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Covid-19 health policy intervention and volatility of Asian capital markets

Ahmed Imran Hunjra a,*, Ploypailin Kijkasiwat b, Murugesh Arunachalam c, Helmi Hammami d

a Department of Business Administration, Ghazi University, Dera Ghazi Khan, Pakistan
b The Faculty of Business Administration and Accountancy, Khon Kaen University, Thailand
c School of Accounting, Finance and Economics, University of Waikato, New Zealand
d Rennes School of Business, Rennes, France

* Corresponding author.
E-mail addresses: ahmedhunjra@gmail.com (A.I. Hunjra), ploypailin@kku.ac.th (P. Kijkasiwat), murugesh@waikato.ac.nz (M. Arunachalam), helmi.hammami@rennes-sb.com (H. Hammami).

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ABSTRACT

The Covid-19 pandemic continues to disturb the global economy and capital markets. Governments across the globe relentlessly enact health policy measures to contain coronavirus and undertake economic relief programs to reduce the impacts on their economies. This paper examines the effects of Covid-19 government health measures on the volatility of capital markets in East Asian economies. The study applies Monte Carlo type simulations to determine stock price volatility over the period when health policy measures were implemented. The findings indicate that different health policy measures have affected investors’ behavior and caused volatility of stock markets. However, there are country-different impacts on the volatility of these capital markets. The findings provide important insights that are useful when reviewing Covid-19 health policy measures to mitigate the impacts on stock markets.

1. Introduction

The impacts of Covid-19 across the globe are severe and still unfolding. In addition to the rise in the number of infections and deaths related to the pandemic, and increase in household poverty (Martin et al., 2020), the economic fallouts include, among others, the decline in gross domestic product, the increase in unemployment, and the loss of thousands of businesses. These economic consequences make stock markets and oil prices more volatile (Akhtaruzzaman et al., 2020a; Baker et al., 2020; CFA Institute, 2020; Zaremba et al., 2020a) and affected equity return (Akhtaruzzaman et al., 2020b). The World Health Organization (WHO) has set a number of public health policies called non-pharmaceutical interventions aimed at mitigation and suppression of the pandemic (WHO, 2020c). The mitigation policies aim at slowing or stopping the epidemic while the suppression policies aim to reverse epidemic growth and reduce case numbers to low levels. The recommended measures include home isolation of suspect cases, home quarantine of those living in the same household as suspect cases, and social distancing of the elderly and others subject to greatest risk of severe diseases. Yoo and Managi (2020) find that these measures can save over US$40 trillion, and social distancing alone can reduce the mortality by 55%. The WHO’s guidelines have prompted a succession of unprecedented government health and protection policy interventions to contain or eliminate coronavirus (Al-Awadhi et al., 2020; Barro et al., 2020; Goodell, 2020; Zhang et al., 2020). The government interventions include business shutdowns, social distancing, investing in personal protective equipment, testing, quarantining, and treating positive cases. To reduce the effects on the economy, governments are providing economic support through stimulus packages, such as wage subsidies, and other fiscal and monetary policies (Zhang et al., 2020).

Within a short period of time, the Covid-19 pandemic jolted the world economy. Gharehgozli et al. (2020) show that the growth rate of real gross domestic product of the United States is expected to decline during the pandemic. To combat the pandemic, many countries around the world are forced to impose travel restrictions, border shutdowns, and lockdowns. Such interventions have a direct effect on supply chains, economic development and foreign trade at all levels (Aslam et al., 2020). Policies such as social distancing, staying at home, school closures, and protection measures at ports and airports, have also been applied internationally to protect individuals. Yoo and Managi (2020) claim that such anti-COVID-19 strategies can save lives and thereby reduce economic losses. The global economy is expected to take about three months, to step into the new equilibrium in the positive and unlikely scenario of the end of all lockdowns (Mandel and Veetil, 2020).
this respect, Nakamura and Managi (2020) show that reducing air travel at airports reduces the risk of spread of COVID-19. Katafuchi et al. (2020) categorize two types of policies that restrict behaviors to prevent the spread of infectious diseases: enforceable behavioral restrictions that are based on the legal system, and unenforceable behavioral restrictions that do not use legal system but rely on self-restraint. Kurita and Managi (2020) indicate that the non-legally binding self-restraint policies reduce people’s going out behavior in a steady state.

Governments around the globe have become targets of criticism by political opposition parties and the public, resulting in demonstrations and a large outcry against policy interventions. This is because the policy interventions are expected to have adverse effects on the economy due to loss of productivity, increase in business losses, and unemployment (Cochrane, 2020; Ichino et al., 2020; Meninno and Wolff, 2020), that quickly spread to financial markets (Ramelli and Wagner, 2020).

The impact of government policy interventions has been regarded as continuously affecting stock markets worldwide. During the first half of 2020 when government policy interventions followed the announcement of the pandemic (WHO, 2020a; 2020b; 2020c), stock markets recorded unparalleled high levels of volatility compared to the levels experienced during previous global financial crises (such as in 1930s, 1987, and 2008), and during the Spanish Flu, SARS and Ebola pandemics (Baker et al., 2020).

Baker et al. (2020) argue that the behavioral and policy reactions of investors provide the most compelling explanation for the stock market volatility. Alfaro et al. (2020) maintain that the volatility of the equity markets in response to the pandemic can be attributed to the inclusion of information about the expected impact of the pandemic into aggregate and firm-level stock returns. Investors and stock analysts would be particularly interested in the impact of policy interventions because the strong volatility of stock markets affects the values and returns of shares as well as the risks associated with their portfolios. The stock market is a strong indicator of the expected future of the whole economy (Ramelli and Wagner, 2020) and as such plays an important role in society. Research on stock market volatility is particularly important in the current era of the Covid-19 pandemic due to the prominent role of the financial markets in the economy.

During the first half of 2020, when the spread and impacts of Covid-19 pandemic continued to be severe, there was a proliferation of finance and economic studies investigating the impacts of the Covid-19 pandemic on the economy and stock markets. In particular, the volatility of the stock markets in response to the pandemic has been a topical area of research interest for many finance scholars. A number of recent studies focus on the aggregate impact of policy interventions on stock market volatility (WHO, 2020c; Baker et al., 2020; Al-Awadhi et al., 2020; Kurita and Managi, 2020) without giving attention to the impact of each of the government policy interventions. The financial contagion indicates the difference in magnitude of stock volatility (Akhtaruzzaman et al., 2020c). In addition, concerns among governments, regulators, corporate managers, and financial scholars about the impacts of their Covid-19 policy interventions on stock market volatility, calls for more research in this area. This situation leaves a gap for exploring the effectiveness of each policy on the stock market. Our study fills this gap and uses a number of public health measures called non-pharmaceutical/government interventions aimed to mitigate and suppress the negative effects of the pandemic and their impact on stock market volatility.

Our study contributes to the growing debate in the literature, by using the Monte-Carlo type simulations to determine the impact of individual health policy interventions on stock market volatility of major East Asian economies: China, Singapore, Thailand, and Japan. These countries play an important role in international trade and the public equity market (Arouiri et al., 2013). To the best of our knowledge, this study is the first to use Monte Carlo analysis to investigate the influence of different health policy measures in Asian economies. The Monte Carlo approach is applicable to run breakpoint tests where each health measure is implemented at a different date (Streeteans and Candelon, 2014). We use the most updated data at August 31st, 2020 to extend the investigation of numerous similar research on the impact of Covid-19 on stock market volatility. We examine seven policy measures, namely, lockdown, quarantine, social distancing, flight restrictions, night curfews, working from home procedure, and active tracking strategies. The findings indicate that different public health measures and protection policies affect the volatility in stock prices differently, and can be country specific in their impact on the stock markets.

The rest of the paper is organized as follows. Section 2 reviews the literature on the impact of Covid-19 pandemic on stock market volatility. Section 3 describes the methodology. Section 4 presents and discusses the empirical results. Section 5 concludes the paper.

2. Literature review

Previous studies have established a link between crises, government intervention, policy uncertainty, and financial market volatility (Corradi et al., 2013; Danielsson et al., 2018; Liu and Zhang, 2015; Manela and Moreira, 2017; Mei and Guo, 2009). In 2020, many studies examined the impact of Covid-19 on various aspects of the economy, including impacts on selected industries (Qin et al., 2020); economic development (Buesso et al., 2020); labor markets (Coibion et al., 2020); and stock market volatility (Baker et al., 2020; Lopatta et al., 2020; Zaremba et al., 2020a). The Covid-19 pandemic disrupted global financial markets and numerous studies analyzed the impact of the pandemic on the financial markets, particularly stock markets (e.g. Ashraf, 2020; He et al., 2020; Liu, 2020; Phan and Narayan, 2020).

Aslam et al. (2020) use high-frequency data of six major currencies traded in forex markets and employ multifractal detrended fluctuation analysis (MF-DFA) to examine the efficiency of forex markets during the period October 1, 2019 to 31 March 31, 2020. Their findings provide evidence of a general decline in forex market efficiency during the COVID-19 period as compared to the pre-pandemic level. Their results also confirm a decline in the efficiency of forex markets during the COVID-19 outbreak and the heterogeneous effects on strength of exchange rate returns. During the initial phase of the COVID-19 outbreak, the largest effect is observed for the Australian dollar, while the Canadian dollar and the Swiss Franc exhibit the highest efficiency. In this volatile climate associated with the COVID-19 pandemic, Gupta et al. (2021) offer evidence in support of using US Treasury securities to hedge financial market risks. Bouri et al. (2020) reveal that return connectedness across different assets classes is positively related to an index of financial uncertainty from infectious diseases.

The relationship between COVID-19 and the stock market is akin to a predator-prey relationship (Lee et al., 2005). While investor resources are required to fight COVID-19, the value of investments has fallen. Hence, a primary research agenda of many finance studies that emerged during the first half of 2020 was about stock market reactions to COVID-19 pandemic and particularly to government policy interventions to contain or eliminate the coronavirus. Uncertainties surrounding the pandemic (Ramelli and Wagner, 2020), have caused mixed reactions among investors. Pastor and Veronesi (2012) point out that uncertainty over government policy is about the policies government might implement as well as uncertainty over the impact of a new government policy. These uncertainties are expected to affect stock prices because if a policy change occurs then investors’ psychology and speculative behavior on the direction of movement of the stock market also change.

Several researchers argue that investors’ behavior affects stock prices (Del Giudice and Paltrinieri, 2017; Engelberg and Parsons, 2011; Kaplanski and Levy, 2010). Public health officials’ message about infectious diseases tends to influence investor sentiment, that in turn affects stock markets (Smith, 2006). Investors are more optimistic with upward trends in stock markets and with lower perceived risk, whereas
with downward trends investor sentiment becomes more pessimistic (Burns et al., 2012; Lu and Lai, 2012). Globalization and the interdependence of global financial markets may have an impact on global investors’ behavior (Siddiqui, 2009) and the correlations between different stock markets (Li, 2020). Some studies investigate the impact of government policy responses to the novel coronavirus pandemic on stock market volatility (Zaremba et al., 2020a). AlAli (2020) shows the presence of a significant negative effect on stock market returns in major Asian stock markets. Pastor and Veronesi (2012) argue positive policy announcements are typically small because much of the effect is anticipated by investors and is priced in before the announcement. They note, by contrast, negative policy announcements contain a bigger element of surprise with a negative impact on stock prices. It appears with greater uncertainty about government policy during a Covid-19 period, the risk and discount rates may increase resulting in decrease in stock prices. Volatilities and correlations of stock returns could also be affected by the introduction of new government policy because policy changes raise the volatility of the stochastic discount factor. As a result, risk rewards go up and stock returns become more volatile and more highly correlated across firms.

In spite of the substantial coverage of stock market-related research in the literature, there is a scarcity of studies that investigate the impact of particular government policies responses to Covid-19 on the volatility of stock markets. Some studies investigate how social restrictions in aggregate, such as school closing, canceled public events, and closed public transport, affect the volatility of the stock markets (Hale et al., 2020; Zaremba et al., 2020b). These interventions are subject to specific areas for preventing the spread of infection which may impact stock markets differently. The gap in the literature is the lack of studies that examine which intervention is the effective means for the individual capital market in each country. To bridge this gap, our study extends this line of research by examining the impacts of each government measure or intervention in four East Asian capital markets.

3. Methodology and mode of analysis

We determine the impact of individual health policy interventions on stock market volatility of four East Asian economies, i.e. China, Singapore, Thailand, and Japan. These four countries are major Asian economies that are dramatically affected by the Covid-19 pandemic with a significant negative effect on their stock markets. They play an important role in international trade and the public equity market (Arouri et al., 2013). We download the data from investing.com for the period 13 January to 31 August 2020 as the first case was reported by the Ministry of Public Health (WHO, 2020a).

Different types of analysis can be used to explore stock volatility. Uncertainty analysis models consider that dependent variables are affected by exogenous variables under certain sets of assumptions in an output model (Saltelli et al., 2008). Sensitivity analysis and scenario analyses are generally carried out to examine the effect of uncertain factors. However, these methods bring difficulties in calculating the probability of outputs when all inputs vary at the same time. Indeed, neither sensitivity nor scenario analysis can determine the likelihood of stock price which falls between the extreme points (Brealey et al., 2011). Further, they produce only single-point estimate results and could give inaccurate outcomes, particularly in high uncertainty contexts and when using historical data to predict the future stock price. Alternatively, Assalakis et al. (2020) use a quantile approach to explore the effect of natural disasters and economic indicators.

We adopt the Monte Carlo approach to investigate the behavior of stock prices when particular health protection policies are applied. The Monte Carlo approach runs simulations to create scenarios of the volatility of stock prices in response to health policies. This method is applicable to run breakpoint tests where each health measure is implemented at a different date (Straetmans and Candelon, 2014). The Monte Carlo approach is deemed to be superior as it makes it possible to calculate the probability of modelled outputs by simultaneously changing all uncertainty factors (Mun, 2006) and can deal with nonparametric data, which offers the opportunity to better understand possible outcomes or default probabilities impacted by each input. Furthermore, several authors show that the Monte Carlo approach can overcome the limitations of traditional approaches (Bouaziz et al., 2020). Therefore, we adopt the Monte Carlo approach for investigating the potential stock prices when particular health protection policies are applied.

As the dates of health policy implementation and the precise start and end dates for the application of health policies differ across countries, these details are cross-checked with the WHO dashboard. A sensitivity analysis is conducted to determine the health policy which led to the highest volatility in potential stock price and calculate the range of volatility. The sensitivity analysis based on ±10% changes varies the stock prices across the different policies implemented. The study controls the country-specific characteristics and focuses on the health protection policies affecting the volatility of stock price.

3.1. Non-pharmaceutical/ government intervention

We categorize non-pharmaceutical/government intervention into public health and local measures. Public health measures include the period of lockdown, quarantine, and social distancing. Local measures involve flight restrictions, night curfews, work from home procedures and active tracking strategies.

One common strategy that was adopted by many countries is termed “lockdown” during which restrictions of varying degrees have been placed on communities and individuals to curb both movement and social interaction. Curtailment of activities may include closing public facilities such as schools, libraries and playgrounds as well as privately owned businesses such as retail stores and restaurants (World Economic Forum, 2020). Lockdown has often been undertaken in parallel with quarantine measures which entail separating people exposed to the virus from the rest of the community for a set period of time. The time period has been set at 14 days from the time of potential exposure to infected people (World Economic Forum, 2020). Quarantine in this paper refers to the requirement that people exposed to the virus are required to stay in the facilities that are provided by authorities of a country.

The flight/travel restriction period is also used as an uncertain variable causing volatility in stock price. Since the WHO declared an international public health emergency, many countries have introduced far-reaching restrictions on air travel. These measures include border closures, refusal of visas and quarantine periods for people returning to their home countries. Nakamura and Managi (2020) confirm that the infectious risk of importation and exportation caused by air traveling can be reduced when a travel restriction policy is implemented.

Other guidelines relating to everyday life include social distancing (keeping at a distance of one or two meters from others), prohibitions on large gatherings, and work from home. The advice to work from home has prevailed in many countries such as Thailand, Singapore, China, India, New Zealand, Japan, and the United States of America. In addition to restrictions on social interaction and travel, active tracking strategies have been implemented. These strategies use mobile software applications which incorporate digital tracking systems to follow up on the interaction among people in order to monitor and control the spread of the COVID-19 virus. Using the QR code scan, Chatbot (online chat system), and tracking applications enables authorities to follow up on infected cases and to report suspected cases. Some countries have set up specialized health facilities for treating patients. For example, in China, the emergency specialty field hospital, Huoshenshan hospital, was set up during the period from 13 January to 31 August 2020 in response to the COVID-19 pandemic.

Our study follows the simulation asset path model provided by Goddard (2020) to generate the potential stock prices. The simulation is run with 5000 iterations to generate the probability of average stock
price in individual capital markets. Then, we estimate the influence of the non-pharmaceutical interventions on stock market volatility by running the following equation:

$$\text{APSP}_i = \alpha + \beta_1(\text{LD})_i + \beta_2(\text{QRT})_i + \beta_3(\text{SD})_i + \beta_4(\text{FR})_i + \beta_5(\text{NC})_i + \beta_6(\text{WFH})_i + \beta_7(\text{ATS})_i + \mu_i + \epsilon_i$$

(1)

where APSP is the average potential stock price; LD denotes lockdown; QRT and SD represent quarantine and social distancing, respectively; and FR, NC, WFH and ATS denote flight restrictions, night curfew, working from home procedures and active tracking strategies, respectively.

For the Monte Carlo simulation, it is assumed that the volatility in stock prices in capital markets is caused by the period when public health measures or epidemic protection policies are applied see Table 1. These public health measures (LD, QRT, SD, FR, NC, WFH and ATS) are used as the explanatory variables. The output variable is the average potential stock price APSP.

### 3.2. Distribution

With the Monte Carlo method, the range of parameters and probability distributions are critical elements for obtaining accurate results (Currie et al., 2020; French and Gabrielli, 2004). Our study uses pragmatic methods which rely on simple parameters, such as minimum, most likely, and maximum typical distribution. We assume that stock price affected by COVID-19 follows a lognormal distribution as the movement of stock price follows Geometric Brownian Motion (Johnson and Shanno, 1987; Reddy and Clinton, 2016).

### 3.3. Simulation model

Following Goddard (2020), we generate the potential stock prices using the following equation:

$$S(\Delta t) = S(0) \exp\left[\mu \Delta t + \frac{\sigma^2}{2} \Delta t + \sigma \sqrt{\Delta t} \epsilon \right]$$

where $S(0)$ is the today’s stock price, $S(\Delta t)$ is the stock price at a (small) time into the future, $\Delta t$ is a small increment of time, $\mu$ is the expected return, $\sigma^2$ is stock price variance, $\epsilon$ is the expected volatility, $\epsilon$ is a random number sampled from a lognormal distribution.

### 4. Empirical results

This section presents the results of our empirical analysis and in particular, the variations in the stock index of the selected four Asian countries. Table 2 reports the descriptive statistics of stock markets of these four countries: FTSE Straits Time (Singapore), Shanghai Composite (China), Nikkei (Japan), and SET (Thailand).

In terms of values of variance and standard deviation, Table 2 reports that FTSE Straits Time, of Singapore, has the lowest variance (43.77) and standard deviation (6.615) as compared to Shanghai Composite, Nikkei and SET Thailand. However, Nikkei reports the highest variance (282.551) and standard deviations (531.550). The findings indicate that with the implementation of non-pharmaceutical/ government interventions, FTSE Straits Time (Singapore) experienced smaller variations in the stock prices as compared to Shanghai Composite (China), Nikkei (Japan), and SET (Thailand), while Nikkei (Japan) experienced the highest variations in stock prices.

The values of skewness in Table 2 depict that skewness is lowest and nearest to zero in the case of SET (0.050) as compared to Shanghai composite (0.144), FTSE Straits Time (0.2079) and Nikkei (0.1323). This suggests that stock prices in Thailand follow a normal distribution and are thus less volatile as compared to China, Singapore and Japan. In Thailand, the highest variations in stock price are caused by social distancing policy resulting in the change of 0.3178 percentage points, following the lockdown policy. The situation in Japan is different where the lockdown policy resulted in the highest variations in stock price, resulting in a 0.4387 percentage points change. In Singapore, flight/travel restriction policies generated the highest variations in stock price with a change of 0.333 percentage points. The two policies that had the least significant impact on variations in stock price were social distancing and lockdown.

#### 4.1. Potential stock index in four countries

As for the effect of individual health policies on stock indices, the results indicate that the normal-shaped distribution could generate less volatility in stock indices as compared to the skewed distribution. Figs. 1, 2, 3, 4 depict the histograms for the different stock indices which show that these stock indices differ. These figures give an indication of the potential stock index for each country. The histograms suggest possible stock indexes in the future and signal each stock index indicator. The Shanghai Composite, FTSE Straits Time, and Nikkei are slightly right-skewed, in contrast to the potential SET index, which was similar to the normal-shaped distribution. The information from the histograms suggests that investors are less likely to invest at all ranges of stock prices in Thailand when health policies are implemented. Therefore, it can be assumed that individuals investing in SET are less likely to earn a wider range of return than those who invest in China, Singapore, and Japan.

At the low end of a stock index, only a small number of lower indices are in Thailand compared to the low end of the stock index for the other three countries. According to the probability distribution of Shanghai Composite, FTSE Straits Time and Nikkei are very low or very high as compared to those in SET. As the two tails of the histogram in Figs. 1, 2 and 3 are longer than those in Fig. 4, it can be concluded that people investing in Shanghai Composite, FTSE Straits Time and Nikkei tend to face higher volatility in investment return than those investing in the SET. From the histograms, for those at the low end of a stock index, the number of people investing in Shanghai Composite, FTSE Straits Time and Nikkei was higher than those investing in SET. High customer demand and flexibility in purchasing may offer an opportunity for investors to earn higher returns (Kindleberger, 1937).

In addition, it can be assumed that if the stock price in SET increases, then investors may not be willing to buy. This could be due to the lower levels of stock index volatility that generates lower potential return. It is important for investors to look at the stock index percentile to have a clear and specific understanding of the stock index. The percentile differences presented in Table 3 show the potential position of the stock index in each country.

Table 3 shows the overall figures of the stock index. The differences in the low percentile range between the 1st and the 5th percentile are lower than the differences in the high percentile range between the 95th and the 99th percentiles. Moving the position of a stock index to the middle range from the 25th to the 50th percentile seems to be the easiest in SET as it leads to only 1% change, while this seems to be the most difficult in Shanghai Composite, FTSE Straits Time, and Nikkei over 1% change. The differences in the low percentile range between the 1st and the 5th percentiles of the FTSE Straits Time are lower as compared to those in the other three indexes. Thus, moving the stock index to a higher position may be easiest in FTSE Straits Time. It is also easier in the high percentile range between the 95th and the 99th percentiles to rise to the position of the higher FTSE Straits Time. This may be because the differences in the high percentile range between the 95th and the 99th percentile of FTSE Straits Time are the lowest among the four indices.

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1. Figures 1, 2, 3 and 4 portray Shanghai Composite, FTSE Straits Time, Nikkei, and SET indices.
4.2. Individual health policies associated with stock index volatility

Individual health policies implemented after the outbreak of the Covid-19 lead to volatility in stock prices. In the four countries, various factors affect the stock index. The intensity of input factors, Figs. 5, 6, 7, and 8 show the key determinants that cause stock index volatility. Figs. 5, 6, 7, and 8 show that individual policies impact the stock index in each country differently. Regulations on flight restriction have the biggest impact on Shanghai Composite and FTSE Straits Time indices. Night curfew regulation causes the highest volatility in Nikkei and social distancing in SET. In China, a key factor causing volatility in

Table 1
The period of health measures and protection policies applied across countries.

| Health measures/ prevention policies | Period of intervention | China | Country | Thailand | Japan | Singapore |
|--------------------------------------|------------------------|-------|---------|----------|-------|-----------|
| ATS (China)                          | Start                  | 11-02-20 | 17-05-20 | 21-03-20 |
| LD (Singapore)                       | Start                  | 11-04-20 | 08-04-20 | 07-04-20 |
| FR (Japan)                           | Start                  | 28-03-20 | 31-05-20 | 04-02-20 |
| WFH (Thailand)                       | Start                  | 30-06-20 | 03-04-20 | 07-04-20 |
| QRT (Singapore)                      | Start                  | 23-01-20 | 12-04-20 | 04-05-20 |
| SD (Thailand)                        | Start                  | 14-06-20 | 03-04-20 | 10-04-20 |
| NC (Singapore)                       | Start                  | 16-06-20 | 04-03-20 | 30-01-20 |

Note: LD denotes lockdown, QRT and SD represent quarantine and social distancing, FR, NC, WFH and ATS denote flight restrictions, night curfew, working from home procedures and active tracking strategies respectively.

Table 2
Volatility in stock index in four countries.

| Output | Shanghai Composite | FTSE Straits Time | Nikkei | SET |
|--------|--------------------|-------------------|-------|-----|
| Minimum| 2737.9539          | 257.7610          | 19,247.1191 | 1222.7189 |
| Maximum| 3293.7204          | 300.5103          | 22,498.3233 | 1401.3496 |
| Mean   | 2983.7801          | 275.9812          | 20,852.3166 | 1310.2771 |
| Std. Dev | 89.8914          | 6.6155          | 531.5557 | 28.4283 |
| Variance| 8080              | 43.77             | 282.551 | 808.2 |
| Skewness| 0.1449           | 0.2079            | 0.1323 | 0.0503 |
| Kurtosis| 3.0021           | 3.2586            | 2.8229 | 3.0590 |
| Errors  | 0                 | 0                 | 0      | 0    |

Note: Descriptive statistics of stock markets of these countries (FTSE Straits Time, Shanghai Composite, Nikkei, and SET) are shown in table 2.
Shanghai Composite is tracking regulation, whereas in FTSE Straits Time the night curfew regulation is the key factor. The least significant determinant causing the smallest volatility in Nikkei work from home and for and SET the state quarantine policy. These findings are in line with those of Zaremba et al. (2020a), who also report a significant impact of government interventions in response to Covid-19 on stock market volatility. It is essential to identify the key health regulation causing stock index instability so that investors can make an investment decision in the long term. It is worth paying attention to these determinants because they can be used as a litmus test to enhance overall stock return.

Our study illustrates the volatility in stock prices that occurs when implementing various health measures. Our findings state that although different countries implemented common public health measures and individual protection policies, the effect of particular policies on stock prices varied from country to country, and thus concurs with the work of Zaremba et al. (2020b). Determining the optimum health measure is difficult due to the contextual nature of the countries and their investment environment. While reducing the number of infected cases of COVID-19 may be the priority for public authorities, ignoring financial and economic impacts could lead to other crises such as unemployment and financial depression (Barro et al., 2020).

Our study confirms the outcomes of research by Zaremba et al. (2020a), that public authorities need to assess the potential economic impacts of health policies and the potential broader consequences of each policy before implementation. Sustainable solutions to deal with this epidemic need to be flexible and include both health and financial impacts, as the global community endeavors to find a means to

Table 3
A comparison of percentiles between four stock indexes.

| Percentile | Shanghai Composite Changes | FTSE Straits Time Changes | Nikkei Changes | SET Changes |
|------------|----------------------------|---------------------------|----------------|-------------|
| 1%         | 2787.5341                  | 261.4071                  | 19,669.45      | 1240.887    |
| 3%         | 2817.7109                  | 263.1844                  | 19,918.65      | 1255.206    |
| 5%         | 2835.7694                  | 265.2459                  | 20,019.63      | 1262.878    |
| 10%        | 2866.0630                 | 267.6385                  | 20,152.20      | 1274.419    |
| 20%        | 2904.8696                  | 270.4246                  | 20,363.47      | 1286.090    |
| 25%        | 2922.5210                  | 271.3301                  | 20,476.19      | 1290.805    |
| 50%        | 2983.9447                  | 275.6909                  | 20,846.08      | 1309.790    |
| 75%        | 3040.6799                  | 280.4407                  | 21,202.67      | 1329.585    |
| 80%        | 3075.0045                  | 281.4588                  | 21,304.85      | 1333.815    |
| 90%        | 3097.0491                  | 284.0963                  | 21,555.89      | 1345.948    |
| 95%        | 3140.5807                  | 286.8981                  | 21,756.49      | 1355.679    |
| 98%        | 3170.4296                  | 289.3697                  | 21,933.71      | 1366.885    |
| 99%        | 3200.8038                  | 292.6437                  | 22,099.52      | 1380.804    |

Note: Table 3 reports comparison of percentiles between FTSE Straits Time, Shanghai Composite, Nikkei, and SET.

Fig. 5. Factors causing stock volatility in Shanghai Composite.

Fig. 6. Factors causing stock volatility in FTSE Straits Time.
immunize against the virus as well as to deal with the financial instability.

5. Conclusion

We adopt the Monte Carlo simulation to determine potential stock price volatility over the period of implementation of government Covid-19 health measures in East Asian countries (China, Singapore, Thailand, and Japan). We discover volatility in the stock indices relating to individual health policies. We also find public health measures and virus protection policies implemented in selected countries affect capital markets differently. Regulation concerning flight restriction is the most important factor causing volatility in the Shanghai Composite and FTSE Straits Time. The highest volatility in Nikkei was caused by the night curfews, and the highest volatility for SET is associated with the social distancing policy. From a financial point of view, the measure termed lockdown worked well in some countries whereas some specific local recommendations, for instance, working from home, caused little volatility in stock prices in other countries.

Our results have implications for policymakers. Regulators and government authorities should consider the policy intervention restrictions which have a considerable effect on stock markets. When implementing Covid-19 health policy measures, policymakers and other related entities, such as the securities and exchange commission authorities, should consider the impacts of the health measures on the stock prices volatility and ensure fair, efficient, dynamic, and inclusive capital market. The limitation of this study is that it focuses on the capital market in only four East Asian countries and does not explore the simulation ability to predict volatilities in other international stock markets. Our findings indicate that different public health measures and protection policies affect the volatility in stock prices differently. Accordingly, these empirical findings could be used as a pilot study to evaluate further the impacts of COVID-19 on stock price in other settings. Future research studies could be further extended by using a quantile-based panel approach, along the lines of Atsalakis et al. (2020). Overall, the findings of our study should encourage investors and policymakers, to be aware of the effects of policy and regulation, being used to deal with Covid-19, and to encourage policies that will increase the overall stock index and reduce stock volatility.

CRediT authorship contribution statement

Ahmed Imran Hunjra: Conceptualization, Writing - original draft, Project administration, Writing - review & editing. Ploypailin Kijkasiwat: Formal analysis, Methodology, Data curation, Conceptualization, Writing - original draft. Murugesh Arunachalam: Conceptualization, Methodology, Writing - review & editing. Helmi Hammami: Conceptualization, Writing - original draft, Writing - review & editing.

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Ploypailin Kijkasiwat is a lecturer in Finance, Faculty of Business Administration and Accountancy and Assistant Dean of International Affairs at Khon Kaen University, Thailand. She received her PhD (Finance and Accounting) from the University of Waikato, New Zealand, in 2019. Ploypailin has more than seven years of teaching and research experience. Her research interests include entrepreneur finance, SMEs and start-up finance, private equity, and venture capital. Ploypailin has published many papers in peer-refereed academic journals.

Murugesh Arunachalam holds a PhD from the University of Waikato, New Zealand, a master’s degree in accounting and finance from the University of Stirling in Scotland, and a bachelor (honours) degree in accounting from the University of Malaya, Malaysia. He is also a Chartered Accountant. Prior to his academic career, Murugesh has 20 years of industrial experience in accounting and financial management and has worked in the public and private sectors as a senior accountant and financial manager. Murugesh has taught in universities in Malaysia and New Zealand, specializing in financial and management accounting as well as corporate finance. His research interests are in the areas of corporate social responsibility, financial and management accounting and methodological issues and has published a number of articles in top-tier peer-reviewed academic journals.

Helmi Hammami is a full professor and academic dean at Rennes School of Business, France. Helmi holds a PhD in Accounting and Finance from Bocconi University – Italy and was a former resident fellow of the Collegio di Milano, and recipient of the French Government fellowship to outstanding overseas academics. Previously, Helmi served as the Senior Advisor to the Dean, the Head of the Department of Finance and Accounting, and the Head of the Department of Strategy and Innovation at Rennes SB. Helmi is specialist in accounting related topics notably International accounting (IFRS), internal control risk assessment, fraud detection and prevention, and accounting information systems. He sits on the board of several professional bodies and SMEs. Helmi has recently published many academic papers in international refereed journals including Advances in Accounting, Annals of Operations Research, Applied Economics, Economics Letters, Finance Research Letters, and The Energy Journal.