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# Covid-19, Structural Breaks, and Capital Market Integration: Indonesian Evidence

**Iman Sofian Suriawinata*, Pristina Hermastuti Setianingrum, Doddi Prastuti, Devvy Rusli, Diah Pranitasari**
Sekolah Tinggi Ilmu Ekonomi Indonesia Jakarta
Jl. Kayu Jati Raya No. 11A, Jakarta Timur, Indonesia
* iman.suriawinata@stei.ac.id

***Abstract–*** *The main purpose of this study is to investigate the cointegration between the Indonesian capital market and the selected four international capital markets – namely the Australian Stock Exchange, the New York Stock Exchange, the London Stock Exchange, and the Hong Kong Stock Exchange - with the presence of two structural breaks due to the COVID-19 pandemic. The non-standard Johansen's, as well as the ARDL methods of cointegration analyses, are applied to five capital market indices - consisting of the Jakarta Stock Exchange Composite Index (JSCI), ASX200, Dow Jones Composite Average (DJC), FTSE 100, and Han Seng Index (HSI) - from January 2019 to December 2020. VEC and ARDL models are employed to investigate the impact of structural breaks on Indonesia's capital market performance. The results show that there are cointegration and long-run causality relationships between the Indonesian capital market and the four international capital markets during the pandemic, and the structural breaks significantly affect market performance. The COVID-19 pandemic has had a devastating global impact on capital markets, but an effective policy response by the Indonesian government might contribute to the relatively rapid recovery of Indonesia's capital market.. There are two important implications relating to the findings of this study. Firstly, as capital markets around the world become more integrated, the benefit of international portfolio diversification decreases. However, stock price efficiency among capital markets increases. Secondly, the results of the Granger causality test might be useful for capital market investors in predicting the impact of the performance of one capital market on the performance of other capital markets.*

***Keywords:*** *COVID-19, cointegration, structural breaks, world capital market indices*

## I. INTRODUCTION

The COVID-19 disease has a devastating global impact on virtually all sectors of the social and economic life of the world society, including global capital markets. According to Baker et al. (2020), the COVID-19 pandemic has the most forceful unprecedented infectious disease-related impact on the US capital market. However, the same claim could also be true regarding the impact of COVID-19 on other capital markets around the world. As an illustration, from January 2020 to March 2020, three months since the outbreak of COVID-19 disease, the Dow Jones Composite Average (DJC) index fell by 23.6%, the Jakarta Stock Exchange Composite Index (JSCI) fell by 27.8%, the Financial Times Stock Exchange

100 (FTSE 100) index fell by 25.4%, the Deutscher Aktien (DAX) index fell by 25.8%, the Euro Stoxx 50 (STOXX50E) index fell by 26.6%, the Nikkei 225 index fell by 18.5%, the Han Seng Index (HSI) fell by 18.8%, and last but not least the Australian Stock Exchange 200 (ASX 200) index fell by 24.1%. Except for the Nikkei 225 and HSI indices, all the remaining stock market indices mentioned before fell in the neighborhood of 23% to almost 28%, indicating the severity of the COVID-19 impact on the performance of major world capital markets.

Recently, there are growing interest from financial scholars to study the impact of COVID-19 as a new empirical research area. For example, many studies have been conducted to analyze the impact of COVID-19 on capital markets and equity prices (e.g. Ashraf, 2020; Au Yong & Laing, 2021; Baker et al., 2020; Huang & Liu, 2021; Ibrahim et al., 2020; Kusumahadi & Permana, 2021; Li et al., 2021; Orhun, 2020; Rahmani, 2020; Singh & Shaik, 2021), portfolio risk management (e.g. Adekoya et al., 2021; Conlon et al., 2020; Conlon & McGee, 2020; Himanshu et al., 2021; Kartal et al., 2021; Mezghani et al., 2021), and capital markets integration (e.g. Kusumah et al., 2021; Pardal et al., 2020; Yarovaya et al., 2020).

Ashraf (2020) finds that stock markets respond negatively to the growth in COVID-19 confirmed cases, as evidenced by a decline in stock market returns when the number of confirmed cases increased. Similarly, by applying the standard event study methodology on a sample consisting of eleven stock markets from certain top affected countries – i.e. Belgium, China, France, Germany, Italy, The Netherlands, South Korea, Spain, Switzerland, United Kingdom, and the United States, Ibrahim et al. (2020) find that the COVID-19 case announcement had a significant negative impact on the stock returns, and the effect was more substantial after the announcement by WHO that COVID-19 disease is a global pandemic. Nevertheless, these two findings reflect the market perception of the potential negative impact of the prolonged and increasing cases of COVID-19 on the economy.

The obvious negative impact of the COVID-19 pandemic on stock returns has stimulated financial scholars to direct their research on finding hedging strategies that could minimize or avoid potential losses in stock investment portfolios due to the pandemic. Research by Adekoya et al. (2021), Himanshu et al. (2021), and Mezghani et al. (2021) claim that market risks associated with stock markets can be effectively hedged by gold during the COVID-19 pandemic period. On the other hand, in examining the widely claimed safe haven properties of cryptocurrencies from the perspective of international equity index investors, Conlon et al. (2020) and Conlon & McGee (2020) show that cryptocurrencies are not safe havens for equity market risks. Furthermore, Conlon & McGee (2020) claim that even a small allocation of cryptocurrencies on an equity portfolio could substantially increase the overall portfolio downside risk.

Another interesting area of research relating to the impact of COVID-19 on the financial sector is its effects on capital markets integration. While capital markets integration reduces the benefits of diversification, on the other hand, it increases price efficiency resulting from the convergence of market risks and prices as well as unhindered capital flows between two and among many capital markets. Market integration is different from market contagion. Although the concepts are related, according to Bekaert et al. (2005), contagion in equity markets refers to the notion that markets move more closely together during periods of crisis. To be more specific, Bekaert et al. (2005) define contagion as the correlation between markets in excess of that implied by economic fundamentals

According to Yarovaya et al. (2020), there are four main drivers that cause market contagion, i.e. : (i) globalization of the world economy, (ii) integration of financial markets, (iii) emergence of new assets classes and markets – such as financial derivatives, commodities and cryptocurrencies, and (iv) an increase in the speed and ease of gathering information about global events that changes the risk perceptions of investors around the world. Undoubtedly, those four drivers have caused the COVID-19 pandemic - regarded as a “black swan” crisis (Yarovaya, Matkovskyy, et al., 2020; Ahmad et al., 2021) - to have a devastating contagion or spill-over effect on capital markets around the world as evidenced by significant declines in major world capital markets’ indices as previously mentioned.

Pardal et al. (2020) examine integration in the Central European capital markets consisting of eight countries in the context of the global COVID-19 pandemic. By applying the cointegration test with a structural break introduced by Gregory & Hansen (1996), they found a significant level of cointegration among Central European capital markets. They also found that significant structural breaks among the eight Central European capital markets occur on March 2020, which was the month when WHO announced COVID-19 as a pandemic.

Using data from 6 developed markets (USA, Australia, Hong Kong, Japan, New Zealand, and Singapore) and 9 emerging markets (China, Indonesia, India, Korea, Malaysia, Pakistan, the Philippines, Thailand, and Taiwan), Kusumah et al. (2021) investigate the time-varying integration of stock markets from a global and regional perspective from January 1991 to May 2021, covering three regional/global crises, i.e., the Asian Financial Crisis, the subprime mortgage, and the COVID-19 pandemic. They concluded that market integrations are time-varying, both globally and regionally. They also found that market integration significantly increased during the Asian Financial Crisis and the subprime mortgage crisis; but sharply declined during the COVID-19 pandemic, especially during the early period of the pandemic.

While there are many studies examining the integration of Indonesia's capital market with other regional as well as global capital markets, currently there exist only a few studies that examine the impact of COVID-19 on the integration of Indonesia's capital market with other capital markets in the world (e.g. Kusumah et al., 2021; Sugiyanto & Robiyanto, 2021; Trihantoro, 2021). This means that there are still many research opportunities on the topic. Moreover, with the pandemic still ongoing, it is possible that new phenomena relating to the impact of COVID-19 on the integration of the world capital markets emerge, making them interesting topics for further investigations.

As another contribution to the literature, the objective of the present study is to investigate the integration and the Granger causality relationships of the Indonesia Stock Exchange with other four major capital markets - namely the Australian Securities Exchange (ASX), the New York Stock Exchange (NYSE), the London Stock Exchange (LSE), and the Hong Kong Stock Exchange (HKG) – from the period of January 2019 to December 2020, covering approximately one year before and one year after the outbreak of COVID-19 disease became known to the world. These capital markets are selected because they are among the 15 largest stock exchanges in the world in 2020, and they also represent certain regional economies outside the ASEAN region which capital markets' integration has been extensively studied (e.g. Karim & Karim, 2012; Kaluge, 2016; Lee & Jeong, 2016; Guesmi et al., 2017; Abdul Karim & Abdul-Rahman, 2020; and Robiyanto et al., 2021). ASX, LSE, and HKG are selected because they represent the Australian, Europe, and East Asia capital markets, respectively. While the NYSE is selected because it represents the North American capital markets as well as it is the largest capital market in the world, whereas its market capitalization is approximately 56.6% of the total remaining 14 largest capital markets in the world.

Unlike other previous studies on the topic, the present study intends to analyze the impacts of the COVID-19 pandemic on the integration and performance of Indonesia's capital market with the presence of multiple structural breaks. The structural breaks occurred on two known dates assumed to be important with regard to: (i) when the COVID-19 disease became publicly known by the world community, and (ii) when the Indonesia Stock Exchange began to recover as a positive response to the Indonesia government's policies and their implementations in mitigating the impacts of COVID-19 towards the health and well-being of its citizen as well as the national economy.

The cointegration analysis will be conducted by employing both the Vector Error Correction Model (VECM) and the Autoregressive Distributed Lag (ARDL) Model taking into account the presence of multiple structural breaks that are presumably caused by the COVID-19 pandemic. Until recently, the VECM model is the standard method to investigate the long- and short-run relationships among nonstationary variables (Lütkepohl, 2005), such as capital market indices. However, the VECM procedure is restricted to time series data with the same degree of integration, i.e. all I(1) variables. On the other hand, the ARDL model as an alternative to the standard cointegration analysis (Pesaran, 2021; Pesaran & Shin, 1998), can be used to investigate the relationships among variables with different degrees of integration, i.e. mixed of I(0) and I(1) variables. In other words, while other cointegration techniques – such as Johansen's cointegration test (Johansen, 1991, 1995) - require that all of the regressors to be integrated of the same order, the ARDL can be applied whether the regressors are I(1) and/or I (0). Other advantages of applying the ARDL model is that it is more robust and performs better for small sample size (Latif et al., 2015; Menegaki, 2019), and it can be used as an alternative tool to avoid the spurious regression problem (Ghouse et al., 2018).

To summarise, based on the above discussion, the present study hypothesizes the followings:

**H1**: *There is a presence of multiple structural breaks represented by two known break dates associated with the COVID-19 pandemic on Indonesia's capital market.*

**H2**: *Indonesia's capital market is cointegrated with other four international capital markets, namely ASX, NYSE, LSE, and HKG, amid the presence of multiple structural breaks.*

**H3**: *There are Granger causality relationships between the Indonesia stock exchange and other four international capital markets, namely ASX, NYSE, LSE, and HKG during the period of study.*

## II. METHOD

This study utilizes daily closing market indices data from Indonesia (Jakarta Stock Exchange Composite Index - JSCI), the Australian Securities Exchange (ASX200), the New York Stock Exchange (Dow Jones Composite Average - DJC), the London Stock Exchange (FTSE100), and the Hong Kong Stock Exchange (Han Seng Index - HSI) from the 1st of January 2019 to the 31st of December 2020 with a total number of 432 observations. Those indices are widely reported and commonly used by capital market communities to indicate market performance. The data are obtained from www.investing.com.

To examine the integration of Indonesia's capital market with the other four international capital markets, the present study employs a multivariate cointegration model with the following standard specification:

$$JSCI_t = \beta_0 + \beta_1 ASX200_t + \beta_2 DJC_t + \beta_3 FTSE100_t + \beta_4 HSI_t + \varepsilon_t \quad (1)$$

where $JSCI_t$ is the dependent variable in year t, while $ASX200_t$, $DJC_t$, $FTSE_t$, and $HSI_t$ are the dependent variables in year $t$, $e_t$ is the error term, and $\beta_o$, $\beta_1$, $\beta_2$, $\beta_3$, and $\beta_4$ are the coefficients to be estimated.

Prior to implementing the cointegration test, unit root tests using Augmented Dickey-Fuller (ADF) method are conducted on all of the five capital markets' indices time series. The objective of the unit root test is to test whether the market indices time series being studied are stationary in first difference, that is they are I(1) or integrated of order one.

In analyzing the impact of the COVID-19 pandemic on Indonesia's capital market integration, the present study identified two break dates. The first date is the 2nd of January 2020, which represents the following business date after the COVID-19 disease became publicly known by the world community through a communique on the 31st of December 2019 between the WHO's Country Office in the People's Republic of China and the International Health Regulations (IHR) about the outbreak of cases of viral pneumonia caused by a virus currently known as SARS-CoV-2 (COVID-19 virus). The second date is the 26th of March 2020, which represents the date when JSCI began to recover after it hit its lowest value on the 24th of March 2020. This study believes that the Presidential Decree No. 7 of 2020 dated the 13th of March 2020 concerning the Task Force for the Acceleration of the Handling of Covid-19 Disease and later amended by the Presidential Decree of the Republic of Indonesia Number 9 of 2020 dated the 20th of March 2020, play an important role in restoring the confidence of capital market community about the prospect of the national economy amid the ongoing COVID-19 pandemic.

To test the statistical significance of the above break dates, the present study uses the Chow break-point test with known break dates, and also complemented with the Bai-Perron multiple break test with unknown break dates. As for the purpose of cointegration analysis, the present study utilizes the Johansen et al. (2000) and Joyeux (2007) methods by using a program routine developed by Giles & Godwin (2012). Additional analysis of unconditional correlation and the Granger causality test during the period of study is also provided.

Due to its advantage in interpreting the long-run and short-run relationships between and among variables being studied, the present study uses VECM in modeling the relationship between the Indonesia stock market with the other four international capital markets. Basically, VECM is a representation of cointegrated VAR that accounts for the intertwined dynamics of time series data. The VECM can generally be expressed as:

$$\beta_{y0} + \beta_{y1}\Delta y_{t-1} + \ldots + \beta_{yp}\Delta y_{y-p} + \gamma_{y1}\Delta x_{t-1} + \ldots + \gamma_{y-p}\Delta x_{t-p} + \delta_y (y_{t-1} - \alpha_0 - \alpha_1 x_{t-1}) + \omega_t^y \quad (2)$$

$$\beta_{x0} + \beta_{x1}\Delta y_{t-1} + \ldots + \beta_{xp}\Delta y_{y-p} + \gamma_{x1}\Delta x_{t-1} + \ldots + \gamma_{x-p}\Delta x_{t-p} + \delta_x (y_{t-1} - \alpha_0 - \alpha_1 x_{t-1}) + \omega_t^x \quad (3)$$

where the $y_t = \alpha_0 - \alpha_1 x_t$ is the long-run cointegrating relation existing between variable *y* and vvariable*x*, while $\delta_y$ and $\delta_x$ are the error correction coefficients which measure the reaction of *y* and *x* in response to the cointegrating error of $y_{t-1} - \alpha_0 - \alpha_1 x_{t-1} = \varepsilon_{t-1}$ (Hill et al., 2018), which represents a deviation from the long-run equilibrium.

For comparison purposes, the present study also employs the Autoregressive Distributed Lag (ARDL) model, which specifies that the value of the dependent variable *y* depends on the lagged values of itself, the current value of the independent variable(s) *x*, as well as the lagged values of the independent variable(s) *x*. Following (Hill et al., 2018), the general specification of the ARDL model is:

$$\delta_0 + \theta_1 y_{t-1} + \ldots + \theta_p y_{t-p} + \delta_1 x_t + \cdots + \delta_q x_{t-q} + \varepsilon_t \quad (4)$$

The model in Equation (4) is an ARDL(*p*,*q*), which contains *p* lags of *y*, the current value of *x*, and *q* lags of *x*. According to Pesaran & Shin (1998) and Pesaran et al. (2001), the ARDL model coupled with bounds testing procedures could be utilized for the analysis and testing of the long-run level relationship between a dependent variable and a set of dependent variables irrespective of whether the underlying dependent variables are integrated of order one – which are I(1), or integrated of order zero – which are I(0).

The hypotheses being tested in this study are: (1) whether there are structural breaks that potentially affect the performance of the Indonesia stock market, (2) whether there is a cointegration relationship between the Indonesia stock market with the four international capital markets - as represented by the relationships of the respective market indices – by taking into consideration the impacts of the structural breaks associated with the COVID-19 pandemic, and (3) whether there are Granger causality relationships between the Indonesia stock exchange and each respective international capital markets during the period under study.

## III. RESULTS AND DISCUSSION

**Descriptive Statistical Analysis**. Table 1 presents the descriptive analysis of 432 observations from the respective market indices time series. Four variables (JSCI, ASX200, DJC, and FTSE100) exhibit a moderate left-tail or negative skewness (between -1.0 and -0.5), which means that the mean and median are less than the mode. On the other hand, with a skewness level of -0.0724, it can be said that the data distribution of HSI is relatively symmetrical (between -0.5 and 0.5). JSCI, FTSE100, and HSI exhibit platykurtic distribution, while ASX200 and DJC exhibit leptokurtic distribution.

The results of the Jarque-Bera test statistic in Table 1 show that the data series of ASX200 are normally distributed, while the remaining four variables reject the null hypothesis that the series is normally distributed at a 1% level of significance.

**Table 1.** Descriptive Statistic

| Statistic | JSCI | ASX200 | DJC | FTSE100 | HSI |
|---|---|---|---|---|---|
| Mean | 5776 | 6286 | 8801 | 6784 | 26461 |
| Median | 6109 | 6325 | 8828 | 7129 | 26498 |
| Maximum | 6541 | 7163 | 10081 | 7687 | 30157 |
| Minimum | 3938 | 4536 | 6100 | 4994 | 21696 |
| Std. Dev. | 661 | 488 | 687 | 668 | 1767 |
| Skewness | -0.7016 | -0.7559 | -0.7071 | -0.5207 | -0.0724 |
| Kurtosis | 2.1154 | 3.3702 | 4.1506 | 1.9413 | 2.3232 |
| Jarque-Bera | 6.4121 | 2.0038 | 19.3631 | 27.8447 | 6.6496 |
| Probability | 0.0405 | 0.3671 | 0.0000 | 0.0000 | 0.0359 |
| Observations | 432 | 432 | 432 | 432 | 432 |

Figure 1 shows the trend of all indices, and it can be seen that all indices exhibit sharp falls during the period of January 2020 till the end of March 2020, signifying the impact of COVID-19 on the capital markets being studied. However, since April 2020 all capital market indices show a gradual recovery as evidenced by the upward trends of all the market indices being studied. It is worth mentioning that after reaching its lowest value of 3937.63 at the end of March 2020, the JSCI rebounds to 5979.07 at the end of December 2020, representing an increase of 51.84% over nine months after it hits its lowest value. Effective policy responses by the Government of Indonesia might contribute to the relatively rapid recovery of Indonesia's capital market.


**Figure 1.** Trend of Capital Market Indices (January 2019 – December 2020)

**Unit root test**. In order to avoid the problem of spurious regression, unit root tests are performed to ensure that the time series data are stationary. Based on the results of the ADF test statistic reported in Table 2, it can be concluded that all capital market indices are non-stationary at level, but they are stationary at first difference.

However, since all the graphs in Figure 1 exhibit some sort of breaks around January 2020, additional analyses are provided to ensure that the variables used in this study are stationary, at least at the first difference level. Perron (1989) shows that the standard tests of the unit root hypothesis cannot reject the null hypothesis of nonstationary if the data series contains a one-time break. Therefore, using endogenously determined break dates based on minimum Dickey-Fuller t-statistic criteria, Table 2 also reports the results of unit root tests with breakpoints. The results show that all the data series are stationary at the first difference level after taking into account the breakpoints.

**Table 2.** Unit root test of Augmented Dickey-Fuller (ADF)

| VARIABLE | ADF test statistic | | | | | |
|---|---|---|---|---|---|---|
| | Level | | 1st Difference (No breakpoint) | | 1st Difference (With breakpoint) | |
| | t-value | probability | t-value | probability | t-value | probability |
| JSCI | -1.1741 | 0.6869 | -19.6272* | 0.0000 | -20.4767* | 0.0000 |
| ASX200 | -2.6130 | 0.0911 | -5.2887* | 0.0000 | -26.0798* | 0.0000 |
| DJC | -2.0020 | 0.2861 | -13.9512* | 0.0000 | -26.1932* | 0.0000 |
| FTSE100 | -1.4398 | 0.5632 | -21.1887* | 0.0000 | -22.7546* | 0.0000 |
| HSI | -2.0486 | 0.2661 | -21.4507* | 0.0000 | -22.2155* | 0.0000 |

*) Significant at 5%

**Break-dates Test**. The present study believes that the 2nd of January 2020 and the 26th of March 2020 are two important dates surrounding the COVID-19 pandemic that caused structural breaks in the Indonesia capital market index (JSCI) time series data. To test the statistical significance of those two dates, the present study employs: (i) the Chow break points test with known dates, and (ii) the Bai-Perron multiple breakpoints test with unknown dates. Table 3 reports the results.

**Table 3.** Break-Dates Test on JSCI Time-Series Data

**A. Chow Breakpoint Test: 1/02/2020 and 3/26/2020**

| | | | |
|---|---|---|---|
| F-statistic | 123.5926 | Prob. F(10,417) | 0.0000 |
| Log likelihood ratio | 594.9572 | Prob. Chi-Square(10) | 0.0000 |
| Wald Statistic | 1235.926 | Prob. Chi-Square(10) | 0.0000 |

**B. Bai-Perron tests of L+1 vs. L globally determined breaks**

| Break Test | F-statistic | Scaled F-statistic | Critical Values** |
|---|---|---|---|
| 0 vs. 1 | 6.2556 | 6.2556 | 8.58 |
| **1 vs. 2 *** | 12.5469 | 12.5469 | 10.13 |
| 2 vs. 3 | 1.3976 | 1.3976 | 11.14 |
| 3 vs. 4 | 0.2140 | 0.2140 | 11.83 |
| 4 vs. 5 | 0.0000 | 0.0000 | 12.25 |

* Significant at 5%
** Bai-Perron critical values

Estimated break dates:
1: 3/26/2020
***2: 12/09/2019, 3/26/2020***
3: 12/09/2019, 3/26/2020, 7/17/2020
4: 5/20/2019, 12/09/2019, 3/26/2020, 7/17/2020
5: 5/08/2019, 8/23/2019, 12/09/2019, 3/26/2020, 7/17/2020

Based on Chow multiple-breakpoint test (Table 3 Panel A), the break dates are statistically significant at a 1% level. Similar results are also provided by the Bai-Perron multiple breaks test (Table 3 Panel B) with two statistically significant unknown globally determined break dates. Although the Bai-Perron test method estimated that the 9th of December 2019 be the initial break date, the present study finds it difficult to justify that the break date was related to the COVID-19 disease. While there is the first case of COVID-19 might occur around mid-November 2019, the present study finds it doubtful that the news about the disease would have impacted global capital markets then.

**Cointegration Test with Multiple Breaks**. Since the standard Johansen's cointegration test (Johansen, 1991, 1995) does not take into account the existence of a structural break, while the Gregory & Hansen (1996) method only allows for one structural break, the present study utilizes the Johansen et al. (2000) method of cointegration test in the presence of either known or unknown multiple breaks. Johansen et al. (2000) propose two variants of the trace test for cointegration with structural breaks, i.e. (i) breaks in the linear trend, or (ii) breaks in the constant level of the data. For simplicity, the present study assumes that the breaks are at the constant level, and the corresponding value of the trace test based on

Johansen et al. (2000), Joyeux (2007), and Giles & Godwin (2012) methods is 114.7. Table 4 reports the results of the cointegration rank test with two breaks that are assumed to be at the constant level. Based on the trace test value of 114.7, it can be concluded that there are at most 5 cointegrating equations since r ≤ 5 can not be rejected at a 5% level of significance.

**Table 4.** Cointegration Rank Test with Two Breaks

| Hypothesis | 95% Critical Value | 99% Critical Value | *p*-value |
|---|---|---|---|
| $r = 0$ | 15.6174 | 19.9206 | 0.0000 |
| $r \leq 1$ | 31.2827 | 36.9389 | 0.0000 |
| $r \leq 2$ | 50.5629 | 57.4645 | 0.0000 |
| $r \leq 3$ | 73.6219 | 81.7206 | 0.0000 |
| $r \leq 4$ | 100.6197 | 109.9147 | 0.0039 |
| $r \leq 5$ | 131.4915 | 141.9891 | 0.3170 |

**Correlation Analyses and Granger Causality Test**. In conducting the correlation analyses between JSCI and the four international capital market indices (i.e. ASX200, DJC, FTSE100, and HSI), the present study classifies the periods of analyses into three periods, i.e. (i) all periods covering 01/02/2019 – 12/31/2020, (ii) the period before the COVID-19 disease became known to the world community, covering 01/02/2019 – 12/31/2019, (iii) the period after the disease became known, covering 01/02/2020 – 12/31/2020.

Table 5 reports the correlation analyses, and it is seen that the pair-wise correlations between JSCI and the other four international capital market indices are all positive and statistically significant at a 1% level during all periods, encompassing both before and after the COVID-19 disease became known. Among the four international capital market indices being studied, FTSE100 has the strongest association with JSCI with a rho (*r*) value of 0.9089 and is statistically significant at 1% level.

Interestingly, during the period before COVID-19 disease became known (1/02/2019 to 12/31/2019), JSCI is negatively associated with ASX200 (Australia) and DJC (USA) at 1% level of significance, is positively associated with HSI (China) at 1% level of significance, but not significantly associated with FTSE100 (UK). Considering that this period coincided with the occurrence of the US-China trade war which started around early July 2018 and continued to early 2020, it might be that the trade war affected the directions of capital market correlations between and among the US and China major trading partners during this period.

**Table 5.** Correlation Analysis of JSCI with Other International Market Indices

| | All Period | Before Pandemic | During Pandemic |
|---|---|---|---|
| **Correlation t-Statistic Probability** | **1/02/2019 - 12/31/2020** | **1/02/2019 - 12/31/2019** | **1/02/2020 - 12/31/2020** |
| ASX200 | 0.7008 | -0.4535 | 0.9444 |
| | 20.3704 | -7.4966 | 41.7152 |
| | 0.0000 | 0.0000 | 0.0000 |
| DJC | 0.3555 | -0.3087 | 0.8141 |
| | 7.8874 | -4.7805 | 20.3645 |
| | 0.0000 | 0.0000 | 0.0000 |
| FTSE100 | 0.9089 | -0.0482 | 0.8532 |
| | 45.2042 | -0.7103 | 23.7650 |
| | 0.0000 | 0.4783 | 0.0000 |
| HSI | 0.8705 | 0.5763 | 0.9289 |
| | 36.6686 | 10.3880 | 36.4258 |
| | 0.0000 | 0.0000 | 0.0000 |

More interesting findings are the increased correlation values between JSCI with the other four international capital market indices during the period after COVID-19 became publicly known (1/02/2020 to 12/31/2020) compared to those of before. The pair-wise correlations of JSCI with ASX200 increased from -0.4535 to 0.9444, with DJC increased from -0.3087 to 0.8141, with FTSE100 increased from -0.0482 to 0.8532, and with HSI increased from 0.5763 to 0.9289. All rho (*r*) values are significant at 1%

level. Although an increase in the correlation between capital markets does not necessarily indicate a contagion effect of a crisis (Bekaert et al., 2005), yet it is widely believed that the COVID-19 pandemic has a contagion effect on global capital markets (e.g. Akhtaruzzaman et al., 2021; Iwanicz-Drozdowska et al., 2021; Okorie & Lin, 2021).

The results of the Granger causality test show that there are causality relationships between the Indonesia capital market and the capital markets in Australia (ASX200), the United States (DJC), the United Kingdom (FTSE100), and Hong Kong – China (HSI) as evidenced by the statistically significant (at 1% or 5% levels) F-test results. Table 6 shows that ASX 200 (Australia), DJC (the United States), and FTSE (the United Kingdom) Granger cause the Indonesia capital market index at either 1% or 5% levels of significance. However, the present study finds that JSCI (Indonesia) Granger causes the HSI (Hong Kong) at a 1% level of significance.

**Table 6.** Granger Causality Test

| Null Hypothesis: | Obs | F-Statistic | Prob. | |
|---|---|---|---|---|
| ASX200 does not Granger Cause JSCI | 430 | 3.6066 | 0.0280 | ** |
| JSCI does not Granger Cause ASX200 | | 2.0048 | 0.1360 | |
| DJC does not Granger Cause JSCI | 430 | 14.0849 | 0.0000 | *** |
| JSCI does not Granger Cause DJC | | 0.1609 | 0.8514 | |
| FTSE100 does not Granger Cause JSCI | 430 | 12.4719 | 0.0000 | *** |
| JSCI does not Granger Cause FTSE100 | | 2.2539 | 0.1062 | |
| HSI does not Granger Cause JSCI | 430 | 1.4678 | 0.2316 | |
| JSCI does not Granger Cause HSI | | 5.1852 | 0.0060 | *** |

*, **, and *** mean significant at 10%, 5%, and 1% respectively

**Vector Error Correction Model (VECM)**. Using the optimal lag selected based on Schwarz information criteria and one cointegrating equation, the present study estimates the vector error correction model. Dummy variables *Z200102* and *Z200326* are included in the model, representing the break dates on the 2nd of January 2020 and the 26th of March 2020. Table 7 shows both the long-term and the short-term relationship between JSCI and the other four international capital market indices. During the period of study, ASX200 (Australia) and HSI (Hong Kong – China) have negative long-term relationships with JSCI, and the relationships are statistically significant at a 1% level. On the other hand, DJC (USA) and FTSE100 (UK) have positive long-term relationships with JSCI.

Except for the error correction model of FTSE100, the negative and statistically significant coefficient of the error correction terms (CointEq1) in the error correction models (short-term models) of JSCI, ASX200, DJC, and HSI indicate that there are long-term equilibrium relationships among these four capital markets. That is, the previous period deviation from the long-run equilibrium is corrected in the current period with an adjustment speed equals to the coefficient value of the error correction term of the respective short-term regression of each capital market.

The results of the VECM also confirm that the events surrounding the COVID-19 pandemic have impacted all of the five capital markets being studied, as evidenced by the statistically significant (at 1% or 5% level) of one or both break dates dummy coefficients in the short-run model of the respective capital market regression. The dummy variable *Z200102*, representing the break-date relating to when the COVID-19 disease became publicly known, has a negative effect on JSCI, and the relationship is statistically significant at a 1% level. On the other hand, the dummy variable Z200326, representing the date when JSCI began to recover as a positive response to the Presidential Decree(s) No. 7 of 2020 and No. 9 of 2020 concerning the Task Force for the Acceleration of the Handling of Covid-19 Disease, has a positive effect on JSCI, and the relationship is statistically significant at 1% level.

While the vector error correction model (VECM) employed in this study has provided interesting results, unfortunately - based on the VEC residual serial correlation LM test and the VEC residual heteroskedasticity test, the model suffers from the problems of autocorrelation and heteroskedasticity (not reported here) which potentially biased the statistical inferences made. Unlike some other regression methods, such as OLS and ARDL, currently, there are no convenient standard procedures to handle the problems of autocorrelation and heteroskedasticity in VECM. Therefore, since the problems of autocorrelation and heteroskedasticity have not been properly dealt with, the results of the VECM in this study should be interpreted cautiously.

**Table 7.** Vector Error Correction Model

| Cointegrating Eq: | CointEq1 | | | | |
|---|---|---|---|---|---|
| JSCI(-1) | 1.0000 | | | | |
| ASX200(-1) | 18.0590 *** | | | | |
| | (2.26383) | | | | |
| | [ 7.9771] | | | | |
| DJC(-1) | -6.6203 *** | | | | |
| | (1.12517) | | | | |
| | [-5.8838] | | | | |
| FTSE100(-1) | -16.8093 *** | | | | |
| | (1.73326) | | | | |
| | [-9.6980] | | | | |
| HSI(-1) | 1.7699 *** | | | | |
| | (0.32746) | | | | |
| | [ 5.4048] | | | | |
| C | 6165.8590 | | | | |
| **Error Correction:** | **D(JSCI)** | **D(I_ASX200)** | **D(DJC)** | **D(FTSE100)** | **D(HSI)** |
| CointEq1 | -0.0040 *** | -0.0118 *** | -0.0073 *** | -0.0010 | -0.0219 *** |
| | (0.0013) | (0.0015) | (0.0028) | (0.0018) | -0.0065 |
| | [-3.0407] | [-8.1275] | [-2.6455] | [-0.5446] | [-3.3935] |
| D(JSCI(-1)) | -0.1059 * | -0.0916 | -0.0519 | -0.0855 | -0.3330 |
| | (0.0564) | (0.0626) | (0.1182) | (0.0785) | (0.2784) |
| | [-1.8767] | [-1.4625] | [-0.4388] | [-1.0891] | [-1.1961] |
| D(ASX200(-1)) | -0.0083 | -0.4216 *** | -0.1160 | -0.0853 | -0.4520 * |
| | (0.0498) | (0.0553) | (0.1043) | (0.0693) | (0.24559) |
| | [-0.1676] | [-7.6300] | [-1.1119] | [-1.2311] | [-1.8405] |
| D(DJC(-1)) | 0.0709 ** | 0.0649 * | -0.2258 *** | 0.0777 | 0.3324 * |
| | (0.0345) | (0.0383) | (0.0723) | (0.0480) | (0.1701) |
| | [ 2.0547] | [ 1.6941] | [-3.1253] | [ 1.6195] | [ 1.9536] |
| D(FTSE100(-1)) | 0.0523 | 0.0233 | -0.0701 | -0.0573 | 0.1733 |
| | (0.0570) | (0.0632) | (0.1194) | (0.0793) | (0.2811) |
| | [ 0.9173] | [ 0.3679] | [-0.5873] | [-0.7227] | [ 0.6167] |
| D(HSI(-1)) | -0.0019 | 0.0182 | 0.0191 | -0.0184 | -0.0817 |
| | (0.0126) | (0.0140) | (0.0264) | (0.0175) | (0.0622) |
| | [-0.1527] | [ 1.3008] | [ 0.7245] | [-1.0483] | [-1.3144] |
| Z010220 | -27.2431 *** | -12.6344 | -53.7784 ** | -50.3560 *** | -48.5883 |
| | (11.6305) | (12.9100) | (24.3710) | (16.1874) | (57.3765) |
| | [-2.3423] | [-0.9786] | [-2.2066] | [-3.1108] | [-0.8468] |
| Z032620 | 31.4335 *** | 66.6394 *** | 51.8767 *** | 8.5566 | 121.1419 *** |
| | (9.5009) | (10.5461) | (19.9085) | (13.2234) | (46.8704) |
| | [ 3.30849] | [ 6.3189] | [ 2.6057] | [ 0.6470] | [ 2.5846] |
| C | -9.5459 * | -20.4809 *** | -5.8577 | 2.2544 | -35.4047 |
| | (5.4191) | (6.0153) | (11.3555) | (7.5424) | (26.7341) |
| | [-1.7615] | [-3.4048] | [-0.5158] | [ 0.2989] | [-1.3243] |
| R-squared | 0.1370 | 0.2825 | 0.0946 | 0.0510 | 0.0861 |
| Adj. R-squared | 0.1206 | 0.2688 | 0.0774 | 0.0329 | 0.0688 |

*, **, and *** mean significant at 10%, 5%, and 1% respectively

**Autoregressive Distributed Lag (ARDL) Model.** For comparison purposes, based on Pesaran & Shin (1998) and Pesaran et al. (2001), the present study estimates the ARDL model to examine the cointegration between the Indonesia capital market index (JSCI) and the four international capital market indices (ASX200, DJC, FTSE100, and HSI) using the ARDL bounds testing approach. This approach is relatively new, and at least has two advantages over the standard Johansen's cointegration test. Firstly, Pesaran et al. (2001) claim that the ARDL approach can be applied whether the independent variables are I(1) and/or I(0), and therefore the ARDL approach of cointegration analysis avoids the pre-testing problems associated with the standard cointegration test, which requires that the variables be classified into I(1) or I(0) based on the results of ADF unit root tests. Secondly, the ARDL approach is more reliable for small samples as compared to the standard Johansen's cointegration methodology (Latif et al., 2015; Menegaki, 2019).

Using level data of the respective capital market indices, Table 8 reports the results of the ARDL model with an unrestricted constant and no trend specification, and the Schwarz criterion is employed to select the best model with a result of ARDL(1, 1, 0, 0, 1, 0, 2). Since the results of the diagnostic tests (reported in Table 10) reveal that model also suffers from the problems of autocorrelation and heteroskedasticity as in the VECM, the ARDL model is estimated using the HAC (Newey-West) coefficient covariance matrix to mitigate those problems.

**Table 8.** Autoregressive Distributed Lag (ARDL) Model

| Variable | Coefficient | Std. Error | t-Statistic | Prob.* | |
|---|---|---|---|---|---|
| JSCI(-1) | 0.9644 | 0.0180 | 53.7257 | 0.0000 | *** |
| ASX200 | 0.1570 | 0.0718 | 2.1859 | 0.0294 | ** |
| ASX200(-1) | -0.1507 | 0.0726 | -2.0773 | 0.0384 | ** |
| DJC | 0.0068 | 0.0121 | 0.5636 | 0.5733 | |
| FTSE100 | 0.0307 | 0.0155 | 1.9759 | 0.0488 | ** |
| HSI | 0.0776 | 0.0139 | 5.5831 | 0.0000 | *** |
| HSI(-1) | -0.0752 | 0.0131 | -5.7517 | 0.0000 | *** |
| Z200102 | -37.4919 | 11.2787 | -3.3241 | 0.0010 | *** |
| Z200326 | 283.0738 | 42.7815 | 6.6167 | 0.0000 | *** |
| Z200326(-1) | -28.2704 | 42.2114 | -0.6697 | 0.5034 | |
| Z200326(-2) | -245.0381 | 21.0624 | -11.6338 | 0.0000 | *** |
| C | -167.7961 | 70.5337 | -2.3789 | 0.0178 | ** |
| R-squared | | 0.9936 | AIC | 10.8365 | |
| Adjusted R-squared | | 0.9934 | Schwarz Crit. | 10.9499 | |
| F-statistic | | 5854.0 | H-Q Crit. | 10.8812 | |
| Prob(F-statistic) | | 0.0000 | D-W Stat | 2.0779 | |

*, **, and *** mean significant at 10%, 5%, and 1% respectively

Overall, the results of the ARDL model show that, except for capital market indices from the United States (DJC), almost all of the regression coefficients are statistically significant at a 1% or 5% level. Moreover, the break dates of the 2nd of January 2020 and the 26th of March 2020 have statistically significant coefficients at 1%. The findings of the statistically significant break dates in the Indonesia capital markets index during the period of study using the ARDL model are consistent with the results of the VECM previously discussed. The 2nd of January 2020 break date has a statistically significant negative sign, indicating a negative market perception of the prospect of the economy due to the COVID-19 disease. On the other hand, the 26th of March 2020 break date has a statistically significant positive sign, indicating market confidence in the Indonesian government's policies, programs, and actions in handling the COVID-19 pandemic.

Table 9 presents the results of the ARDL method of cointegration analysis using the F-bound test. Pesaran et al. (2001) develop asymptotic critical values of lower and upper bounds for the F-statistics covering various model specifications relating to the intercept and trend. According to (Pesaran et al. (2001), if the computed F-statistic falls outside the critical value bounds, a conclusive decision regarding the relationship between the dependent variable and the independent variables. To be more specific, if the computed F-statistic is below the critical value of the lower or I(0) bound, then the null hypothesis of no cointegration can not be rejected. On the other hand, if the computed F-statistic is above the critical value of the upper or I(1) bound, then the null hypothesis of no cointegration is rejected in favor of the alternative hypothesis that there is a cointegration between the dependent variable and the independent variables. However, if the F-statistic falls within I(0) and I(1), then the statistical inference would be inconclusive.

The ARDL approach of the cointegration test provided in Table 9 shows that the computed F-statistic with a value 5.22 lies above the critical values of upper or I(1) bounds at 10%, 5%, 2.5%, and 1% level of significance. Therefore, the null hypothesis of no cointegration is rejected in favor of the alternative hypothesis that there is cointegration or long-run relationships among JSCI, ASX200, DJC, FTSE100, and HSI.

**Table 9.** ARDL F-Bounds Test for Cointegration

| Test Statistic | Value | Null Hypothesis: No levels of relationship | | |
|---|---|---|---|---|
| | | Signif. | I(0) | I(1) |
| | | | Asymptotic: n=1000 | |
| F-statistic | 5.22*** | 10% | 2.12 | 3.23 |
| k | 6 | 5% | 2.45 | 3.61 |
| | | 2.50% | 2.75 | 3.99 |
| | | 1% | 3.15 | 4.43 |

*, **, and *** mean significant at 10%, 5%, and 1% respectively

**Diagnostic Tests of the ARDL Model**. To ensure that the statistical inferences derived from the ARDL model are not biased, several diagnostic tests are conducted, and appropriate steps have been taken to correct the problems encountered as described above. Table 10 reports the results of the diagnostic tests on autocorrelation, heteroskedasticity, model specification, and model stability.

**Table 10.** Diagnostic Tests of the ARDL Model

| **A. Breusch-Godfrey Serial Correlation LM Test:** | | | |
|---|---|---|---|
| F-statistic | 3.726269 | Prob. F(2,416) | 0.0249 |
| Obs*R-squared | 7.567769 | Prob. Chi-Square(2) | 0.0227 |
| **B. Breusch-Pagan-Godfrey Heteroskedasticity Test:** | | | |
| F-statistic | 3.887021 | Prob. F(11,418) | 0.0000 |
| Obs*R-squared | 39.90303 | Prob. Chi-Square(11) | 0.0000 |
| Scaled explained SS | 79.33719 | Prob. Chi-Square(11) | 0.0000 |

| **C. Ramsey RESET Test:** | | | |
|---|---|---|---|
| | Value | Df | Probability |
| t-statistic | 0.988724 | 417 | 0.3234 |
| F-statistic | 0.977575 | (1, 417) | 0.3234 |
| Likelihood ratio | 1.006871 | 1 | 0.3157 |

Based on the Breusch-Godfrey Serial Correlation LM test and the Breusch-Pagan-Godfrey Heteroskedasticity test, the ARDL model has autocorrelation and heteroskedasticity problems, where the null hypotheses of no serial correlation and no heteroskedasticity are rejected at 5% and 1% level of significance respectively. As described above, to mitigate these problems, the ARDL model has been estimated using the HAC (Newey-West) coefficient covariance matrix. However, based on the Ramsey RESET test, it can be concluded that the functional form of the ARDL model is correctly specified.

Additionally, to test for the model stability, the present study uses the CUSUM and CUSUM Squares tests. Figure 2 shows the results, and since the plots in the CUSUM and CUSUM squares are within the 5% significance level, it can be concluded that the ARDL model is stable.

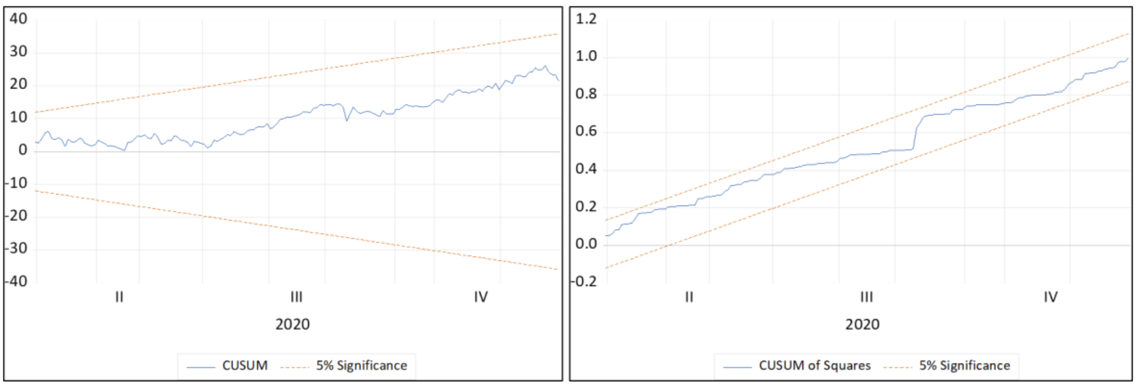


**Figure 2.** CUSUM and CUSUM of Squares from the ARDL Model

## IV. CONCLUSION

By employing two different approaches, i.e. the non-standard Johansen et al. (2000) and the Pesaran et al. (2001) methods of cointegration analysis, the present study finds that there is cointegration between the Indonesia capital market index and the four international capital market indices amid the ongoing COVID-19 pandemic. After taking into consideration the structural breaks relating to the events surrounding the pandemic, the results of the Johansen et al. (2000), Joyeux (2007), and Giles & Godwin (2012) methods of cointegration test indicate that at most there are five cointegrating equations. Based on the Granger causality test, the present study shows that there are long-run causality relationships between the Indonesian capital market and the capital markets in Australia, the United States, the United Kingdom, and Hong Kong – China. Except the Hong Kong (China) capital market, the majority of the nature of relationships are unidirectional towards the Indonesian capital market.

Two important implications relating to the above findings. Firstly, as capital markets around the world become more integrated and correlated, the benefit of international portfolio diversification decreases. However, stock price efficiency among capital markets increases. Secondly, the results of the Granger causality test might be useful for capital market investors in predicting the impact of the performance of one capital market on the performance of other capital markets.

Relating to the COVID-19 pandemic, two important dates causing structural breaks in the Indonesian capital market are identified and tested. The date when the COVID-19 disease became known to the public had a negative impact on the Indonesia capital market index. However, subsequent actions by the Indonesian government might contribute to the successful recovery of capital market confidence amid COVID-19; and as a consequence, the Indonesian capital market has rebounded since the 26th of March 2020. These results are derived from both the VECM and the ARDL model, even though caution should be taken relating to the statistical inferences resulting from the VECM which might be potentially biased due to the problems of autocorrelation and heteroskedasticity. Nevertheless, when the same problems are found and mitigated in the ARDL model, the same conclusions on the significance of the break dates as in the VECM are obtained.

Other limitations worth mentioning are that the present study does not take into account the differences in the legal, political, and economic factors facing each of the capital markets being studied, as well as the policy responses by respective governments in dealing with the COVID-19 pandemic. Ostensibly, all the previously mentioned factors affect the behavior and performance of the capital markets being studied. Therefore, the results of the present study should be interpreted with these limitations.

Since the COVID-19 pandemic is still ongoing, it is recommended that its impact on the financial sector and economy as a whole be investigated to better understand the repercussions of the "black swan phenomena" of the COVID-19 pandemic. Additionally, with the continuous advancement in econometric methods, it is hoped that future research would be able to overcome the problems of inference due to the nature of the data encountered by the present study.

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