TEST Engineering & Management

May – June 2020
ISSN: 0193-4120 Page No. 28529 - 28548

Co-Integration and Causality among Stock Market Indices: Evidence from Asia-Pacific Markets

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Article Info
Volume 83
Page Number: 28529 - 28548
Publication Issue:
May - June 2020

Abstract

The purpose of this paper is to analyse the nature and level of interdependence of various stock markets of the Asia-Pacific region. This paper attempted to analyse whether there had been stock market interdependencies and dynamic interactions among selected global indices. This paper also ascertained the degree of association between stock markets. This study included the closing values of daily prices of various indices from January 2005 to May 2018 collected from the respective websites of the stock exchanges. This study investigated the stock market behaviour and the extent of integration among 12 stock indices from the Asia-Pacific region. This study involved a two-stage methodology. In the first part, normality, stationarity, and causality of the time series were tested. In the second part of the methodology, the focus was given to analyse the different stock markets interdependencies, to ascertain the degree of association, and to measure the market efficiency. The findings show that a considerable amount of interdependency exists among stock markets. It was also found that there is an association between markets. These results are recommended to policymakers, regulators, and researchers on the one hand and firms' managers as well as investors on the other. These results provided few insights to the investors to those who are seeking portfolio diversification.

Article History
Article Received*: 11 May 2020*
Revised*: 19 May 2020*
Accepted*: 29 May 2020*
Publication*: 12 June 2020*

Keywords:*co-integration, cross-correlation, stock markets, market efficiency, interdependence, causality, international financial markets.*

I. INTRODUCTION

In the last thirty years, global capital market integration has noticed major strategic deviations like, foreign investment limits have been reduced, exchange controls have been almost abolished, free movement of capital, humans and technology has been encouraged and the fundamental structures of most of the world's economies have been changed. Such technological advances will shift the relationship between different markets around the globe. The promotion of market integration through liberalization has critical implications for investment decisions and policies.The dynamics of the economic development are inevitable. Great attention is being paid nowadays on examining associations between global

May – June 2020
ISSN: 0193-4120 Page No. 28529 - 28548

stock markets. Native countries can be connected with the international capital markets through financial integration. Increasing regional financial-market convergence helps diversify risk. Global financial transparency can mitigate the risk of financial pandemic and crisis (Cyn& Jong, 2011).

Correlations can be used as a technique to examine variations in stock prices over the years to obtain the variations in the degree of integration among markets. A higher correlation can be inferred as an increase in the degree of integration, and can have a major potential to spread impact of economics shock of one country's financial market to other markets. As such, this approach is not considered to be very helpful, because the correlations can be observed as a consequence of short and long-term relationships.

Cointegration method is used to analysis of a long-term relationship or co-movements within an equilibrium setting between two variables. In stock markets, the cointegration relationship suggests the existence of a common phenomenon that links stock markets. The existence of co-integration between stock markets decreases opportunities for asset risk diversification, as similar investment risks share the across the co-integrated stock markets. The consequences of no integration between international stock markets are widening the benefits of investing in various stock markets. As a result, foreign investors looking for global investment opportunities will devise portfolios that include securities of a single asset class or multiple classes, but that extend to non-cointegrated capital markets of different countries. In addition, the non-integrated stock markets have less impact on their domestic stock markets from global news. Cointegration of the stock market analysis allows international investors, houses of mutual funds and hedge funds quest for investment opportunities through international capital markets.

Studies on co-integration among stock markets have been a crucial theme in the financial literature since Granger's works (1983) formalized Co-integration concept. Later Granger & Weiss studies (1983); Engle & Granger (1987) evolved into a model for evaluating the linear relationships between the financial markets. For one market unfavorable events trigger stock price volatility. The fluctuations are spreading to the interconnected markets as a Pandemic because of the inter linkages with other markets.

The cointegrated and interlinked stock markets can lead to a world-wide crash to begin by a particular news event in one country (Roll 1989). The studies of Arshanapalli&Doukas (1993); Masih&Masih (1997); Kizys&Pierdzioch (2011) among others have reported the interlinkages among developed markets of USA, Japan, and Europe. The interlinkages between the US, Japan, and Asian markets were evidenced by Arshanapalli, Doukas& Lang (1995); Anoruo, Ramchander&Thiewes (2003); Asgharian, Hess & Liu (2013) among others. Further, these studies attributed the decline in the stock indices after the United States stock market crash of October 1987, Asian Financial Crisis of 1997 and Global Financial Crisis of 2008 to cointegration and interlinkages of stock markets.

Normally a bivariate cointegration relationship determines the long-term equilibrium relationship. The deviation from the equilibrium relationship is found to be stationary in such a relationship, with

May – June 2020
ISSN: 0193-4120 Page No. 28529 - 28548

a mean value of zero. It can be translated into an application that can be evaluated as a combination of two non-stationary series which is stationary in itself. Such sequence of bivariate is considered to be cointegrated according to Engle and Granger (1987).

These relationships can be extended to multivariate relationships. For such a relationship, the aggregation of all the time series will establish a divergence in the price factors from the long-term relationship. Multivariate cointegration is a long-term relation between the non-stationary time series and there is a stationary combination of non-stationary time series. Bivariate relationships in such a situation can lead to incorrect findings and inferences. It was observed that cointegration is supposed to be seen more in larger structures than smaller ones, which can be interpreted as reflecting the wider interaction between international stock markets and these markets are integrated to a greater degree. The long-term relationship between global stock markets can be explained by a change in the degree of cointegration among factors / variables. This can be done by comparing the relationship of cointegration over various periods of the sub-samples. For this analysis, Cointegration's multivariate approach is applied to investigate multi-country cointegration.

II. LITERATURE REVIEW

Schleicher (2001) observed co-integration between Eastern European Market and Western European Market. The study had used VAR model with multivariate GARCH and concluded that Eastern markets were more influenced by the Western markets.

Click & Plummer (2005), Majid, Meera, Omar and Aziz (2009) and Phuan, Lim &Ooi (2009) studied about the stock market integration in ASEAN after the financial catastrophe and found that co-integration of five ASEAN markets have not been completed in economic sense. Mukherjee and Mishra (2005) observed long-term co-integration among Indian stock market and other Asian stock markets.

Serwa and Subramanian (2008) studied the relationship among five stock exchanges in East Asia. He used co-integration test and Granger causality test to study the relationship and concluded that these stock exchanges were co-integrated and diversification across various markets can be beneficial in the short-term but not in the long-term.

A study done by Guidi (2010) shown contradictory results which have found that there was no co-integration found in Indian stock market and Asian stock markets. The study revealed that the long-term benefits for investing in India are very limited. Another study done by Chittedi (2010) observed the relationship between developed countries stock markets and Indian stock market and found that these markets were not co-integrated. He used Granger causality test and found unidirectional relationship between Indian stock market and US market and Japan whereas UK and Australia were found to have no causality. Nath & Verma (2003) found that there is no co-integration among three South Asian stock markets i.e. India, Taiwan and Singapore.

Alagidede (2008) studied about the African stock market integration with the implications for portfolio diversification and international risk sharing. Integration of stock markets has tended to be more efficient when compared to the segmented markets. Co-integrating vector numbers

May – June 2020
ISSN: 0193-4120 Page No. 28529 - 28548

have revealed with the integration extent across stock markets. Geographical proximity has not clearly dealt with the African stock markets. Further they suggested that the efforts at integrating African stock markets have remained futile to date.

Tirkkonen (2008) studied about the stock and bond market integration with evidence from Russian financial markets. Long-run relationships testing with the autoregressive model (VAR) has played an important role on the Russian stock market integration.

Wang & Moore (2008) studied the stock market integration for the transition economies by using time-varying conditional correlation. They found a very high level of correlation after entering to the European Union. Financial market integration has seemed to be a largely self-fueling process and it also has dependent on the development of financial sector at the existing levels.

Chen & Shen (2009) studied the co-integration among stock markets of U.K., U.S.A., Japan and Germany Markets by using Granger causality and co-integration test and found the integration among markets. Chancharat (2009) studied stock market integration by using econometric techniques such as Co-integration test, factor analysis and GARCH models which are found to be useful to investigate the relationship among the economic variables and the stock market integration. These techniques also have the tendency to examine whether the international stock markets have a capability to move together in the context of the stock market integration.

Co-integration among developing stock markets in Asia was studied by Raju &Khanapuri (2009) and they found an existence of high degree of co-integration among the markets used in the sample.

Baumöhl&Výrost (2010) analysed co-integration using granger causality test with respect to non-synchronous trading effects. They used classical mean-variance methodology and concluded that there was no significant lead-lag relationship of stock market integration in the pre and post crisis period. Karagöz& Ergun (2010) observed market co-integration among Balkan countries and found that economic and financial integration has helped to reduce the political risk and to promote the stability of the economy and local markets size. Yeoh, Hooy&Arsad (2010) studied co-integration between Malaysia and Singapore stock markets. They concluded that the Malaysian stock market was having higher degree of co-integration.

Babecký, Komarek&Komárková (2013) studied co-integration between Chinese and Russian stock markets by using beta-convergence and sigma-convergence approaches. Bhunia& Das (2012) studied about the financial market integration from India and select south Asian countries. The global crisis of finance has focused more attention on the linkages among the Asian countries stock market. Authors have predicted that the stock index of the Indian stock market has not co-integrated with the developed markets. Indian stock market has integrated with the mature markets effectively.

Birau& Trivedi (2013) studied stock market co-integration and contagion of emerging markets with respect to global financial crisis. The financial system turbulence has turned into the heavy reduction on stock market around the world.

May – June 2020
ISSN: 0193-4120 Page No. 28529 - 28548

Joshi (2013) examined the co-integration among BRIC's stock indices and concluded that India had a long-term equilibrium relationship with Russia and China but not with Brazil

Mohamed (2014) investigated the existence of co-integration among GCC stock markets. Most of the GCC stock markets have relatively small closed to the foreign investors which also have led the blocking inflows of foreign portfolio investment effectively.

Patel (2014) proposed a study regarding co-integration of Indian and selected Asian stock markets. This study examined the Indian stock market independence with other equity markets of Asia like Sri Lanka, Pakistan, Korea, Japan, Malaysia, China, Singapore and Taiwan. The major suggestion derives is that the government of India must supervise the Asian equity markets movements very closely because crisis in any country of Asia may influence the Indian stock market performance.

Seth & Sharma (2015) studied the co-integration among the Asian and US markets by applying the Granger causality test, Johnsen co-integration test and found the existence of short term and long term cointegration among the market. Mitra & Bhattacharjee (2015) found co-integration of BSE with other markets.

Bhattacharjee & Swaminathan (2016) studied stock market integration of India and few selected countries and found that cointegration of Indian market with other indices have improved over the years due to liberalization and during the recession, Indian market was more responsive to Asian markets.

Everaert and Pozzi (2016) studied co-integration among 19 European stock markets for a period from 1970 to 2015 by using a penal of monthly stock market returns. They developed a model of dynamic factor which decomposes equity risk premium into a country risk factor of Europe with stochastic volatilities and time varying factor loadings. This model was evaluated using Bayesian MCMC (Markov Chain Monte Carlo) methods. The study concluded that there was an existence of co-integration in few developed European countries from late 1980s to early 1990s but also neither euro area membership nor European Union has developed the integration of stock market. Shahzad, Kanwal, Ahmed &Rehman, (2016) studied co-integration among the stock markets applying ARDL and found the existence of co-integration among the markets.

Patel (2017) explored the co-integration among 14 stock markets. The correlation analysis showed that BSE remained somewhat positively correlated. Results of Johansen cointegration test concluded that there was a long run relationship among selected stock markets.

Kiviet& Chen (2018) reviewed the literature on the analysis of co-integration between the price indices of stocks or their realized returns at various markets and registered frequently recurring methodological deficiencies such as omitted regressor problems, neglecting to verify agreement of estimation outcomes with adopted model assumptions, employing particular statistical tests in inappropriate situations and, occasionally and lack of identification.

Nautiyal and Kavidayal (2018) examined cross-country returns and co-integration of 11 stock indices of developed and developing countries by using VECM and found that there was a slow but significant price adjustment and stock market co-integration was found.

TEST Engineering & Management

May – June 2020
ISSN: 0193-4120 Page No. 28529 - 28548

III. DATA AND METHODOLOGY

1. Data Sources

This study included closing values of daily and monthly prices of various indices from January 2005 to December 2018 which were collected from the respective websites of the stock exchanges. The stock market behaviour and the extent of co-integration was investigated among 12 stock indices from Asia. The major stock indices Asian markets (SENSEX, HSI, JAKARTA, KLSE, KOSPI, NIKKEI 225, NZSE50, SHANGHAI, STRAITS, TAIWAN, ISRAEL and NIFTY) were selected for this study. The indices are chosen based on judgmental sampling.

Table 1: Indices used in the Study

INDICES	COUNTRY	Status
HIS	Hong Kong	Developed
JAKARTA	Indonesia	Emerging
KLSE	Malaysia	Emerging
KOSPI	South Korea	Emerging
NIFTY 50	India	Emerging
NIKKEI 225	Japan (Tokyo SE)	Developed
NZSE50	New Zealand	Developed
SENSEX	India	Emerging
SHANGHAI	China	Emerging
STRAITS	Singapore	Emerging
TAIWAN	Taiwan	Emerging
TEL AVIV	Israel	Developed

2. Methodology and Hypothesis

This study involved a two-stage methodology. In the first part, normality, stationarity and causality of the time series was tested using statistical techniques like Jarque-Bera Statistic, ADF Test and Granger Causality Test respectively. The hypothesis statements were developed for each test as follows.

H_0 [1]: Stock indices prices are normally distributed.

H_0[2]: A Unit Root is present in the stock indices prices. (Dickey & Fuller, (1979 & 1981))

H_0 [3]: x(t) doesn't Granger-cause y(t). (There is no causal relationship between stock indices)

In the second part of the methodology, the focus was given to analyse the stock markets interdependencies, to ascertain the degree of association and to measure the market efficiency using various techniques like Johansen's Cointegration test, Cross Correlation test and Hurst Exponent. Johansen's Cointegration test was used with two approaches i.e. trace test and eigenvalue test.

H_0[4]: the number of cointegration vectors is $r = r^* < k$ (Null Hypothesis for trace test as well as eigenvalue test)

H^{05}: cross-correlation is not significantly different from zero.

H_0[6]: stock price variations are independent.

IV. ANALYSIS AND RESULTS

1. Descriptive Statistics

The descriptive statistics of the variables under study are shown below which include mean, median, maximum-minimum values, standard deviation, JB statistic, skewness and kurtosis. These figures are taken from

May – June 2020
ISSN: 0193-4120 Page No. 28529 - 28548

the original data, daily prices and include annotations from 2005 to 2018.

The descriptive statistics show that mean returns of the most of the indices in the sample were positive though it was found that the mean daily return of JAKARTA index was highest (0.07) among all the indices followed by NIFTY 50 index whereas the average daily return of STRAITS and TAIWAN index was lowest (0.02) among all. The fact that the emerging markets are more volatile is evident from statistics on standard deviation of daily returns in these markets. In general, the developed market returns are less volatile with standard deviation lesser than the emerging markets. The SHANGHAI market though provides maximum standard deviation of 1.75 followed by HIS (1.56) and NIFTY (1.52).

Skewness values of India is near to zero exhibits only asymmetrical distribution. All the Kurtosis values of the stock markets investigated in this study display a value more than three, showing a leptokurtic curve, which demonstrates that the distribution of stock returns in these countries contain extreme values. The values of Kurtosis accompanied with those of Jarque-Berra statistic clearly indicate that the returns of markets are not normally distributed. These findings are consistent with Harvey (1995), Bekaert, Erb, Harvey &Viskanta (1998). Under large departure from normality, the mean-variance criterion given by Markowitz (1952) can lead to application of wrong portfolio weights Jondeau&Rockinger (2005). For risk-averse investors, the use of sub-optimal mean-variance criterion in portfolio construction can result in substantial opportunity cost. The non-normality of returns in emerging markets therefore compels the international investors to use distinct and typical models for determining expected returns of portfolios comprising emerging market assets.

May – June 2020
ISSN: 0193-4120 Page No. 28529 - 28548

Table 2: Descriptive Statistics

INDICES	Mean	Median	Max	Min	Std. Dev.	Kurtosis	Skewness	JB	P	Sum	Sum Sq. Dev.
HIS	0.03	0.03	14.35	-12.7	1.56	12.82	0.3	11528.07	0	72.68	6952.63
JAKARTA	0.07	0.13	7.92	-10.38	1.4	9.57	-0.47	5116.35	0	184.15	5454.53
KLSE	0.03	0.05	17.38	-14.42	0.93	97.95	0.8	1060287	0	70.85	2427.87
KOSPI	0.04	0.06	11.95	-10.57	1.31	11.36	-0.36	8290.24	0	104.01	4837.42
NIFTY 50	0.06	0.07	17.74	-12.2	1.52	13.44	0.23	12936.76	0	167.66	6531.2
NIKKEI225	0.03	0.06	14.15	-11.41	1.57	10.65	-0.25	6876.55	0	74.97	6907.84
NZSE50	0.03	0.07	5.99	-4.82	0.71	8.04	-0.3	2990.83	0	89.39	1390.54
SENSEX	0.06	0.09	17.34	-10.96	1.52	12.53	0.32	10688.63	0	170.96	6511.39
SHANGHAI	0.04	0.06	9.45	-8.84	1.75	6.77	-0.37	1744.42	0	127.04	8680.17
STRAITS	0.02	0.03	7.82	-8.33	1.14	9.47	-0.07	5034.85	0	48.58	3735.75
TAIWAN	0.02	0.07	6.74	-6.51	1.21	6.56	-0.3	1531.11	0	53.59	4127.48
TEL AVIV	0.03	0	6.97	-10	1.16	10.47	-0.78	6836.68	0	85.47	3766.01

Source: Author's Calculation

May – June 2020
ISSN: 0193-4120 Page No. 28529 - 28548

2. Examining Stationary of Variables

In order to check the co-integration, a requirement is to check that all factors are non-stationary. The ADF test was used to determine that the variables are stationary or not. AIC was used to find out that the optimal lag structure for conducting the test.

The ADF test was performed for each of the index in the sample included. The findings of the ADF test are shown in Table 3.

Table 3: Results of Unit Root Test for Stationarity for All Indices

ADF test statistic	T-statistic	Probability
HIS	-55.05	0.0001***
JAKARTA	-47.92	0.0001***
KLSE	-58.55	0.0001***
KOSPI	-52.11	0.0001***
NIFTY 50	-3.76	0.0034***
NIKKEI 225	-55.35	0.0001***
NZSE50	-49.04	0.0001***
SENSEX	-49.23	0.0001***
SHANGHAI	-52.12	0.0001***
STRAITS	-52.78	0.0001***
TAIWAN	-50.10	0.0001***
TEL AVIV	-53.79	0.0001***

*Source: Author's Calculation, *** Significant at 1% level*

As can be seen from Table 3 that the p-value is less than 5% for all the variables at 1st difference level. It was found that all the stock indices prices are non-stationary at the original level and they are stationary at the 1st difference.

3. Test for Causality

Granger causality test was performed to examine the causal relationship among these markets. Since cointegration—at any level—exists, the Granger causality testing is appropriate for bilateral pairs of markets. As Granger (1988) pointed out, if two variables are cointegrated, causality must exist at least uni-directional.

From the causality analysis it can be inferred that there is an existence of bi-directional causality. Among 12 indices, HIS causes 3 indices, Jakarta causes 3 indices, KLSE causes 4 indices, KOSPI causes 5 indices, Nifty causes 4 indices, Nikkei225 causes 3 indices, NZSE50 causes 1 index, Sensex causes 4 indices,Straits causes 7 indices, Taiwan causes 3 indices and Tel Aviv causes 5 indices.

As far as uni-directional causality concerned, HIS causes 5 indices, Jakarta causes 6 indices, KLSE doesn't cause any indices in one way, KOSPI causes 3 indices, Nifty causes 7 indices, Nikkei225 causes 1 index, NZSE50 doesn't cause any indices in one way, Sensex causes 7 indices, Shanghai causes 5 index, Straits causes 3 indices, Taiwan causes 1 indices and Tel Aviv causes 4 indices.

TEST Engineering & Management

May – June 2020
ISSN: 0193-4120 Page No. 28529 - 28548

Table 4: Results showing Bi-directional and Uni-directional Causality of All Indices

	HIS	JAKARTA	KLSE	KOSPI	NIFTY 50	NIKKEI 225	NZSE 50	SENSEX	SHANGHAI	STRAITS	Taiwan	Tel Aviv
HIS	---	3.75988	50.378	19.675	0.94232	27.869	42.643	0.7579	0.27129	5.5441	28.196	9.088
P – value	---	0.0234	0	0	0.3898	0	0	0.4687	0.7624	0.0039	0	0.000
JAKARTA	2.9831	---	31.636	5.986	8.168	7.56792	16.2147	8.897	5.6309	1.4831	17.326	9.315
P – value	0.0508	---	0	0.0025	0.0003	0.0005	0	0.0001	0.0036	0.2271	0	0
KLSE	2.4671	1.29735	---	1.787	0.22656	6.5027	5.691	0.3186	1.21187	3.6067	3.541	2.381
P – value	0.085	0.2734	---	0.1676	0.7973	0.0015	0.0034	0.7272	0.2978	0.0273	0.029	0.093
KOSPI	3.8203	1.04788	33.66	---	4.32855	10.5921	23.377	3.8974	0.4254	1.3653	5.538	6.607
P – value	0.022	0.3508	0	---	0.0133	0	0	0.0204	0.6536	0.2555	0.004	0.001
NIFTY 50	41.967	9.89124	61.166	47.866	---	71.5085	51.866	4.4195	7.23349	10.117	59.299	19.99
P – value	0	0	0	0	---	0	0	0.0121	0	0	0	0
NIKKEI 225	1.7382	1.28605	9.8386	4.014	0.49626	---	9.6751	0.6034	0.2412	3.8312	1.407	1.287
P – value	0.176	0.2765	0	0.0182	0.6089	---	0	0.547	0.7857	0.0218	0.245	0.276
NZSE 50	3.0041	2.81207	9.0213	2.0188	2.19451	2.94387	---	2.296	1.6829	0.1684	1.877	0.815
P – value	0.0497	0.0602	0.0001	0.133	0.1116	0.0528	---	0.101	0.186	0.845	0.153	0.443
SENSEX	44.637	11.3735	62.418	49.141	8.065	75.2394	55.375	---	7.9685	10.684	62.10	19.87
P – value	0	0	0	0	0.0003	0	0	---	0.0004	0	0	0
SHANGHAI	7.1077	0.31296	4.1727	4.893	3.1548	0.2915	4.9493	3.2524	---	4.078	0.0005	2.179
P – value	0.0008	0.7313	0.0155	0.0075	0.0428	0.7472	0.0071	0.0388	---	0.017	0.9995	0.113
STRAITS	56.3272	9.4847	78.461	36.983	4.2558	81.778	64.8268	3.9061	3.431	---	59.43	15.501
P – value	0	0	0	0	0.0143	0	0	0.0202	0.0325	---	0	0
Taiwan	1.0227	1.75936	13.329	0.10127	1.81537	1.8433	14.959	1.6006	1.25528	7.0002	---	5.129
P – value	0.3597	0.1723	0	0.9037	0.1629	0.1585	0	0.2019	0.2851	0.0009	---	0.006
Tel Aviv	18.3786	13.2085	34.171	35.056	2.39798	45.1556	50.9452	2.7442	7.4151	7.1483	21.646	---
P – value	0	0	0	0	0.0911	0	0	0.0645	0.0006	0.0008	0	---

Source: Author's Calculation

May – June 2020
ISSN: 0193-4120 Page No. 28529 - 28548

4. Co-integration Test

The Johansen (1988, 1991, 1995) efficient maximum likelihood test was used to examine the existence of a long-term relationship among indices. A model of the Johansen procedure was used: the one with a linear trend in level and intercept in the co-integrating equations (CE). This version was found to be more appropriate to our data since we have trending series with stochastic trends. The test was performed using a formulation of a VAR model with lag length determined according to AIC and Akaike's Final Prediction Error (FPE). Determination of co-integration rank (r) depends on values of eigenvalue and trace statistics.

The Johansen co-integration test was performed for the set of 12 stock exchanges to investigate integration of these markets as a group. Analysis using the multiple equations was based on a VAR model, which is required before constructing a related VECM system. The VAR model of order 2, which was chosen according to AIC, contains a 5x1 vector that contains logarithms of share price index of the five markets. The multivariate approach examined the existence of a co-integrating vector in the stochastic matrix, and a sequence of hypotheses test using maximum likelihood methods, establishing the greatest possible number of vectors within the system. In this study, the null hypotheses assume for each row of numbers: zero and at most one co-integrating equations. The alternative hypothesis states one, co-integrating equations, respectively, for each row. As long as trace statistics exceed critical values at 5 or 1 percent, the alternative hypothesis was accepted (null hypothesis was rejected). The results of the Johansen co-integration test for the group of stock markets are presented in Table 5.

As illustrated in the table, trace statistics indicated one co-integrating vector at the 5 percent significance level among the markets. Since the trace statistic exceed the 5 percent critical value, it is possible to reject the null hypothesis of no co-integrating vectors, indicating that there are one or more co-integrating equations.

TEST Engineering & Management

May – June 2020
ISSN: 0193-4120 Page No. 28529 - 28548

Table 5: Results of Co-integration Test for All Indices

					Trace			Maximum Eigen value	
SENSEX			**Hypothesized No. of CE**	**Eigen Value**	**Trace statistics**	**P value**	**Eigen Value**	**Max Eigen statistic**	**P value**
	HIS		None *	0.18041	630.3075	3.8414	0.180418	630.3075	3.8414
	JAKARTA	Cointegration exists	None *	0.20172	1267.780	15.494	0.201727	713.7659	14.264
			At most 1 *	0.16044	554.0141	3.8414	0.160441	554.0141	3.8414
	KLSE	Cointegration exists	None *	0.20070	1222.104	15.494	0.200705	709.7124	14.264
			At most 1 *	0.14933	512.3919	3.8414	0.149338	512.3919	3.8414
	KOSPI	Cointegration exists	None *	0.21608	1336.856	15.494	0.216086	771.2668	14.264
			At most 1 *	0.16350	565.5891	3.8414	0.163503	565.5891	3.8414
	NIFTY50	Cointegration exists	None *	0.20977	1336.120	15.494	0.209771	745.8496	14.264
			At most 1 *	0.16999	590.2706	3.8414	0.169994	590.2706	3.8414
	NZSE50	Cointegration exists	None *	0.217979	1345.150	15.494	0.217979	748.3627	14.264
			At most 1 *	0.184555	578.2875	3.8414	0.184555	578.4139	3.8414
	NIKKEI 225	Cointegration exists	None *	0.20818	1306.123	15.494	0.208181	739.4812	14.264
			At most 1 *	0.16378	566.6421	3.8414	0.163781	566.6421	3.8414

May – June 2020
ISSN: 0193-4120 Page No. 28529 - 28548

	STRAITS	Cointegration exists	None *	0.20274	1265.366	15.494	0.202743	717.7991	14.264
			At most 1 *	0.15873	547.5673	3.8414	0.158730	547.5673	3.8414
	TAIWAN	Cointegration exists	None *	0.19971	1283.925	15.494	0.199710	705.7722	14.264
			At most 1 *	0.16681	578.1531	3.8414	0.166814	578.1531	3.8414
	TEL AVIV	Cointegration exists	None *	0.20246	1278.761	15.494	0.202467	716.7013	14.264
			At most 1 *	0.16257	562.0594	3.8414	0.162570	562.0594	3.8414

May – June 2020
ISSN: 0193-4120 Page No. 28529 - 28548

5. Cross Correlation

The examination of correlation structure of log returns from Table 6 and 7 give following important findings:

The markets exhibit mixed correlation coefficients with each other In emerging market context China stock market is having relatively low degree of correlation coefficients with other counterparts. This indicates that Chinese market is by far the most isolated market in the region which further is an indication of potential diversification benefits.

India stock market exhibits significant correlation coefficients with Singapore and with Japan stock market. Sensex and Nifty Index are positively correlated with all the indices. Sensex is highly correlated with other stock market indices i.e. STRAITS (0.57) and HIS (0.54). There is low positive correlation exist between Sensex and KLSE, SHANGHAI and NZSE50.

The below table is representing the test result of cross – Correlation among the stock markets. In these cross-correlation test results data is significant at 1% levels. In case of developing countries, the cross-correlation results of India and Malaysia show that there are mostly positive lags values which show positive correlation with SENSEX stock return.

Table 6: Findings and Inference of High Correlation of Indices

Highly Correlated :>0.65	
HIS	STRAITS, KOSPI
STRAITS	HIS
NIFTY50	SENSEX
KOSPI	HIS, TAIWAN
SENSEX	NIFTY 50

May – June 2020
ISSN: 0193-4120 Page No. 28529 - 28548

Table 7: Results of Cross Correlation for All Indices

	STRAITS	HIS	NIFTY50	KOSPI	KLSE	SENSEX	NIKKEI 225	SHANGHAI	JAKARTA	Taiwan	NZSE50	ISRAEL
STRAITS	1.00	0.73	0.56	0.62	0.45	0.57	0.54	0.30	0.38	0.56	0.34	0.39
HIS	0.73	1.00	0.53	0.65	0.39	0.54	0.58	0.45	0.34	0.58	0.31	0.37
NIFTY 50	0.56	0.53	1.00	0.43	0.28	0.99	0.34	0.22	0.30	0.38	0.22	0.34
KOSPI	0.62	0.65	0.43	1.00	0.38	0.43	0.61	0.29	0.32	0.67	0.34	0.30
KLSE	0.45	0.39	0.28	0.38	1.00	0.29	0.35	0.19	0.25	0.39	0.26	0.23
SENSEX	0.57	0.54	0.99	0.43	0.29	1.00	0.34	0.22	0.30	0.38	0.23	0.34
NIKKEI 225	0.54	0.58	0.34	0.61	0.35	0.34	1.00	0.26	0.27	0.53	0.41	0.27
SHANGHAI	0.30	0.45	0.22	0.29	0.19	0.22	0.26	1.00	0.13	0.29	0.16	0.17
JAKARTA	0.38	0.34	0.30	0.32	0.25	0.30	0.27	0.13	1.00	0.31	0.19	0.19
Taiwan	0.56	0.58	0.38	0.67	0.39	0.38	0.53	0.29	0.31	1.00	0.33	0.33
NZSE 50	0.34	0.31	0.22	0.34	0.26	0.23	0.41	0.16	0.19	0.33	1.00	0.21
TEL AVIV	0.39	0.37	0.34	0.30	0.23	0.34	0.27	0.17	0.19	0.33	0.21	1

May – June 2020
ISSN: 0193-4120 Page No. 28529 - 28548

6. Hurst Exponent Analysis

There is a basic assumption in theories of quantitative finance that the changes in stock prices are independent. Such changes can be exhibited using Brownian motion. For this purpose, Hurst exponent analysis is used as a test for independence in time series data. Hurst exponent value of 0.5 explains that the time series is independent. But predetermined Brownian motion data will give a value of Hurst exponent which can be higher or lower than 0.5. Such value can be wrongly inferred as an evidence of long-term memory in case on absence of proper test.

Based on the Hurst exponent value H, a time series can be classified into three categories.

(1) H=0.5 indicates a random series.

(2) 0<H<0.5 indicates an anti-persistent series.

(3) 0.5<H<1 indicates a persistent series.

Mean-reversion is an attribute of a time series which is anti-persistent. Mean-reversion shows reverse movement of the previous value. In case Hurst Exponent, the characteristic of mean-reversion improves when the value of H moves towards 0. On the other hand, a persistent time seri

es reinforces the trend of previous value. Persistent trend improves when the value of H moves towards 1. Majority of the time series are found to be persistent when the Hurst exponent value is more than 0.5.

Table 8: Results of Hurst Exponent Analysis

Indices	H for Return	H Return result
HIS	0.5746	Persistence
JAKARTA	0.6050	Persistence
KLSE	0.5141	Random walk
KOSPI	0.5440	Persistence
NIFTY 50	0.5003	Random walk
NIKKEI 225	0.5110	Random walk
NZSE 50	0.6226	Persistence
SENSEX	0.5205	Random walk
SHANGHAI	0.6967	Persistence
STRAITS	0.6902	Persistence
TAIWAN	0.5677	Persistence
TEL AVIV	0.6688	Persistence

It can be found that out of total 12 indices in the sample, 8 indices follow persistence trend and4 indices follow random trend. In a persistent time-series, an increase in values will most likely be followed by an increase in the short term and a decrease in values will most likely be followed by another decrease in the short term. Random trend means there is no correlation between observations and future observations. Series of this kind is very difficult to predict. In anti-persistence trend an increase will most likely be followed by a decrease and vice versa. This means that future values have a tendency to return to a long-term mean.

V. CONCLUSION

The study has analyzed the co-integration among 12 stock indices across the Asia-Pacific region. This study explored the stock market interdependencies and dynamic interactions using co-integration test and found that co-integration was existed between Indian Stock Market (Sensex) and other indices. As the trace statistic was higher than critical value at 5 percent; therefore, the null hypothesis of no co-integration was rejected. The result implied that there was at most one co-integrating equation between the two variables.

May – June 2020
ISSN: 0193-4120 Page No. 28529 - 28548

Co-integration test was performed for the set of 12 stock exchanges to investigate integration of these markets as a group using multiple equations based on a VAR model. Trace statistics indicated at least one co-integrating vector at the 5 percent significance level among the markets.

This study also ascertained the degree of association between markets. Cross correlation was used to ascertain the association and found that out of 12 indices, there were 5 indices who were highly correlated with one or more indices.

This study also found bi-directional as well as uni-directional causality among the stock market indices. The Hurst Exponent analysis found that out of total 12 indices in the sample, 8 indices follow persistence trend and 4 indices follow random trend.

VI. RESEARCH IMPLICATIONS

This study contributes in the following ways. First, positive co-integration is compatible with the concept of stock market integration, which assumes a similarity in securities offerings and the ability of investors from each market to hold investments in all securities.

Further, these results are recommended to policymakers, regulators and researchers on the one hand and firms' managers as well as investors on the other. FIIs, HNIs, individual, institutional and public investors can make decisions regarding their investments based on short-term and long-term integration among the markets. These results provide insights to the investors for portfolio diversification which can help reduce the systematic risk of the portfolio.

VII. LIMITATION OF THE STUDY

This study is constructed on the secondary data of stock market indices which included daily closing prices. This study does not involve the weekly or monthly prices which can be used for further analysis such as seasonality in stock indices.

One of the procedural issues to be handling in the context of log return correlation matrix is the existence of timing difference or difference in trading hours between emerging stock markets and select developed stock markets especially for US stock market.

Another limitation of the study is that it does not cover event specific co-integration. It may also be possible that cointegration is not a suitable framework to analyse the interdependence or the integration of international financial markets.

VIII. SCOPE FOR FURTHER RESEARCH

The study has further scope of research. The dependency of each market to other markets can be studied using the Regression analysis. The analysis of dependency can help in taking the investment in a better way. The effect of volatility among markets can also be analyzed.

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May – June 2020
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May – June 2020
ISSN: 0193-4120 Page No. 28529 - 28548

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