2017/v10i19/112258

[49]. **Wang, L.(2014):** Who moves East Asian stock markets? The role of the 2007–2009 global financial crisis, Journal of International Financial Markets, Institutions & Money, 28,182– 203.

[50]. **Wong et al. (2005):** "Financial Integration for India Stock Market, a Fractional Cointegration Approach". Available from: file:///D:/Paper/Wong.pdf [accessed Dec 12 2018].

[51]. **Yang et al. (2003) :** "Stock market integration and financial crises: the case of Asia". Applied Financial Economics, Volume 13, Issue 7, 477-486.

[52]. **Zheng, YiandSwee Liang Tan(2009):** "An empirical analysis of stock market integration: Comparison study of Singapore and Malaysia". Singapore Economic Review. 54, (2), pp217-232.

[53]. **Usman et al (2017):** Application of Vector Error Correction Model (VECM) and Impulse Response Function for Analysis Data Index of Farmers' Terms of Trade. Indian Journal of Science and Technology, Vol 10(19), DOI: 10.17485/ijst/2017/v10i19/112258

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