

# Exploring the Cointegration Relation among Top Eight Asian Stock Markets

Muhammad Rizwanullah<sup>1</sup>, Lizhi Liang<sup>1\*</sup>, Xiuyuan Yu<sup>1</sup>, Jinan Zhou<sup>1</sup>, Muhammad Nasrullah<sup>2</sup>, Muhammad Uzair Ali<sup>3</sup>

<sup>1</sup>Collage of Public Administration, Xiangtan University, Xiangtan, China

<sup>2</sup>College of Agricultural Economics and Management, Northeast Agricultural University, Harbin, China

<sup>3</sup>Collage of Business, Xiangtan University, Xiangtan, China

Email: \*188793258@qq.com

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## Abstract

Asian stock market faces many favorable and unfavorable incidents of collapsing internal market in last decades. The local investors are interested especially in the countries like China, Malaysia, UAE and Bangladesh which are politically, geographically and strategically important as investment portfolio point of view. The investors have experience of moving many markets together in long run which is a bad news for investors to diversify their investment in different markets. Therefore, the objectives of the study is to find the direction and short and long run association among top eight Asian stock Markets by applying Johansen cointegration test and Granger Causality Test. The augmented unit root test and Phillips-Peron proved the presence of unit root in data at level. The cointegration analysis test based on trace statistics shows five cointegrating equation, while the maximum eigen value test indicates two cointegrating equation at 5 percent significant level. Results imply that these markets are strongly cointegrated in long term which can diversify local and foreigner investors. The Granger Causality shows that 13 pairs of markets are bidirectional while 12 pairs are unidirectional and 3 pairs have no causality. From the result it is obtained that integrated markets are useful for decreasing the chances of financial stability and asymmetric shocks, which can strengthen the capability of the economy to absorb the shocks and adequate the risk of international financial contagion. It is concluded that for investor views there are still possibilities for efficient portfolio diversification across these markets. In addition further study should be carried out to find the reason of cointegration.

## Keywords

Cointegration, Eigenvalue, Portfolio, Granger Causality

## 1. Introduction

Studies of financial market integration are motivated during the last two decades, due to many countries in the world undertaken the measure of increasing liberalization. This liberalization of stock markets can be in form of removal of ownership barriers, exchange controls or capital barriers (Ragunathan, 1999). In 1970 government restricted the flow of international capital in major countries. In addition, it has been noted that during 1980, when the barriers to international capital mobility were eliminated, it provides easy way to access one country's capital market and thus lead to integration in financial market (Throop, 1994).

Various studies are carried out to find the level of integration by using new technique among various stock markets (Narayan et al., 2015). Due to one of the fastest growing research area, stock market cointegration provides a strong link to reduce the risk from a holding portfolio, fundamental tenant of investment strategy and a relevant implication for the investors, who hold a diversified portfolio in international security (Wuthisatian, 2014). Financial integration exists among various stock markets in the world can repel the international investors in order to minimize the potential risk of their each and every investment. Indices of different countries stock market are not following the same trend or not integrated; then such market attract international investor to diversify their portfolio investment among these countries. International investors are mostly interested in emerging markets, but the interdependency among these stock markets and developed stock markets affect the diversification (Pretorius, 2002). Convergence of stock markets is possible due to sharing of short-term and long-term relationship existing among different countries stocks markets which means the markets indices are integrated (Narayan et al., 2011). For making policy, regional integration play an important role in expanding the base for investors and also broaden the range of financial product, which is helpful for strengthening domestic capital market to compete global market. An integrated markets are useful for decreasing the chances of financial stability and asymmetric shocks, which can strengthen the capability of the economy to absorb the shocks and adequate the risk of international financial contagion (Umutlu et al., 2010; Beine et al., 2010; Narayan et al., 2011).

Interest of researchers increases due to presence of correlation among global markets. Benefits gained by researchers from global market integration are documented and categorized the study into; relationship existing among developed and emerging stock market (Benzion et al., 1996), relationship between stock prices and international macroeconomics variable (Dimitrova, 2005) and interdependency of neighborhood market (Ali et al., 2011). Among other benefits, raising the allocation of capital globally and reducing share risk of countries by decreasing consumption volatility, increase in investment opportunity and increasing the growth rate (Daly, 2003).

Based on the previous literature, the research is carried out to explore the long

run relation among top 8 Asian market indices and to find out the causal relation among top 8 Asian markets.

## 2. Literature

Many researches are carried out in last two decades to find the possible cointegration among international stock markets. However, the results are incompatible and showing no consent on the result of cointegration even in between major international stock markets.

Largest Europe stock markets are examined from 1975-1991 by [Corhay et al., \(1993\)](#) and got the evidences of cointegration existing among France, Germany, Italy, Netherland and UK. Similar results are obtained by [Chen et al., \(2002\)](#), by using the six major stock markets indices of Latin America. [Kasa \(1992\)](#) strongly reject the hypothesis of no cointegration by using monthly and quarterly data from 1974-1990 of five major stock market of Canada, Germany, England, Japan and USA. A solid evidence of one cointegrating vector is founded for these stock markets and his conclusion is not similar with previous work in this area, which implies low or no cointegration among stock markets. [Richards \(1995\)](#) criticize the study work of [Kasa \(1992\)](#) and investigate cointegration by using both Johansen test and Engle Granger methodology from 1964-1994 between 16 national equity market and world equity index. The study reject null hypothesis of no cointegration, as a result the author concludes that in long run the foreign and domestic equity markets will move significantly differently, highlighting the reason of investment in abroad to reduces the risk. [Kanas \(1998\)](#), analyses daily data from 1983 to 1986 to find the pairwise cointegration between US and six European major stock markets. [Ahlgren and Antell \(2002\)](#) carried out study by using data from time period 1980-1997 to find cointegration. The study concluded the evidence for cointegration is weak in between Germany, France, Finland, US, UK and Sweden. [Choudhry \(1997\)](#) investigates the evidence of long-run relationship exist among their nominated markets. [Wong et al. \(2005\)](#) find out the short- and long-term relationship between India, United States, Japan and United Kingdom. The results concluded that India is cointegrated with these mature markets and is sensitive in the long run to the dynamics change in these markets.

By moving one step further on the concept of cointegration, some authors also studied cointegration of various stock markets during the period of crises and period of pre crises. [Sheng and Tu \(2000\)](#) took interest to investigate different degrees of relationship amongst the North-East Asian and South-East Asian countries during and before the Asian financial crisis which started in 1997. Their study revealed the evidence of no cointegrational relationship exist among the five North-East country indices during and before crises period while there is at least one cointegrational relationship exist during and pre crises period of the five South-East Asian country indices. Similar study was conducted by [Fan \(2003\)](#) to find out the cointegration of Taiwan in China, Thailand, Singapore,

Hong Kong in China, Japan and United State during and before the Asian crises and find out no evidence of cointegrational relationship before crisis, but after the crisis a cointegrational relationship was founded in Asia-Pacific indices.

During examining the study of cointegration test among international indices, many researchers also examined the causality of these indices. [Sheng and Tu \(2000\)](#) suggested that during the period of financial crisis, US market still causes some Asian markets (South Korea and Hong Kong in China) which reflect the dominant role on Asian market indices. [Wong et al. \(2005\)](#) find out that the Indian market is sensitive to dynamics changes in Japan, UK and US markets. In the study there is no causality from India market to any developed markets but in short run both Japan and US Granger cause the Indian stock market. [Fan \(2003\)](#) reveals that sudden changes in United State market have an intensive effect on the Asia-Pacific markets. Japan can only affect Thailand but none of other market Taiwan in China, Singapore and Hong Kong in China in the study.

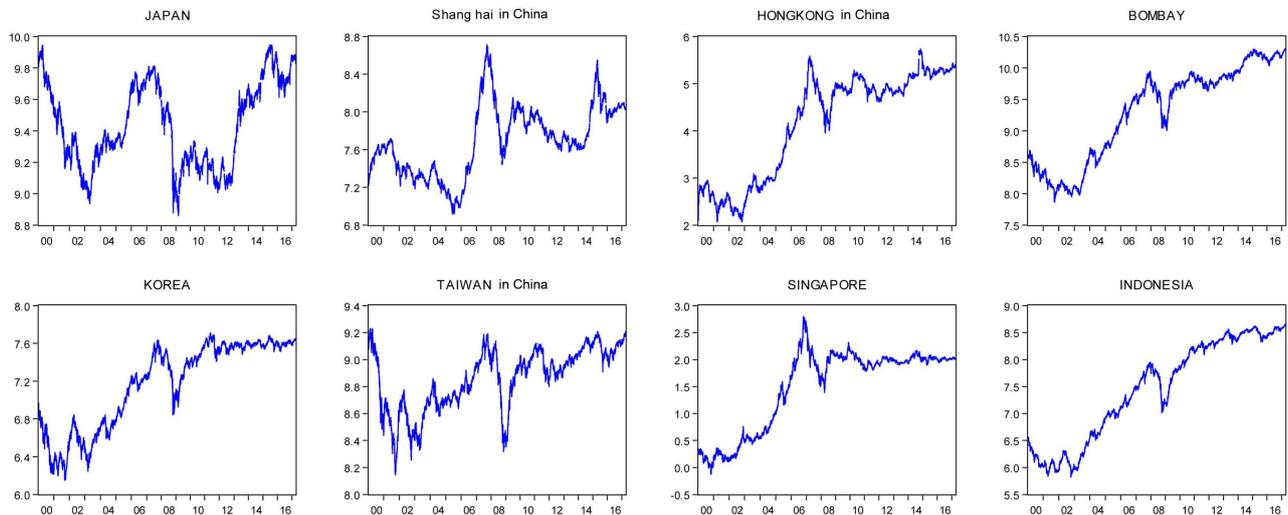
### 3. Data

To provide updated and robust results, the study uses top eight Asian stock markets ranked on the basis of their market capitalization shown in [Table 1](#) and key indicators of selected exchanges shown in [Table 2](#). Research study uses daily price index of last eighteen years spanning from 01 January 2000 to 29 December 2017 and analyzed in local units obtained from yahoofinance.com. Following stock returns that are used in study are ^N225 (Japan), ^SSEC (Shanghai in China), 0388.HK (Hong Kong in China), ^BSESN (Bombay), ^KS11 (Korea), ^TWII (Taiwan in China), S68.SI (Singapore) and ^JKSE (Indonesia). During analysis the study faces the problem of missing observation due to difference in stock market holidays which are adjusted through filling the data of adjusted day, following the study of [Hirayama and Tsutsui \(1998\)](#) and [Majid et al. \(2008\)](#). Based on the previous studies [Kasa \(1992\)](#) and [Richards \(1995\)](#) all index values are transferred into log form in order to get absolute changes instead of relative changes. The study also plotted time series of 8 indices shown in [Figure 1](#).

**Table 1.** History of selected stock markets at the end of 2016.

Region/Country	Stock exchange	Market capitalization, billion USD	Number of listed companies	Trading volume, billion USD
Japan	Tokyo SE	4955	3541	5626
China	Shanghai SE	4100	1182	7510
Hong Kong in China	Hong Kong SE	3193	1973	1350
India	Bombay SE	1567	5821	113
South Korea	KOSPI CI	1255	2059	1665
Taiwan in China	Taiwan SE	844	911	512
Singapore	Singapore exchange	640	757	197
Indonesia	Indonesi SE	426	537	92

Source: OECD Equity Markets Review 2017.



**Figure 1.** Daily stock price index of 8 regions or countries, January 2000-December 2017.

**Table 2.** Key indicators of selected stock exchange, as of end 2016.

Region/ Country	Stock Exchanges	Market capitalization/GDP	Total value traded/GDP	Turnover
Japan	Tokyo SE	1.12	1.27	1.14
China	Shanghai SE and Shenzhen SE	0.64	1.68	2.61
Hong Kong in China	Stock Exchange of Hong Kong	9.90	4.19	0.42
India	National SE	0.67	0.30	0.45
South Korea	Korea Exchange	0.95	1.26	1.33
Taiwan in China	Taiwan SE and Taipei Exchange	1.82	1.01	0.55
Singapore	Singapore Exchange	2.17	0.67	0.31
Indonesia	Indonesia SE	0.45	0.10	0.22

Source: OECD Equity Markets Review 2017.

#### 4. Methodology

It is important to check the data before analyzing data for various problems (Nasrullah et al., 2019; Saddozai et al., 2015). Long run equilibrium relationship between non-stationary variable existing in time series data is one of the important issues for economists. To capture this relationship, Engle and Granger (1987) introduce a concept of cointegration. Stock (1987) investigate that if two variables of series data have unit root and cointegrated with each other then there estimation of parameters is highly efficient and if they have the same trend, then they have a long run relationship. Cointegration test is important to find the nature and trend in time series variable.

Dickey Fuller (1979, 1981) developed a procedure to check the stationarity of time series variable before empirical analysis. A series  $X_t$  is supposed to be coin-

tegrated of order “ $b$ ” if they have stochastic ARMA and stationarity at differencing “ $b$ ” times which is represented as:  $X_t = I(b)$ . Mostly, non-stationary time series variable are co-integrated of order  $I(1)$ , if data set are stationary at level and integrated also then it is denoted by  $I(0)$ . Suppose if two variables  $A_t$  and  $B_t$  are integrated at order  $I(0)$ , then regression equation ( $A_t = \alpha_0 + \alpha_1 B_t + e_t$ ) is applied to estimate the long term relationship between these variables and stationarity of residuals will be estimated through stationarity test. If the estimated results of the variables are not cointegrated at level ( $I(0)$ ) then at order  $I(1)$  the estimated residuals will be integrated. Furthermore, the results of regression in case of non-stationary series will be misleading, spurious in such conditions.

$$A_t = \alpha_0 + \alpha_1 B_t + e_t \quad (1)$$

$e_t$  presents estimated residuals of data variables which is important for checking stationarity by applying common tests of stationarity that is Phillips-Perron (PP) and Augmented Dickey-Fuller (ADF).

Possibilities of having more than one integrating vector will occur if there are more than two variables in the model which implies that variables are forming numerous equilibrium relationship, which generate a joint evolution for all variable. Usually, for  $n$  numbers of variable has  $n - 1$  cointegrating vector but if  $n = 7$ , then a simple single equation approach is not enough to resolve this serious problem. So, an alternate approach is required and thus [Johansen and Julius \(1990\)](#) developed a multiple equations approach. The Johansen method of cointegration has unique characteristics that it can measure the second order series data which other approaches cannot estimate like ARDL.

Simple error correction model is extended to a multivariate equation. Supposing that there are six variables  $T_t, U_t, V_t, W_t, X_t$  and  $Z_t$  then we have using (matrix notation for  $A_t = [T_t, U_t, V_t, W_t, X_t, Z_t]$ )

$$A_t = \alpha_1 A_{t-1} + \alpha_2 A_{t-2} + \dots + \alpha_k A_{t-k} + u_t \quad (2)$$

Equation (2) is similar to simple Equation (1) having only variables of  $A_t$  and  $B_t$ .

Reformulate Equation (2) in a vector error correction model (VECM) is below:

$$\Delta A_t = \Gamma_1 \Delta A_{t-1} + \Gamma_2 \Delta A_{t-2} + \dots + \Gamma_k \Delta A_{t-k-1} - \Pi A_{t-1} + u_t \quad (3)$$

where

$$\Gamma_i = (I - \alpha_1 - \alpha_2 - \dots - \alpha_k) \quad (i = 1, 2, \dots, k-1)$$

$$\Pi = -(I - \alpha_1 - \alpha_2 - \dots - \alpha_k)$$

Residual  $u_t$ 's are supposed to be independent and distributed identically as a multi-normal distribution having  $\delta$  variance and zero mean. Suppose there are six variables in  $A_t = [T_t, U_t, V_t, W_t, X_t, Z_t]$ , require to check  $6 \times 6$   $\Pi$  matrix. The information about long run equilibrium relationship contains in  $\Pi$  matrix shown in Equation (3). This long run information of matrix ( $\Pi$ ) are decomposed into  $\Pi = \gamma\beta$  where  $\gamma$  contain the adjustment of speed to attain the level of long-run equilibrium while the coefficient of long-run matrix is  $\beta$ . Thus, in case

of two variables model  $\gamma A_{t-1}$  term is equal to error correction term ( $A_{t-1} - \gamma - \gamma_1 B_{t-1}$ ), by accepting the facts that  $\gamma A_{t-1}$  having up to  $(n - 1)$  vectors in a multivariate structure. For simplifying the reason, it is considered that there are only two lags ( $k = 2$ ), model are as follow:

$$\begin{pmatrix} \Delta X_t \\ \Delta U_t \\ \Delta V_t \\ \Delta W_t \\ \Delta X_t \\ \Delta Z_t \end{pmatrix} = \Gamma_1 \begin{pmatrix} \Delta X_{t-1} \\ \Delta U_{t-1} \\ \Delta V_{t-1} \\ \Delta W_{t-1} \\ \Delta X_{t-1} \\ \Delta Z_{t-1} \end{pmatrix} + \Pi \begin{pmatrix} X_{t-1} \\ U_{t-1} \\ V_{t-1} \\ W_{t-1} \\ X_{t-1} \\ Z_{t-1} \end{pmatrix} + e_t \tag{4}$$

Equation (4) can be written as follow:

$$\begin{pmatrix} \Delta X_t \\ \Delta U_t \\ \Delta V_t \\ \Delta W_t \\ \Delta X_t \\ \Delta Z_t \end{pmatrix} = \Gamma_1 \begin{pmatrix} \Delta X_{t-1} \\ \Delta U_{t-1} \\ \Delta V_{t-1} \\ \Delta W_{t-1} \\ \Delta X_{t-1} \\ \Delta Z_{t-1} \end{pmatrix} + \begin{pmatrix} \alpha_{11} & \alpha_{12} \\ \alpha_{21} & \alpha_{22} \\ \alpha_{31} & \alpha_{32} \\ \alpha_{41} & \alpha_{42} \\ \alpha_{51} & \alpha_{52} \\ \alpha_{61} & \alpha_{62} \end{pmatrix} \begin{pmatrix} \beta_{11} & \beta_{21} & \beta_{31} & \beta_{41} & \beta_{51} & \beta_{61} \\ \beta_{12} & \beta_{22} & \beta_{32} & \beta_{42} & \beta_{52} & \beta_{62} \end{pmatrix} \begin{pmatrix} X_{t-1} \\ U_{t-1} \\ V_{t-1} \\ W_{t-1} \\ X_{t-1} \\ Z_{t-1} \end{pmatrix} + e_t \tag{5}$$

Error correction (i.e. for  $\Delta X_t$  on left hand side) in Equation (5) can be investigated as in following equation:

$$\Pi Z_{t-1} = \begin{pmatrix} \begin{bmatrix} \alpha_{11} \\ \beta_{11} \end{bmatrix} + \begin{bmatrix} \alpha_{11} \\ \beta_{12} \end{bmatrix} + \begin{bmatrix} \alpha_{11} \\ \beta_{21} \end{bmatrix} + \begin{bmatrix} \alpha_{11} \\ \beta_{22} \end{bmatrix} + \begin{bmatrix} \alpha_{11} \\ \beta_{31} \end{bmatrix} + \begin{bmatrix} \alpha_{11} \\ \beta_{32} \end{bmatrix} + \begin{bmatrix} \alpha_{11} \\ \beta_{41} \end{bmatrix} + \begin{bmatrix} \alpha_{11} \\ \beta_{42} \end{bmatrix} + \begin{bmatrix} \alpha_{11} \\ \beta_{51} \end{bmatrix} + \begin{bmatrix} \alpha_{11} \\ \beta_{52} \end{bmatrix} + \begin{bmatrix} \alpha_{11} \\ \beta_{61} \end{bmatrix} + \begin{bmatrix} \alpha_{11} \\ \beta_{62} \end{bmatrix} \end{pmatrix} \begin{pmatrix} X_{t-1} \\ U_{t-1} \\ V_{t-1} \\ W_{t-1} \\ X_{t-1} \\ Z_{t-1} \end{pmatrix} \tag{6}$$

$\Pi_1$  shows the first row of the  $\Pi$  matrix. Simplified form of Equation 6 as follows:

$$\begin{aligned} \Pi Z_{t-1} &= \alpha_{11} (\beta_{11} X_{t-1} + \beta_{21} U_{t-1} + \beta_{31} V_{t-1} + \beta_{41} W_{t-1} + \beta_{51} Y_{t-1} + \beta_{61} Z_{t-1}) \\ &+ \alpha_{12} (\beta_{12} X_{t-1} + \beta_{22} U_{t-1} + \beta_{32} V_{t-1} + \beta_{42} W_{t-1} + \beta_{52} Y_{t-1} + \beta_{62} Z_{t-1}) \end{aligned} \tag{7}$$

The cointegrating vectors with  $\alpha_{11}$  and  $\alpha_{12}$  terms of their respective speed of adjustment are clearly shown in Equation (7).

Johansen (1988) developed a reduced rank regression procedure through which the rank of  $\Pi$  matrix can be tested. In order to determine the number of cointegration equations, Johansen and Julius (1990) explained two ways of estimation  $\Pi$  matrix. Maximum eigenvalue denoted by  $\lambda_{max}$  is the first method proposed by Johansen in which largest eigenvalue is ordered in descending by considering either they are significantly different from zero. The following statistics are used to find the number of characteristics roots that are significantly different from zero:

$$\lambda_{max} (rr + 1) = -T \ln(1 - \lambda r + 1) \tag{8}$$

Second method of johenson is known as trace test which is based on likelihood ratio test about the trace of the matrix. The aim of this test is to focus either the trace is increases by adding more eigenvalue beyond the  $r$ th eigenvalue. The test statistic will be:

$$\lambda_{\text{trace}}(r) = -T \sum t = r + \ln(1 - \lambda r + 1) \quad (9)$$

Johansen and Julius (1990) provide critical values for both statistics. Bivariate VAR model is used to find out the granger causality relationship if long run relationship exists among stock price index variables. For investigating further pairwise granger causality among two variables ( $A$  and  $B$ ) bivariate regression model is used to find  $A$  causes  $B$  and  $B$  causes  $A$

$$B_t = \alpha_0 + \alpha_1 B_{t-1} + \dots + \alpha_n B_{t-k} + \beta_1 A_{t-1} + \dots + \beta_n A_{t-k} + \varepsilon_t \quad (10)$$

$$A_t = \alpha_0 + \alpha_1 A_{t-1} + \dots + \alpha_m A_{t-1} + \beta_1 B_{t-k} + \dots + \beta_m B_{t-k} + u_t \quad (11)$$

Acceptation or rejection of hypothesis is based on the calculated F-statistics. Model 10 is used for testing hypothesis of “ $A$  does not granger cause  $B$ ” and Equation (11) is used for hypothesis that “ $B$  does not granger cause  $A$ ”.

## 5. Empirical Findings

### 5.1. Tests of the Unit Roots

Before starting cointegration, checking the problem of stationarity of a given data series is important. The study uses Phillips-Peron (PP) and Augmented Dickey-Fuller (ADF) (PP) unit root for stationarity based on model with constant and trend. Number of lag selection is based on the minimum Akaike Information criterion (AIC). ADF and PP results show that all data variables accept the hypothesis of unit root at level, which means that data are not stationary except Korea and Taiwan in China which is significant at 10 percent level. In order to make it stationary, same test are used at first difference of stock market variables and resulted that at first difference all variables become stationary. This result shows that all variable indices are integrated at same order  $I(1)$ . Presence of unit root suggesting the evidence of weak efficiency form of selected Asian markets (Mcmiken, 2014; Nasrullah et al., 2020). Results are shown in **Table 3**.

**Table 3.** Unit root test.

Market indices	ADF		PP	
	Level	1st Difference	Level	1st difference
Japan	-2.28	-68.79***	-2.17	-68.99***
Shanghai in China	-1.78	-64.48***	-1.83	-64.49***
Hong Kong in China	-1.53	-62.02***	-1.78	-62.21***
Bombay	-2.30	-47.13***	-2.30	-61.69***
Korea	-3.13*	-65.08***	-3.04	-65.24***
Taiwan in China	-3.36*	-63.80***	-3.41**	-63.80***
Singapore	-1.14	-63.21***	-1.17	-63.16***
Indonesia	-2.44	-59.86***	-2.47	-59.77***

Note: \*, \*\*, \*\*\* denotes at 10, 5, 1 percent significance level.

## 5.2. Johanson Cointegration Test

Proper lag selection is important for applying the Johanson and Julius cointegration test. Proper lag should be selected where the AIC value is less. Minimum value of AIC is founded on lag 7 which is used during analysis. Cointegration has been checked through critical trace statistics and maximum Eigen value. The result of trace statistics implies that there are 5 series of cointegrating vector at 5% confidence interval. Similarly, maximum Eigen value implies that there are 2 number of cointegration equation, which implies that these all markets can easily diversify foreign investment (Pretorious, 2002). Null hypothesis of no cointegration is not accepted. Result shows a long term relationship among all top 8 Asian stock market which are shown in **Table 4** and **Table 5**.

**Table 4.** Cointegration test of top 8 Asian indices (trace).

No. Cointegration Equation (s)	Eigen value	Trace statistics	Critical value (0.05)	Probability**
0*	0.014225	241.9711	159.5297	0.0000
1*	0.012606	179.9079	125.6154	0.0000
2*	0.009070	124.9534	95.75366	0.0001
3*	0.007827	85.48172	69.81889	0.0017
4*	0.006487	51.44157	47.85613	0.0222
5	0.002623	23.24770	29.79707	0.2341
6	0.002037	11.87047	15.49471	0.1633
7	0.000701	3.037789	3.841466	0.0813

Note: MacKinnon Haug Michelis et al. (1999) *p*-values.

**Table 5.** Cointegration test of top 8 Asian indices (Maximum Eigenvalue).

No. Cointegration Equation (s)	Eigen value	Max-eigen Statistics	Critical value (0.05)	Probability**
0*	0.014225	62.06321	52.36261	0.0038
1*	0.012606	54.95450	46.23142	0.0046
2*	0.009070	39.47164	40.07757	0.0584
3*	0.007827	34.04015	33.87687	0.0478
4*	0.006487	28.19387	27.58434	0.0418
5	0.002623	11.37723	21.13162	0.6097
6	0.002037	8.832678	14.26460	0.3003
7	0.000701	3.037789	3.841466	0.0813

Note: MacKinnon Haug Michelis et al. (1999) *p*-values.

### 5.3. Granger Casualty Test

The study continues to use Granger causality test to find out the short term relation among 8 Asian stock markets indices. The most suitable lag is 7 based on AIC series according to test requirement. Results of causality test show that mostly (13) stock market indices are bidirectional, which implies that both markets have short term relationship and can effect each other while 12 market indices are unidirectional which implies that one market have short term relation but the other is free. In the above market indices, 3 pairs of market are totally free from each other cannot cause granger causality. Results are shown in **Table 6**.

### 6. Summery and Conclusion

This study is carried out among top Asian stock market indices based on market capitalization based on daily price index of last 18 years spanning from January 2000 to December 2017. Data are analyzed in local currency unit obtained from yahoo finance. Problems of missing data due to difference in holidays are fixed by filling the data of adjusted day. Data are transformed into log form for getting absolute changes. Before cointegration analysis the data are checked through ADF and PP test at level for stationarity, which confirmed the existence of unit root at level. To make it stationary, data are analyzed at first difference which indicates that all indices are integrated at same order  $I(1)$  implying that unit root suggesting the evidence of weak efficiency form of selected Asian markets. Cointegration analysis based on trace statistics shows five cointegrating equation, while the maximum eigen value test indicates two cointegrating equation at

**Table 6.** Granger causality test (2000-2017).

Hong Kong in China => Bombay	Unidirectional	Korea <=> Indonesia	Bidirectional
Indonesia <=> Bombay	Bidirectional	Shanghai in China <=> Indonesia	Bidirectional
Japan <=> Bombay	Bidirectional	Singapore => Indonesia	Unidirectional
Korea <=> Bombay	Bidirectional	Taiwan in China <=> Indonesia	Bidirectional
Shanghai in China <=> Bombay	Bidirectional	Korea => Japan	Unidirectional
Singapore => Bombay	Unidirectional	Shanghai in China <= Japan	Unidirectional
Taiwan in China <=> Bombay	Bidirectional	Singapore = Japan	No causality
Indonesia <= Hong Kong in China	Unidirectional	Taiwan in China <=> Japan	Bidirectional
Japan = Hong Kong in China	No causality	Shanghai in China = Korea	No causality
Korean <= Hong Kong in China	Unidirectional	Singapore <=> Korea	Bidirectional
Shanghai in China <=> Hong Kong in China	Bidirectional	Taiwan in China <=> Korea	Bidirectional
Singapore => Hong Kong in China	Unidirectional	Singapore <=> Shanghai in China	Bidirectional
Taiwan in China <= Hong Kong in China	Unidirectional	Taiwan in China <= Shanghai in China	Unidirectional
Japan => Indonesia	Unidirectional	Taiwan in China <= Singapore	Unidirectional

Note: significance at 5%.

5 percent significant level which implies that these markets are strongly cointegrated in long run which can diversify foreign investors. The results of granger causality test show 13 pair of markets are bidirectional while 12 pairs are unidirectional and 3 pairs have no causality.

Due to the presence of stationarity, results of unit root suggesting the evidence of weak form of selected Asian market efficiency. It is concluded from the results of Johansen cointegration test that trace statistic shows the evidence of 5 cointegrating vectors while max-eigenvalue shows 2 cointegration vector. These results indicate that all these 8 indices are moving in equilibrium which explores the inefficiency of Asian market. Causality test also shows the indication of short term relation. The result suggest that although there is evidence of cointegration among selected market but still there is scope for efficient portfolio diversification across these markets. For making policy, regional integration play an important role in expanding the base for investors and also broaden the range of financial product, which is helpful for strengthening domestic capital market to compete global market. An integrated markets are useful for decreasing the chances of financial stability and asymmetric shocks, which can strengthen the capability of the economy to absorb the shocks and adequate the risk of international financial contagion.

Further study should be carried out to find the factors that are responsible for the co-movement of these markets together.

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### **Conflicts of Interest**

The authors declare no conflicts of interest regarding the publication of this paper.

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