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

Reetika Verma

*Department of Financial Administration, Central University of Punjab, Bathinda, India*

## 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.

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.
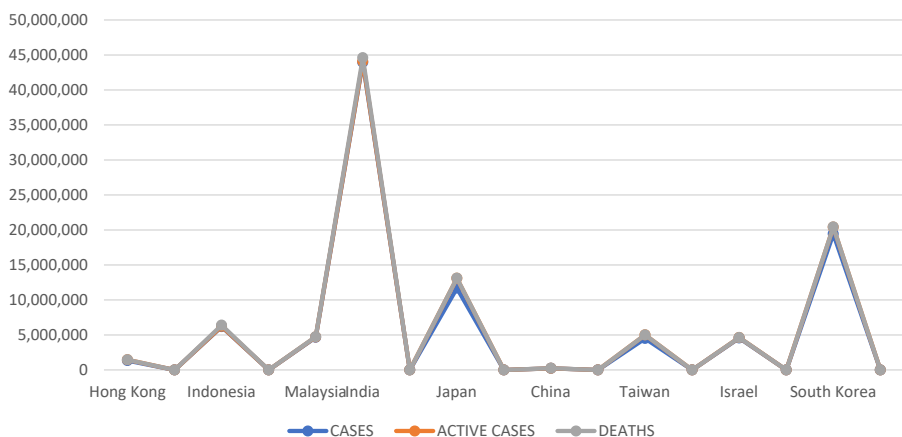


**Figure 1.**
Total cases, active cases and deaths caused by COVID-19 in selected Asian nations as of 28 July, 2022

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

## 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, &

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

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

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

| INDEX | | 2019 ADJ.T-stat | Prob | 2020 ADJ.T-stat | Prob | 2021 ADJ.T-stat | Prob | 2022 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 (−3.534868) | 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 | −0.880798 (−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)*

| | | 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 (−3.533204) | 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

Table 2.

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 |

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

**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

| 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

| 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

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

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.

| 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

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

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.

## References

Al-Awadhi, A. M., Alsaifi, K., Al-Awadhi, A., & Alhammadi, S. (2020). Death and contagious infectious diseases: Impact of the COVID-19 virus on stock market returns. *Journal of Behavioral and Experimental Finance*, *27*, 100326.

Ansotegui, C., & Esteban, M. V. (2002). Cointegration for market forecast in the Spanish stock market. *Applied Economics*, *34*(7), 843–857.

Bhardwaj, N., Sharma, N., & Mavi, A. K. (2022). Impact of COVID-19 on long run and short run financial integration among emerging Asian stock markets. *Business, Management and Economics Engineering*, *20*(2), 189–206.

Boamah, N. A. (2017). The global financial market integration of selected emerging markets. *International Journal of Emerging Markets*, *12*(4), 683–707.

Chong, L., Drew, M., & Veeraraghavan, M. (2003). Stock market interdependence: Evidence from Australia. *Pacific Accounting Review*, *15*(2), 51–76.

Das, A., & Gupta, A. (2022). Comovement of stock markets after the first COVID wave: A study into five most affected countries. *IIM Ranchi Journal of Management Studies*.

Deo, M., & Prakash, P. A. (2017). A study on integration of stock markets: Empirical evidence from national stock exchange and major global stock markets. *ICTACT Journal on Management Studies*, *3*(2), 479–485.

Fernandez-Perez, A., Gilbert, A., Indriawan, I., & Nguyen, N. H. (2021). COVID-19 pandemic and stock market response: A culture effect. *Journal of Behavioral and Experimental Finance*, *29*, 100454.

Gilmore, C. G., & McManus, G. M. (2004). The impact of NAFTA on the integration of the Canadian, Mexican, and US equity markets. In *North American economic and financial integration*. Vol. 10 (pp. 137-151). Emerald Group Publishing.

Granger, C. J. (1986). Developments in the study of cointegrated economic variables. *Oxford Bulletin of Economics and Statistics*, *48*(3), 213–228.

Gulzar, S., Mujtaba Kayani, G., Xiaofen, H., Ayub, U., & Rafique, A. (2019). Financial cointegration and spillover effect of global financial crisis: A study of emerging asian financial markets. *Economic Research-Ekonomska Istraživanja*, *32*(1), 187–218.

Habiba, U. E., Peilong, S., Zhang, W., & Hamid, K. (2020). International stock markets integration and dynamics of volatility spillover between the USA and South Asian markets: Evidence from global financial crisis. *Journal of Asia Business Studies*, *14*(5), 779–794.

Huang, B. N., & Fok, R. C. (2001). Stock market integration-an application of the stochastic permanent breaks model. *Applied Economics Letters*, *8*(11), 725–729.

Johansen, S. (1988). Statistical analysis of cointegration vectors. *Journal of Economic Dynamics and Control*, *12*(2-3), 231–254.

Kasa, K. (1992). Common stochastic trends in international stock markets. *Journal of Monetary Economics*, *29*(1), 95–124.

Komariah, S., Mulyani, I. S., Afriandi, F., Indriani, P., & Septiana, A. E. (2022). Stock exchange cointegration in developed and developing countries in Asia during the covid-19 pandemic. *Review of International Geographical Education Online*, *12*(1), 674–682.

Kumari, S., & Jain, V. (2021). Integration between South East Asian stock markets before and during the occurrence of covid-19. *Ilkogretim Online*, *20*(1), 2065–2074.

Liu, X., Song, H., & Romilly, P. (1997). Are Chinese stock markets efficient? A cointegration and causality analysis. *Applied Economics Letters*, *4*(8), 511–515.

Liu, M., Choo, W. C., & Lee, C. C. (2020). The response of the stock market to the announcement of global pandemic. *Emerging Markets Finance and Trade*, *56*(15), 3562–3577.

Mukhopadhyay, D. (2022). Economic contagion of COVID-19 pandemic on international stock markets: A study based on cointegration approach with selected countries. *Vision*, 09722629221087375.

Panda, A. K., & Nanda, S. (2017). Market linkages and conditional correlation between the stock markets of South and Central America. *Journal of Financial Economic Policy*, *9*(02), 174–197.

Papavassiliou, V. G. (2014). Equity market integration: The new emerging economy of Montenegro. *Review of Accounting and Finance*, *13*(3), 291–306.

Parker, M. E., & Rapp, T. (1998). An empirical investigation of the comovement between stock market indexes. *Studies in Economics and Finance*, *19*(1/2), 108–122.

Roy, A. S., & Sen, S. S. (2019). Co-Movement and Co-integration: A study on nifty, dow jones, and N225. In *The Gains and Pains of Financial Integration and Trade Liberalization* (pp. 169–181). Emerald Publishing.

Salisu, A. A., Sikiru, A. A., & Vo, X. V. (2020). Pandemics and the emerging stock markets. *Borsa Istanbul Review*, *20*, S40–S48.

Seth, N., & Sharma, A. K. (2015). International stock market efficiency and integration: Evidences from asian and US markets. *Journal of Advances in Management Research*.

Song, G., Xia, Z., Basheer, M. F., & Shah, S. M. A. (2021). Co-Movement dynamics of US and Chinese stock market: Evidence from COVID-19 crisis. *Economic Research-Ekonomska Istraživanja*, *35*(1), 2460–2476.

Taylor, M. P., & Tonks, I. (1989). The internationalisation of stock markets and the abolition of UK exchange control. *The Review of Economics and Statistics*, 332–336.

Thomas, N. M., Kashiramka, S., & Yadav, S. S. (2017). Dynamic linkages among developed, emerging and frontier capital markets of Asia-Pacific region. *Journal of Advances in Management Research*, *14*(3), 332–351.

Topcu, M., & Gulal, O. S. (2020). The impact of COVID-19 on emerging stock markets. *Finance Research Letters*, *36*, 101691.

Verma, R. P., & Rani, P. (2016). Emerging stock market integration in the post financial crises era: An empirical analysis of the short-term and long-term linkages. *Emerging Economy Studies*, *2*(1), 91–109.

Vo, X. V., & Daly, K. J. (2005). International financial integration: An empirical investigation into asian equity markets pre-and post-1997 asian financial crisis. In *Asia Pacific financial markets in comparative perspective: Issues and implications for the 21st century* (pp. 75–100). Emerald Group Publishing Limited.

Yang, F. (2012). A note on cointegration methodology in studying stock markets integration. *Applied Economics Letters*, *19*(16), 1583–1586.

Zhang, P., Gao, J., & Li, X. (2021). Stock liquidity and firm value in the time of COVID-19 pandemic. *Emerging Markets Finance and Trade*, *57*(6), 1578–1591.

**Further reading**

Al-Qudah, A. A., & Houcine, A. (2021). Stock markets' reaction to COVID-19: Evidence from the six WHO regions. *Journal of Economic Studies*, *49*(2), 274–289.

Aloy, M., Boutahar, M., Gente, K., & Péguin-Feissolle, A. (2013). Long-run relationships between international stock prices: Further evidence from fractional cointegration tests. *Applied Economics*, *45*(7), 817–828.

Bahrini, R., & Filfilan, A. (2020). Impact of the novel coronavirus on stock market returns: Evidence from GCC countries. *Quantitative Finance and Economics*, *4*(4), 640–652.

Caporale, G. M., Gil-Alana, L. A., & Orlando, J. C. (2016). Linkages between the US and European stock markets: A fractional cointegration approach. *International Journal of Finance & Economics*, *21*(2), 143–153.

Chang, C. P., Feng, G. F., & Zheng, M. (2021). Government fighting pandemic, stock market return, and COVID-19 virus outbreak. *Emerging Markets Finance and Trade*, *57*(8), 2389–2406.

Chen, M. P., Lee, C. C., Lin, Y. H., & Chen, W. Y. (2018). Did the SARS epidemic weaken the integration of asian stock markets? Evidence from smooth time-varying cointegration analysis. *Economic Research-Ekonomska Istraživanja*, *31*(1), 908–926.

Harjoto, M. A., Rossi, F., & Paglia, J. K. (2021). COVID-19: Stock market reactions to the shock and the stimulus. *Applied Economics Letters*, *28*(10), 795–801.

Hung, D. V., Hue, N. T. M., & Duong, V. T. (2021). The impact of COVID-19 on stock market returns in Vietnam. *Journal of Risk and Financial Management*, *14*(9), 441.

Huo, X., & Qiu, Z. (2020). How does China's stock market react to the announcement of the COVID-19 pandemic lockdown?. *Economic and Political Studies*, *8*(4), 436–461.

Kanas, A. (1998). Linkages between the US and European equity markets: Further evidence from cointegration tests. *Applied Financial Economics*, *8*(6), 607–614.

Liu, H., Manzoor, A., Wang, C., Zhang, L., & Manzoor, Z. (2020). The COVID-19 outbreak and affected countries stock markets response. *International Journal of Environmental Research and Public Health*, *17*(8), 2800.

Madhavan, V. (2017). How interrelated are MIST equity markets with the developed stock markets of the world?. *Cogent Economics & Finance*, *5*(1), 1362822.

Mishra, P. K., & Mishra, S. K. (2021). COVID-19 pandemic and stock market reaction: Empirical insights from 15 asian countries. *Transnational Corporations Review*, *13*(2), 139–155.

Orhun, E. (2021). The impact of COVID-19 global health crisis on stock markets and understanding the cross-country effects. *Pacific Accounting Review*, *33*(1), 142–159.

Pojanavatee, S. (2014). Cointegration and causality analysis of dynamic linkage between stock market and equity mutual funds in Australia. *Cogent Economics & Finance*, *2*(1), 918855.

Rahman, M. A., Khudri, M. M., Kamran, M., & Butt, P. (2021). A note on the relationship between COVID-19 and stock market return: Evidence from South Asia. *International Journal of Islamic and Middle Eastern Finance and Management*, *15*(2), 359–371.

Rahman, M. L., Amin, A., & Al Mamun, M. A. (2021). The COVID-19 outbreak and stock market reactions: Evidence from Australia. *Finance Research Letters*, *38*, 101832.

Seabra, F. (2001). A cointegration analysis between Mercosur and international stock markets. *Applied Economics Letters*, *8*(7), 475–478.

Shankar, R., & Dubey, P. (2021). Indian stock market during the COVID-19 pandemic: Vulnerable or resilient?: Sectoral analysis. *Organizations and Markets in Emerging Economies*, *12*(1), 131–159.

Shen, C. H., Chen, C. F., & Chen, L. H. (2007). An empirical study of the asymmetric cointegration relationships among the Chinese stock markets. *Applied Economics*, *39*(11), 1433–1445.

Wu, W., Lee, C. C., Xing, W., & Ho, S. J. (2021). The impact of the COVID-19 outbreak on Chinese-listed tourism stocks. *Financial Innovation*, *7*(1), 1–18.

**Corresponding author**
Reetika Verma can be contacted at: reetikaverma20@gmail.com