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Comovement of stock markets pre- and post-COVID-19 pandemic: a study of Asian markets

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Abstract

Purpose – The study aims is to explore the cointegration level among major Asian stock indices from pre-COVID-19 to post COVID-19 times.

Design/methodology/approach – Johansen cointegration test is employed to know the long run relationship among the stock market indices of Hong Kong, Indonesia, Malaysia, Korea, India, Japan, China, Taiwan, Israel and South Korea. The empirical testing was done to analyze whether any significant change has been induced by the COVID-19 pandemic on the cointegrating relationship of the selected markets or not. Through statistics of trace test and maximum eigen value, total number of cointegrating equations present among all the indices during different study periods were analyzed.

Findings – The presence of cointegration was found during all the sample periods and the findings suggests that the selected stock markets are associated with each other in general. During COVID-19 crisis period the cointegration level was reduced and again it regained its original level in the next year and again reduced in the subsequent next year. So, the cointegrating relationship among selected stock market indices remains dynamic and no evidence of impact of COVID-19 on this dynamism was found.

Originality/value – The study has explored the level of cointegration among the major stock indices of Asian nations in the pre, during, post-crisis and the most recent periods. The interconnectedness of the stock markets during the COVID-19 times has been compared with similar periods in different years immediately preceding and succeeding the COVID-19 times which has not been done in any of the existing study.

Keywords Stock market integration, Asian stock market, Augmented dickey-fuller test, Johansen cointegration test

Paper type Research paper

1. Introduction

The upsurge of the COVID-19 infectious disease in China in December, 2019 very soon spread all over the world and till January, 2020, the entire global economy faced major disruptions due to the deadliest coronavirus disease. This health crisis resembles similarities to previous epidemics like the H1N1 virus in 1918, the H2N2 virus in 1957 and 1958, H3N2 virus in 1968, the Swine flu during 2009–2010, Ebola virus during 2014–2016 and the MERS (Middle East respiratory syndrome) virus in 2012, which greatly affected many economies (Salisu, Sikiru, & Vo, 2020).

During any kind of health, political or economic crisis, the working of financial systems gets disturbed. Just like the historical crisis, the COVID-19 pandemic also flustered business and economic activities widely all over the world. The global economy succeeded towards depression due to the imposition of various restrictions. It has consequently caused major decline in revenues causing corporate indebtedness and deficient stock market performances.

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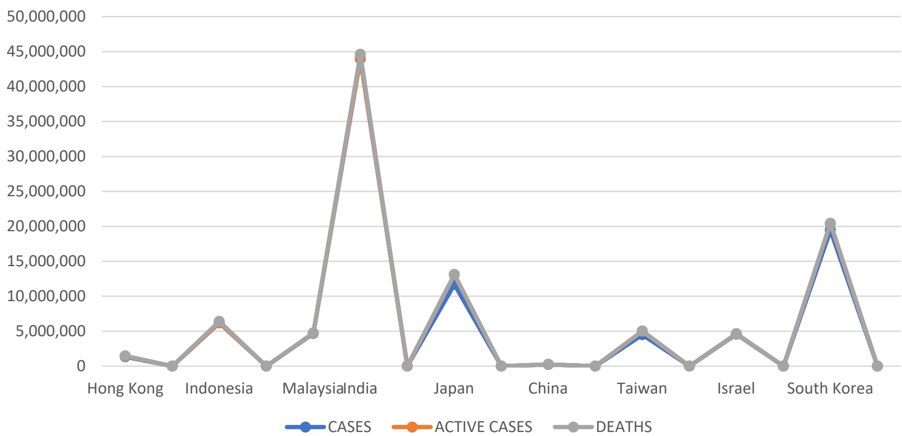
Recurring financial crises in the global markets have increased the level of interest in exploring the correlation among different financial markets, particularly during financial turmoil (Song, Xia, Basheer, & Shah, 2021). Das & Gupta suggests that global stock markets are expected to be interrelated and sensitive if the nations belong to the same political or economic zone or status.

The degree of association among different stock market indices also gets influenced due to the pandemic situations. The extent to which different markets are interlinked with each other has been proved to be dynamic in nature like Mukhopadhyay (2022) found presence of cointegration among the stock markets of the United States of America (USA), China, Japan, Germany and India during the COVID-19 pandemic period and absence of cointegration during the pre-COVID-19 period.

Only few studies like Kumari and Jain (2021), Komariah, Mulyani, Afriandi, Indriani, and Septiana (2022), Bhardwaj, Sharma, and Mavi (2022) have investigated the influence of COVID-19 on cointegration level of Asian stock markets. The present study is an attempt to provide more evidence on the matter. It seeks to find the degree of association among Asian stock market indices from pre-COVID-19 period to post-COVID-19 period.

To get insight into the simultaneous movement of stock market indices of different nations, 10 major Asian economies namely Hong Kong, Indonesia, Malaysia, Korea, India, Japan, China, Taiwan, Israel, South Korea were considered. The selected economies faced massive disruptions due to COVID-19 pandemic. Figure 1 displays total cases, active cases and deaths caused by COVID-19 in selected Asian nations. To empirically interpret the nature and degree of linkages among these markets, Johansen cointegration test was employed. The study has looked into the association of the markets during pre-COVID-19, COVID-19 and post-COVID-19 times. The study has explored whether there is any difference in the interdependence among the markets during the COVID-19 times and non-COVID-19 times. Period of three months from the date of World Health Organization (WHO) announcement of COVID-19 as global health emergency has been taken as COVID-19 times and a similar period in the preceding year, in the succeeding year and in the recent year has been taken into consideration to explore the cointegrating relationship in the corresponding periods.



Source(s): Author’s compilation using information from https://en.wikipedia.org/wiki/COVID 19_pandemic_in_Asia

Figure 1.
Total cases, active cases and deaths caused by COVID-19 in selected Asian nations as of 28 July, 2022

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2. Literature review

As different Stock markets located at different parts of the world are interlinked with each other, any changes in one market may cause changes in other interlinked markets too. The dynamics of interlinked relationship between different markets has been explored by various researchers and it has been indicated that problems in market of one economy can get rapidly migrate to the other nations of the same continent.

Studies have provided the empirical evidence of different financial markets of the world to be interlinked like Verma and Rani (2016) investigated the relationship among the markets of Brazil, Russia, India, China and South Korea and the impact of shocks on the cointegration level of the markets and found the evidence of causal relationships among different markets.

Papavassiliou (2014) found long term equilibrium between financial markets of Montenegro, the developed countries of Western Europe and the USA. Similarly Seth and Sharma (2015) found stock markets of USA and Asia to be correlated and integrated in the long run. Chong Drew, & Veeraraghavan (2003) found short and long run linkages between Australian and United States (US) market. Gilmore and McManus (2004) also indicated the presence of cointegration among the stock markets of Canada, Mexico and the U.S. However, Vo and Daly (2005) indicated that no long-run relationship exists between the stock market indices of Asian and advanced industrial nations. Thomas *et al.* (2017) examined the long term equilibrium relationship among frontier, emerging and developed markets of Asia-Pacific region. The study found emerging markets of Thailand and China and the frontier markets of Pakistan and Sri Lanka to be fairly separated from most of the markets of Asia-Pacific region. The study also indicated that frontier and emerging markets impacts developed markets.

As stated by Parker and Rapp (1998), no long run comovement should exist among the stock indices if the respective markets are efficient. Thus examining the comovement of one market with other markets of the world also helps in determining the efficiency of the financial market. The cointegration test results can help in understanding the dynamic relation between the stock prices of two markets. When two series of stock price move together during some time period but move apart during the period of external shocks, it is still possible for the investors to predict the stock prices of one market using stock prices information of the other market (Huang and Fok, 2001).

Panda and Nanda (2017) examined the relationship among the financial markets of South America and Central America. The study found long term equilibrium relationship among major stock markets of the region. It was also revealed that stock market returns of Argentina, Venezuela, Chile and Brazil significantly influences each other. Boamah (2017) found that the extent of global integration of emerging markets surpasses their level of integration with themselves. Roy and Sen (2019) investigated the comovements and cointegration between Nifty, DJI (Dow Jones) and N225 index. The study found synchronous movement among indices in the short run and cointegration among the indices in the long run. High correlation and strong cointegration among the indices was revealed in the study.

Cointegration implies at least one long term equilibrium relationship between different stock indexes (Liu *et al.*, 1997). The presence of cointegration has multiple interpretations and the most intuitive one is that the cointegrated variables evolve together over time and the cointegrating relationship acts as an attractor for the variables in the system (Ansotegui and Esteban, 2002). If different stock indices are correlated with each other and cointegration relationship exists among them, it implies that there is no scope for short run or long run investment diversifications at international level.

The interrelatedness or interdependence among different stock markets of the world also gets significantly influenced due to the occurrence of any kind of crisis. The influence of the Covid-19 crisis on performance of different stock market has extensively been studied by the researchers all over the world such as Fernandez-Perez, Gilbert, Indriawan, & Nguyen (2021), Zhang, Gao, & Li, 2021, Al-Awadhi, Alsaifi, Al-Awadhi, & Alhammadi (2020), Liu, Choo, &

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Lee, 2020, Topcu *et al.* (2020) etc. The studies have provided evidence of significant influence of pandemic on functioning of the global financial markets.

Kumari and Jain (2021) examined long term and short term cointegration between stock indexes of South East Asian countries before and during the covid-19 pandemic period. The study found evidence of long term association among the indices before and during the crisis. Change in short run cointegration was also confirmed in this study. Habiba, Peilong, Zhang, and Hamid (2020) found long-run integration among the stock markets of USA and South Asian emerging economies in pre-, during and post-crisis periods.

To test the presence of cointegration among different stock markets, Johansen cointegration test has been extensively used by various researchers. This technique was originated by Granger (1986) and Johansen (1988) and has been widely applied in investigating stock market integration like Taylor *et al.* (1989), Kasa (1992), Gulzar, Mujtaba Kayani, Xiaofen, Ayub, and Rafique (2019) etc. Das and Gupta (2022) used Johansen cointegration test to examine the comovement of stock indices of five most COVID affected nations after first wave along with the market indices of three least affected nations during the first wave. The study found evidence of cointegration between different indices during the pandemic period and no integration between least three COVID-affected countries during the pandemic time.

Chong *et al.* (2003) used correlation, vector auto regression framework, Johansen cointegration test to investigate the interrelationship among stock markets of Australia and the five largest international markets. The study found short and long run relationships among the stock markets of Australia and US and only little evidence of interdependence was found with the other markets. It was also indicated that US market granger causes the Australian market. Parker and Rapp (1998) used Johansen cointegration test and common serial correlation test to study the stock market efficiency of the U.S. and foreign markets. The study considered the Footsie index, the S&P 500 index, the Nikkei index, Wilshire 5000 index, the Hang Seng index and the NASDAQ (National Association of Securities Dealers Automated Quotations Stock Market) index and the Nikkei index as a substitute to world stock market indices. The study found mixed findings for different stock markets and it was revealed that most of the world markets were jointly efficient.

There have been various crises that made the global financial sector suffered but the impact created by COVID-19 pandemic has been more significant than the earlier epidemics. Even the most developed nations could not remain untouched by the unprecedented effects of the pandemic. Thus, the current study aims to examine the linkages among the Asian stock markets around the COVID-19 pandemic period.

This study adds to the existing literature by exploring the level of cointegration among the major stock indices of Asian nations in the pre-, during, post-crisis and the most recent periods. The interconnectedness of the stock markets during the COVID-19 times has been compared with the similar periods in different years immediately preceding and succeeding the COVID-19 times which has not been done in any of the existing study.

3. Methodology

3.1 Study period

The sample period of this study is classified into 4 parts namely pre-COVID-19 period, COVID-19 crisis period, post-COVID-19 period and the most recent period. On 11th march, 2020, COVID-19 crisis was announced as an international pandemic and public health emergency by WHO. Taking this announcement date into consideration three months period from 11 March 2020 to 11 June 2020 is considered as COVID-19 crisis period. A similar three months period in the previous year, i.e. from 11 March 2019 to 11 June 2019 is taken as pre-COVID-19 period. In most of the Asian nations, the first wave of the COVID-19 pandemic started in March 2020, reached its peak in September 2020 and diminished till the end of

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November 2020. Thus, a three month period after the first wave ended, starting from 11 March 2021 to 11 June 2021 is taken as post-COVID-19 period. A similar period in current year, i.e. from 11 March 2022 to 11 June 2022 is taken as most recent period. The entire study period ranges from 11 March 2019 to 11 June 2022.

3.2 Data Source

Market integration literature using cointegration methodology often carelessly employs different categories of data, like price indices, return indices or adjusted indices with risk-free rate (Yang, 2012). In the present study, daily closing values of indices has been considered and the data was collected from the website of Yahoo finance. Missing value of the indices on any particular day has been replaced by its previous day value. In order to study the dynamics of cointegrating relationship among Asian stock markets, 10 major Asian stock market indices were selected. Table 1 displays the name of the stock indices and the nations considered.

3.3 The econometrics

To explore the degree of association among the stock market indices of selected nations during the study period, firstly the test of stationarity has been applied and then the test of cointegration was employed.

As this study is concerned with data of different stock indices, i.e. time series data, it is imperative to test the stationarity of the selected series before applying further tests. The augmented dickey-fuller (ADF) test is used and stationarity of all the series are checked at the level and at the first difference.

To test the cointegrating relations among the time series, the data has to be nonstationary at the level and has to be stationary at the first difference. After checking the stationarity of the indices series, Johansen cointegration test is used to examine the cointegration among the series of indices. The technique of Johansen cointegration uses statistics of two tests, i.e. trace test and maximum eigenvalue test statistics. The values of these test statistics are used to determine the presence or absence of cointegration among different series and it also indicates total number of cointegrating equations present among all the selected series. If the critical value of the test statistics obtained from the Johansen table is less than the calculated value of test statistics, then it can be affirmed that cointegration exists between the respective indices.

4. Findings

4.1 Unit root test results

The study has applied the ADF test to know the stationarity of the selected indices. The stationarity is tested at the level and at the first difference during the selected study periods. The ADF test results are reported in Table 2.

S.No.	Index	Symbol	Nations
1	HANG SENG INDEX	HSI	Hong Kong
2	JAKARTA COMPOSITE INDEX	JKSE	Indonesia
3	FTSE Bursa Malaysia KLCI	KLSE	Malaysia
4	KOSPI composite index	KS11	Korea
5	NIFTY 50	NSEI	India
6	Nikkei 225	N225	Japan
7	SSE Composite Index	SSE	China
8	TSEC weighted index	TWII	Taiwan
9	Tel Aviv 125 Index	TA-125	Israel
10	Kosdaq Composite Index	KQ11	South Korea

Source(s): Author's Compilation

Table 1. Selected Asian stock market indices and nations

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Table 2.
ADF test results on indices series at level and at first difference during different study periods

		2019		2020		2021		2022	
INDEX		ADJ.T-stat	Prob	ADJ.T-stat	Prob	ADJ.T-stat	Prob	ADJ.T-stat	Prob
HIS	Intercept	−0.644083 (−3.533204)	0.8528	−2.854351 (−3.534868)	0.0564	−3.470840 (−3.533204)	0.0119	−2.216238 (−3.533204)	0.2026
	Trend&int	−2.060580 (−4.103198)	0.5576	−3.774681 (−4.105534)	0.0243	−3.453278 (−4.103198)	0.0531	−2.203810 (−4.103198)	0.4795
	None	−0.463026 (−2.600471)	0.5110	−0.129201 (−2.601024)	0.6354	−0.328641 (−2.600471)	0.5632	0.235821 (−2.600471)	0.7516
HSI(−1)	Intercept	−8.297847 (−3.534868)	0.0000	−9.360463 (−2.601596)	0.0000	−9.043984 (−3.534868)	0.0000	−7.552685 (−2.601024)	0.0000
JKSE	Intercept	−1.074377 (−3.533204)	0.7211	−2.469076 (−3.534868)	0.1277	−1.810807 (−3.533204)	0.3723	−2.216238 (−3.533204)	0.2026
	Trend&int	−1.468527 (−4.103198)	0.8305	−3.864645 (−4.105534)	0.0192	−1.146233 (−4.103198)	0.9127	−2.203810 (−4.103198)	0.4795
	None	−0.222941 (−2.600471)	0.6022	−0.380773 (−2.601024)	0.5433	−0.431682 (−2.600471)	0.5235	0.235821 (−2.600471)	0.7516
JKSE(−1)	Intercept	−7.606810 (−3.534868)	0.0000	−7.341768 (−3.536587)	0.0000	−7.659869 (−3.534868)	0.0000	−7.530553 (−3.534868)	0.0000
KLSE	Intercept	−1.504691 (−3.533204)	0.5251	−0.129933 (−3.534868)	0.9412	−2.907432 (−3.533204)	0.0499	0.115504 (−3.533204)	0.9646
	Trend&int	−0.889055 (−4.103198)	0.9508	−3.999718 (0.0134)	−4.105534	−3.638335 (−4.103198)	0.0341	−1.930144 (−4.103198)	0.6276
	None	−0.168419 (−2.600471)	0.6217	0.696055 (0.8634)	−2.601024	−0.668756 (0.4237)	−2.600471	−0.986281 (−2.600471)	0.2872
KLSE(−1)	Intercept	−7.296374 (−3.534868)	0.0000	−7.355665 (−3.536587)	0.0000	−9.303128 (−3.534868)	0.0000	−7.626445 (−3.534868)	0.0000
KS11	Intercept	−0.948290 (−3.533204)	0.7666	−0.231069 (−3.536587)	0.9284	−1.650700 (−3.533204)	0.4513	−1.712405 (−3.533204)	0.4204
	Trend&int	−1.763686 (−4.103198)	0.7110	−4.401505 (−4.105534)	0.0043	−2.424214 (−4.103198)	0.3641	−2.848359 (−4.103198)	0.1859
	None	−0.223105 (−2.600471)	0.6022	0.991703 (−2.601596)	0.9135	1.241136 (−2.600471)	0.9440	−0.364227 (−2.600471)	0.5497
KS11(−1)	Intercept	−7.942764 (−3.534868)	0.0000	−8.411559 (−3.536587)	0.0000	−7.984433 (−3.534868)	0.0000	−8.792336 (−3.534868)	0.0000
NSEI	Intercept	−2.152063 (−3.533204)	0.2256	−2.414748 (−3.534868)	0.1417	−0.843630 (−3.533204)	0.7997	−1.140720 (−3.533204)	0.6948
	Trend&int	−2.287822 (−4.103198)	0.4344	−4.560436 (−4.105534)	0.0026	−2.614580 (−4.103198)	0.2755	−2.659086 (−4.103198)	0.2567
	None	0.909753 (−2.600471)	0.9013	−0.289042 (−2.601024)	0.5780	0.436973 (−2.600471)	0.8056	−0.309586 (−2.600471)	0.5704
NSEI(−1)	Intercept	−8.396988 (−3.534868)	0.0000	−10.20027 (−3.536587)	0.0000	−8.343396 (−3.534868)	0.0000	−8.658993 (−3.534868)	0.0000
N225	Intercept	−1.510372 (−3.533204)	0.5223	−0.500135 (−3.534868)	0.8839	−2.339379 (−3.533204)	0.1630	−2.702776 (−3.533204)	0.0789
	Trend&int.	−1.971324 (−4.103198)	0.6058	−3.934290 (−4.105534)	0.0160	−2.962413 (−4.103198)	0.1506	−2.600006 (−4.103198)	0.2818
	None	0.018021 (−2.600471)	0.6850	0.793476 (−2.601024)	0.8818	−0.143790 (−2.600471)	0.6303	0.945946 (−2.600471)	0.9069
N225(−1)	Intercept	−8.462388 (−3.534868)	0.0000	−6.916408 (−3.536587)	0.0000	−8.588700 (−3.534868)	0.0000	−7.540752 (−3.534868)	0.0000
SSE	Intercept	−0.860798 (−3.533204)	0.7946	−2.074518 (−3.534868)	0.2555	−2.074518 (−3.534868)	0.2555	−0.985391 (−3.533204)	0.7538
	Trend&int.	−2.010398 (−4.103198)	0.5848	−4.984643 (−4.105534)	0.0007	−4.984643 (−4.105534)	0.0007	−2.439798 (−4.103198)	0.3564
	None	−0.547100 (−2.600471)	0.4764	−0.148014 (−2.601024)	0.6288	−0.148014 (−2.601024)	0.6288	0.827026 (−2.600471)	0.8877
SSE(−1)	Intercept	−7.907216 (−3.534868)	0.0000	−8.375578 (−3.536587)	0.0000	−8.375578 (−3.536587)	0.0000	−8.283526 (−3.534868)	0.0000

(continued)

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Table 2.

		2019		2020		2021		2022	
TWII	Intercept	−1.766925 (−3.533204)	0.3935	−0.453896 (−3.534868)	0.8928	−1.771984 (−3.533204)	0.3910	−1.346188 (−3.533204)	0.6031
	Trend&int.	−2.018956 (−4.103198)	0.5802	−5.295913 (−4.105534)	0.0002	−1.815030 (−4.103198)	0.6863	−1.982056 (−4.103198)	0.6001
	None	0.501685 (−2.600471)	0.8212	0.501911 (−2.601024)	0.8213	0.508199 (−2.600471)	0.8228	−0.578353 (−2.600471)	0.4631
TWII(−1)	Intercept	−8.217885 (−3.534868)	0.0000	−8.005851 (−3.536587)	0.0000	−6.881751 (−3.534868)	0.0000	−7.911792 (−3.534868)	0.0000
TA-125	Intercept	−2.177563 (−3.533204)	0.2163	−1.142994 (−3.534868)	0.6937	−1.419974 (−3.533204)	0.5674	−0.954171 (−3.533204)	0.7646
	Trend&int.	−2.112203 (−4.103198)	0.5294	−3.516696 (−4.105534)	0.0459	−3.155429 (−4.103198)	0.1025	−2.824773 (−4.103198)	0.1939
	None	0.389400 (−2.600471)	0.7935	0.579056 (−2.601024)	0.8389	1.088865 (−2.600471)	0.9267	−0.390667 (−2.601596)	0.5394
TA125(−1)	Intercept	−9.405041 (−3.534868)	0.0000	−10.79842 (−3.536587)	0.0000	−9.610197 (−3.534868)	0.0000	−6.737578 (−3.536587)	0.0000
KQ11	Intercept	−1.294092 (−3.533204)	0.6276	−0.127231 (−3.534868)	0.9415	−2.668323 (−3.533204)	0.0850	−1.243372 (−3.534868)	0.6506
	Trend&int.	−1.808119 (−4.103198)	0.6897	−4.232100 (−4.105534)	0.0070	−2.280065 (−4.103198)	0.4385	−2.574944 (−4.103198)	0.2928
	None	−0.204196 (−2.600471)	0.6090	1.205788 (−2.601024)	0.9403	1.143881 (−2.600471)	0.9333	−0.108537 (−2.601024)	0.6426
KQ11(−1)	Intercept	−8.340193 (−3.534868)	0.0000	−7.857403 (−3.536587)	0.0000	−7.127790 (−3.534868)	0.0000	−9.589249 (−3.534868)	0.0000

Note(s): Terms in parentheses denote critical value for rejection of the hypothesis of ADF Test at 1% level
Source(s): Author's Calculations

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From Table 2, it can be observed that all the selected indices are nonstationery at level and reaches stationarity at first difference. When the data is considered at the level, the null hypothesis of ADF test is accepted in all the cases. It implies that unit root exists at the level data and the indices are non-stationary at level form. However, considering the first difference data, the null hypothesis of ADF test is rejected in all the cases. It implies that unit root is not present at the first difference data and the indices are stationary at the first difference. It implies that the data of considered indices is integrated of order one for all the sample periods. The obtained results are significant at significance level of 1%. So, the basic requirement for the application of Johansen's cointegration methodology is being fulfilled.

After testing the stationarity of the selected indices, the cointegrating relation among the selected indices is checked through the application of Johansen Cointegration test. To accept the presence cointegrating relationship between the variables, Trace and Max-Eigen Statistics value should be higher than the critical value at 5% significance level (Deo and Prakash, 2017).

4.2 Johansen test results

For all the sample periods trace statistics are obtained and in order to confirm the trace test results, maximum eigenvalue statistics are also considered for all the sample periods. For both the test results significance level of 5% is considered.

Table 3 represents results of trace statistics and maximum eigenvalue statistics during the sample period of pre-COVID-19 i.e. from 11th March, 2019 to 11th June, 2019. Presence of 9 cointegrating equations is indicated by the trace statistics whereas the maximum eigenvalue statistics indicates the presence of 5 cointegrating equations during the precrisis sample period.

Similarly Table 4 displays results of the trace statistics and maximum eigenvalue statistics during the sample period of COVID-19 crisis, i.e. from 11th March, 2020 to 11th June, 2020. Trace statistics suggests the presence of 5 cointegrating equations and maximum eigen value shows the existence of 4 cointegrating equations.

Table 5 represents indicates of the trace statistics and maximum eigenvalue statistics during the sample period of post COVID-19 crisis, i.e. from 11th March, 2021 to 11th June,

Number of cointegrating relations	Eigenvalue	Trace Statistic	0.05 Critical value	Prob.**	Max-eigen Statistic	0.05 Critical value	Prob.**
None *	0.782461	406.6155	239.2354	0.0000	97.62404	64.50472	0.0000
At most 1 *	0.649216	308.9914	197.3709	0.0000	67.04540	58.43354	0.0058
At most 2 *	0.608451	241.9460	159.5297	0.0000	60.00920	52.36261	0.0069
At most 3 *	0.558575	181.9368	125.6154	0.0000	52.33589	46.23142	0.0099
At most 4 *	0.510236	129.6009	95.75366	0.0000	45.68523	40.07757	0.0106
At most 5 *	0.348686	83.91570	69.81889	0.0025	27.44090	33.87687	0.2405
At most 6 *	0.292359	56.47480	47.85613	0.0063	22.13238	27.58434	0.2137
At most 7 *	0.252901	34.34242	29.79707	0.0140	18.65968	21.13162	0.1071
At most 8 *	0.182305	15.68274	15.49471	0.0468	12.88099	14.26460	0.0817
At most 9	0.042833	2.801745	3.841465	0.0942	2.801745	3.841465	0.0942

Note(s): Trace test indicates 9 cointegrating eqn(s) and max-eigenvalue test indicates 5 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
***p*-values
Source(s): Author's calculations

Table 3.
Johansen test results during pre-COVID-19 period-unrestricted cointegration rank test (Trace and maximum Eigenvalue)

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Number of cointegrating relations	Eigenvalue	Trace Statistic	0.05 Critical value	Prob.**	Max-eigen Statistic	0.05 Critical value	Prob.**
None *	0.762135	356.7044	239.2354	0.0000	90.47122	64.50472	0.0000
At most 1 *	0.623646	266.2332	197.3709	0.0000	61.56521	58.43354	0.0238
At most 2 *	0.585354	204.6680	159.5297	0.0000	55.46085	52.36261	0.0233
At most 3 *	0.533039	149.2071	125.6154	0.0008	47.97506	46.23142	0.0322
At most 4 *	0.448549	101.2321	95.75366	0.0199	37.49771	40.07757	0.0950
At most 5 *	0.322033	63.73434	69.81889	0.1389	24.48540	33.87687	0.4206
At most 6 *	0.286191	39.24894	47.85613	0.2505	21.23982	27.58434	0.2620
At most 7 *	0.175403	18.00912	29.79707	0.5654	12.15022	21.13162	0.5329
At most 8 *	0.063187	5.858904	15.49471	0.7121	4.112110	14.26460	0.8473
At most 9	0.027346	1.746794	3.841465	0.1863	1.746794	3.841465	0.1863

Note(s): Trace test indicates 5 cointegrating eqn(s) and Max-eigenvalue test indicates 4 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
***p*-values
Source(s): Author's calculations

Table 4.
Johansen test results during COVID-19 crisis period-unrestricted cointegration rank test (Trace and maximum Eigenvalue)

Number of cointegrating relations	Eigenvalue	Trace Statistic	0.05 Critical value	Prob.**	Max-eigen Statistic	0.05 Critical value	Prob.**
None *	0.668443	354.1772	239.2354	0.0000	70.65316	64.50472	0.0116
At most 1 *	0.656036	283.5241	197.3709	0.0000	68.30191	58.43354	0.0041
At most 2 *	0.610263	215.2221	159.5297	0.0000	60.30615	52.36261	0.0064
At most 3 *	0.559105	154.9160	125.6154	0.0002	52.41267	46.23142	0.0097
At most 4 *	0.474716	102.5033	95.75366	0.0158	41.20419	40.07757	0.0372
At most 5 *	0.346825	61.29913	69.81889	0.1976	27.25825	33.87687	0.2498
At most 6 *	0.256379	34.04089	47.85613	0.4996	18.95834	27.58434	0.4177
At most 7 *	0.136794	15.08254	29.79707	0.7747	9.414488	21.13162	0.7977
At most 8 *	0.084605	5.668053	15.49471	0.7343	5.657609	14.26460	0.6575
At most 9	0.000163	0.010444	3.841465	0.9183	0.010444	3.841465	0.9183

Note(s): Trace test indicates 5 cointegrating eqn(s) and Max-eigenvalue test indicates 5 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
***p*-values
Source(s): Author's calculations

Table 5.
Johansen test results during post-COVID-19 period-unrestricted cointegration rank test (Trace and maximum Eigenvalue)

2021. Both trace test statistics and maximum eigenvalue test statistics confirms the existence of 5 cointegrating equations.

Table 6 represents shows of the trace statistics and maximum eigenvalue statistics over the most recent sample period, i.e. from 11th March, 2022 to 11th June, 2022. Trace statistics suggests the presence of 4 cointegrating equations and maximum eigen value shows the existence of 3 cointegrating equations.

Presence of cointegrating equation implies the existence of linear combinations among the selected indices. For all the sample periods, null hypothesis for absence of cointegration cannot be rejected on the basis of the trace statistics and maximum eigenvalue statistics. Although trace test statistics and maximum eigenvalue test statistics indicates inconsistent results but the presence of cointegartion during all the sample periods among the selected

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Table 6.
Johansen test results during most recent period-unrestricted cointegration rank test (Trace and maximum Eigenvalue)

Number of cointegrating relations	Eigenvalue	Trace Statistic	0.05 Critical value	Prob.**	Max-eigen Statistic	0.05 Critical value	Prob.**
None *	0.846620	392.7454	239.2354	0.0000	119.9896	64.50472	0.0000
At most 1 *	0.702374	272.7558	197.3709	0.0000	77.56265	58.43354	0.0003
At most 2 *	0.637797	195.1931	159.5297	0.0001	64.99530	52.36261	0.0016
At most 3 *	0.466725	130.1978	125.6154	0.0255	40.23800	46.23142	0.1903
At most 4 *	0.384521	89.95981	95.75366	0.1171	31.06272	40.07757	0.3569
At most 5 *	0.296061	58.89709	69.81889	0.2708	22.46807	33.87687	0.5714
At most 6 *	0.270870	36.42901	47.85613	0.3750	20.21778	27.58434	0.3263
At most 7 *	0.147266	16.21123	29.79707	0.6974	10.19567	21.13162	0.7260
At most 8 *	0.089446	6.015561	15.49471	0.6937	5.996929	14.26460	0.6136
At most 9	0.000291	0.018632	3.841465	0.8913	0.018632	3.841465	0.8913

Note(s): Trace test indicates 4 cointegrating eqn(s) and Max-eigenvalue test indicates 3 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
***p*-values
Source(s): Author's calculations

Asian market indices is confirmed by both the tests. It is also suggested that level of association is not static during different periods and it remains dynamic.

During precrisis period at least 5 linear combinations among the selected indices are being confirmed by both tests. During the crisis period at least 4 linear combinations among the selected indices are being indicated by both trace test and maximum eigenvalue test. During post-crisis period or new normal period 5 cointegrating equations are being confirmed by both test and during the most recent period at least 3 linear combinations were indicated by both the tests. Table 7 shows total number of cointegrating equations indicated by trace statistics and maximum eigenvalue statistics during different study periods.

These results implies that the selected indices are being more associated during precrisis period, the level of cointegration or association reduced slightly during the crisis period, returned back to the original level in the next year and again the level of association was found to be minimum in the subsequent year.

It can be observed that the Asian market indices are generally being associated with each other however during the crisis period the level of association got slightly affected as comparatively less linear combination of cointegrating equations were found during the crisis period. However the dynamic cointegrating relationship among the indices in different years suggests that COVID-19 crisis cannot be the sole reason for the changed cointegrating relationship among the indices and the level of association between the selected indices is dynamic and not static or constant for different years.

Table 7.
Total number of cointegrating equations indicated by trace statistics and maximum eigenvalue statistics during different study periods

Time period	Unrestricted cointegration rank test (trace)	Unrestricted cointegration rank test (maximum eigen value)
Period-I (Pre-COVID-19 period)	9	5
Period-II (COVID-19 period)	5	4
Period-III (Post-COVID-19 period)	5	5
Period-IV (Most recent period)	4	3

Source(s): Author's calculations

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During the last two decades, the integration of the financial markets has been greatly influenced by various factors like globalization, liberalization, digitalization, technological advancements, reduced trade and investment barriers etc. The cross nations trade and international capital flows also changes during pandemic periods and the financial sectors always remains vulnerable to the crises. This study has found dynamic relationship among the Asian markets which remains unaffected by the pandemic as well. It implies that the long run dynamic relationship of the Asian markets cannot be solely due to COVID-19 pandemic and various other factors like trading relations among the nations or other macro or micro economic factors of the nations may be the reason behind this dynamism.

The empirical results of this study confirm the relationship of cointegration among the Asian market indices over different sample periods. The presence of cointegration suggests that there is no or very less opportunity for the investors to obtain benefits from the investment diversification among the considered stock markets.

5. Conclusion

The study has examined the cointegrating relationships among Asian stock market indices from pre-COVID-19 to post-COVID-19 time period. Using the Johansen cointegration methodology, the cointegrating relationship among the stock indices of Hong Kong, Indonesia, Malaysia, Korea, India, Japan, China, Taiwan and Israel was empirically examined. The findings have confirmed the presence of cointegrating relationships among the selected Asian stock market indices during different sample periods. Ratio of confirmed cointegrating equations among all the selected Asian stock indices was found to be 5:4:5:3 during pre-COVID-19 period, COVID-19 period, post-COVID-19 period and most recent period respectively. Significant evidence indicating the presence of long term cointegrating relationship has been confirmed by both trace test statistics and maximum eigenvalue test statistics during all the sample periods. It is revealed that in general the Asian stock markets are associated, during COVID-19 crisis period the cointegration level was reduced and again it regained its original level in the next year and again reduced in the subsequent next year. So, the cointegrating relationship among the selected stock market indices remains dynamic and no evidence of impact of COVID-19 on this dynamism was found. The results of the study would provide relevant implications for policymakers of countries affected by COVID-19 in framing the strategies for reviving the performances of stock markets. The results would also be relevant for the investors willing to understand the nature of linkages shared by selected Asian markets. The present study has only considered stock markets of Asian region, the cointegration level among different stock markets of other continents may also be examined in future. Moreover, this study has confirmed the presence of association among the selected Asian markets, it may be extended by applying other multivariate analysis techniques such as vector error correction model and impulse response in future.

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