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Financial Market Responses to Government COVID-19 Pandemic Interventions: Empirical Evidence from South-East and East Asia

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Abstract: *This study investigates the impact of various government interventions on the spread of COVID-19 as well as stock markets in South-East and East Asia. It finds that stricter interventions – including gathering restrictions, public event cancellations, and mask requirements – helped mitigate the severity of the pandemic significantly in the region. Total border closures had a moderate effect on flattening COVID-19 spread, especially during the onset of the pandemic. Other policies, such as school closures or stay-at-home orders, worked effectively later in the pandemic. The study also shows evidence of herding behaviours in regional stock markets during the pandemic. School closures, gathering restrictions, stay-at-home orders, domestic travelling bans, robust testing policies, and government income support programmes tended to reduce herding behaviour. More stock market integration is found during the onset of the pandemic, compared to the periods before and later in the pandemic, implying the short-term impact of a sudden shock from COVID-19.*

Keywords: COVID-19, stock markets, minimum spanning trees, government interventions

JEL classification: G15, G18, C13, H12

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1. Introduction

The COVID-19 pandemic has affected the world at a level not observed in recent history (Del Rio and Malani, 2020). The World Health Organization (WHO) declared the outbreak a public health emergency on 30 January 2020 and a global pandemic 40 days later (WHO 2021). About 99.7 million cases have been reported, with 2.14 million deaths worldwide as of 26 January 2021 (Worldometer, 2021). To control the disease from overwhelming health care systems, billions of people have been in self-isolation in their homes, borders between countries have been closed, domestic and international travel have been restricted, and schools and non-essential businesses are shuttered.

The COVID-19 outbreak itself – as well as the associated containment policies – have led to an economic and financial downturn. Although aligning with economic growth through impacts on savings and companies' ability to access capital with lower transaction costs, stock markets have fallen to their lowest levels in a decade, reflecting the high uncertainty caused by the pandemic (Narjoko, 2020).

The heterogeneity in affected cases, mortality, and economic burden across countries has become increasingly apparent. This fact is especially notable in South-East and East Asia, a region with considerable divergence in population density, income levels, and health care systems. By 26 January 2021, regional confirmed COVID-19 cases varied from 44 in the Lao People's Democratic Republic (Lao PDR) to about 999,000 in Indonesia. While some – including China, the Philippines, Singapore, Taiwan, and Viet Nam – appear to be managing the transmission of the coronavirus effectively, others have had continuously increasing COVID-19 cases and deaths (e.g. Malaysia and Indonesia) and a second-wave risk of infection (e.g. Hong Kong, Japan, Republic of Korea, and Thailand). This may be due to the variations in government efforts regarding timing, intensity, and breadth of interventions to control the pandemic across the region. Interventions affect not only transmission speed but also the economy in general and financial markets in particular, given the varying extent of regional and global integration in the South-East and East Asia stock markets.

Some countries and/or areas in the region have temporarily become leaders in the control of and recovery from the COVID-19 pandemic. Empirical findings from this study can highlight the prompt responses that countries in the region took and can take to strengthen economic regionalism to confront the current pandemic and similar shocks in the future.

This study seeks to address the following questions:

- To what extent did interventions relieve the spread of COVID-19 in the region?
- How extensively did government pandemic responses affect regional stock market outcomes? Was this effect positive or negative?
- Which government actions effectively mitigated COVID-19 transmission and risks to regional financial markets?
- How did stock market integration in East and South-East Asia change during the pandemic regarding government reactions to COVID-19?

The study has a number of values added. It is the first to examine how the COVID-19 pandemic and stock markets reacted to government actions aimed at controlling the infection as well as the role of stock market integration during the pandemic in a specific region. Second, it offers a real-time snapshot with the capacity to update data and research findings until December 2020. The study aims to help policymakers evaluate the consequences of their decisions, inform them on how to manage the pandemic, and the economy recover quickly. Moreover, the success of some countries can suggest policy implications for others.

The paper is organised as follows. Section 2 reviews the literature, while methodology and data are described in Section 3 and Section 4. Section 5 summarises the situation of COVID-19, associated government containment measures, and stock market fluctuations in the region. Results are presented in Section 6, and the final section concludes the study.

2. Literature Review

Many studies have evaluated the effectiveness of government measures in controlling COVID-19 transmission. For example, in a study of 142 countries, Koh, Naing, and Wong (2020) found that complete travel bans, and all forms of lockdown measures, effectively reduce the average number of COVID-19 cases over 14 days. Similar results were found by Li et al. (2020) across 131 countries, showing that COVID-19 fell after containment policies were enacted, after 1–3 weeks; Cho (2020), after around 5 weeks in Sweden; Cowling et al. (2020) within 7 days in Hong Kong; and Hartl, Wälde, and Weber (2020) after 7–8 days in Germany. Effectiveness is enhanced if measures are implemented quickly in countries with lower population density and lower temperatures, or in countries with a larger share of the elderly or stronger health systems (Deb, Furceri, Ostry, and Tawk, 2020).

This finding is further supported by Dergiades, Milas, and Panagiotidis (2020), who used daily data for 32 countries and found that the greater the strength of government interventions at an early stage, the more effective these were in slowing down or reversing the rate of deaths. Also, Chen and Qiu (2020) suggested from their study of nine countries that interventions, like mask-wearing and centralised quarantines, can replace costly national lockdowns without significantly heightening the epidemic's peak.

The impact of the COVID-19 pandemic on financial markets has also been examined in a number of studies. In one of 74 countries from January to April 2020, Capelle-Blancard and Desroziers (2020) found that stock markets ignored the pandemic until 21 February, before reacting strongly to the growing number of infected people from 23 February to 20 March, while volatility spread after the intervention of central banks from 23 March to 30 April. However, after this point, shareholders no longer seemed bothered by news of the health crisis. The study also showed that stock markets were less sensitive to each country's macroeconomic fundamentals before the crisis than to their short-term reactions during the crisis.

When examining intra-day returns and volatility in the United States equity market, Akbar and Tahir (2020) posited that COVID-19 cases and deaths were related to stock returns and realised volatility. A similar result was also found by

Baker et al. (2020) and Alfaro, Chari, Greenland, and Schott (2020) for the United States; Al-Awadhi, Alsaifi, Al-Awadhi, and Alhammadi (2020) for China; and Zhang, Hu, and Ji (2020) for 10 stock markets in countries with the most confirmed cases during January–February 2020. Similarly, Ashraf (2020b) examined data from 64 countries and found that stock markets reacted negatively to the COVID-19 outbreak. However, this reaction was only significant to the growth in the number of confirmed cases but not to the growth in the number of deaths.

Few studies, however, have been conducted on how government responses to the pandemic have affected stock markets. Ashraf (2020a), investigating 77 countries in Europe and Asia and using daily data January–April 2020, found a direct negative effect of announcements of government social distancing measures on stock market returns due to their direct adverse effect on economic activity and an indirect positive effect through fewer confirmed COVID-19 cases. Government announcements of public awareness programmes, testing and quarantining, and income support packages mainly resulted in positive market returns.

Similarly, Kizys, Tzouvanas, and Donadelli (2021) examined whether government responses to the pandemic mitigated investor herding behaviour – that is, an investor's imitation of others' actions due to informational externalities (Devenow and Welch 1996) – in the stock markets of 72 countries in the first quarter of 2020. Indeed, the COVID-19 pandemic has caused growing uncertainty around the economy and induced massive sales of risky assets from stock market investors (Baker, Bloom, Davis, and Terry, 2020). During periods of financial market jitters and intensified uncertainty, investors do tend to mimic their peers' decisions or to follow the crowd (Kurz and Kurz-Kim, 2013), which threatens financial stability and makes financial systems more vulnerable (Philippas, Economou, Babalos, and Kostakis, 2013). Although investors obtain noisy information from observing others' actions, externalities can be so strong that investors can decide to ignore their information (Bikhchandani, Hirshleifer, and Welch, 1992; Welch, 1992).

However, government responses to the pandemic may signal to investors that the pandemic is under control, which can diminish uncertainty and restore investor confidence in stock markets (Sharif, Aloui, and Yarovaya, 2020). Overall, Kizys, Tzouvanas, and Donadelli (2021) did find evidence of investor herding behaviour during the pandemic but also demonstrated that government responses mitigated this behaviour by reducing the multidimensional uncertainty surrounding the pandemic.

Asian stock markets have also become increasingly integrated in recent years (Chien, Lee, Hu, and Hu, 2015), accompanied by joint policy efforts to build up a regionally integrated market and to promote capital mobility within the region (Wu, 2020). Massive inflows of foreign direct investment, accompanied by cross-border financial transactions, have contributed to the region's boom of local equity markets. According to Wu (2020), the market capitalisation of major East and South-East Asia stock markets has grown substantially during the last 2 decades (e.g. 61.13 times for China, 9.48 times for Indonesia, 6.51 times for Hong Kong, and 6.06 times for the Philippines by the end of 2018). The stock markets in the region have become an important part of fund managers' international portfolios to increase their returns and to reduce their risks (Narayan, Sriananthakumar, and Islam, 2014).

The literature shows that financial market integration changes during a crisis. For example, Aswani (2017) – when examining the network dynamics of 14 Asian stock markets in the three phases (i.e. pre, during, and post) of the global financial crisis – found that this network was more interconnected during the crisis than during the pre- and post-crisis periods. It also found that the stock market of Hong Kong, India, Japan, and Korea played a significant role in these networks, and any shock to these markets could lead to contagion. Similarly, Wu (2020) explored financial integration amongst the stock markets of ASEAN-5 economies, plus China, Japan, and Korea, demonstrating that the level of interconnectedness amongst these markets seemed to be high but was mostly driven by common global factors. After filtering these factors, the magnitude of interconnectedness fell substantially, suggesting that stock market integration in East and South-East Asia is not as strong as it looks. The overestimated interconnectedness is a reflection of stronger global influences on individual markets, and their interconnectedness shows a descending trend after the crisis.

Some studies have examined financial market integration change before and during the COVID-19 pandemic. Pang, Granados, Chhajer, and Fille Legara (2020) investigated the pandemic's impact on sovereign bond yields in Europe, finding that the average correlation between sovereign bonds during the pandemic decreased from the peak observed in 2019–2020. Similarly, Aslam et al. (2020) analysed the effects of the pandemic on 56 global stock indices from October 2019 to August 2020 by using a complex network method. Their findings revealed structural change, reduced connectivity, and significant differences in network characteristics due to COVID-19.

3. Methodology

To answer the first and third research questions, the model suggested by Koh, Naing, and Wong (2020) is modified:

$$\Delta C_{c,t} = \beta + \mathbf{G}'_{c,t-14}\mathbf{\Lambda} + \delta_c + \eta C_{c,t-14} + \zeta t + \epsilon_{c,t} \qquad (1)$$

where:

- $\Delta C_{c,t}$ measures the growth rate of new COVID-19 cases in country *c* between *t - 14* and *t*.[1]
- $C_{c,t-14}$ represents 14-day new cases reported in the last 2 weeks.
- *t = 0* when the first 100 cases are detected in each country;[2] this number is identified to indicate an outbreak.
- $G_{c,t-14}$ is a set of government response variables that country *c* took on the date *t - 14*. Fourteen days are selected to allow enough time for the pandemic to respond to policy interventions. The use of lagged measures also helps control for the endogenous response to a viral transmission. The column vector of $\mathbf{\Lambda}$ measures the impact of different government responses on disease transmission.

[1] If $\Delta C_{c,t} < 0$, it is equivalent to the less-than-1 reproduction number.

[2] Except for China, data on COVID-19 cases were not available until day 45 after the first case on 17 November 2019.

- β represents constant terms; $\epsilon_{c,t}$ represents error terms; δ_c represent country fixed effects dummy variables, which control for heterogeneous, institutional, and cultural contexts (Ashraf, 2020b) and sociological, demographic, economic, and geographic characteristics as well as the quality of implementing the government intervention measures in each country in the region.
- Heteroskedastic-robust standard errors are applied.

To answer the second and third research questions, the model suggested by Christie and Huang (1995) and Kizys, Tzouvanas, and Donadelli (2021) is used to ascertain if government responses to the pandemic can mitigate the herding behaviour of investors in regional stock markets. In this model, investor herding behaviour is measured by the cross-sectional standard deviation *(CSSD)* and the cross-sectional absolute deviation *(CSAD)*. These two indices reflect the average distance between an individual stock return representative of each country and the market return proxied by a major global stock. If the investor decides to mimic the group's behaviour during heightened stock market volatility, individual stock returns become less dispersed around the market return. Therefore, the model builds on the following regression:

$$CS_{c,t} = \alpha_0 + \alpha_1|Y_{m,t}| + \alpha_2 Y_{m,t}^2 + \mathbf{G'}_{c,t}\boldsymbol{\Theta} + \pi_c + u_{c,t} \quad (2)$$

where:

- $CS_{c,t}$ is either $CSSD_{c,t}$ or $CSAD_{c,t}$, measuring investor herding behaviour. These two indices for country *c* on day *t* are defined as:

$$CSSD_{c,t} = \sqrt{\frac{\sum_{s=0}^{\tau-1}(Y_{c,t-s} - Y_{m,t-s})}{\tau - 1}} \quad (3)$$

$$CSAD_{c,t} = \frac{1}{\tau}\sum_{s=0}^{\tau-1} |Y_{c,t-s} - Y_{m,t-s}| \quad (4)$$

- $Y_{m,t}$ is the global market return proxied by a global stock index. During the period of market stress, $Y_{m,t}$ is likely to sustain a non-linear relation (Lux, 1995). In the absence of herding, α_1 is positive, and α_2 becomes insignificant (Mobarek, Mollah, and Keasey, 2014). In the presence of investors herding, α_2 is negative (Chang, Cheng, and Khorana, 2000), and in the case of anti-herding behaviour, α_2 is positive (Bouri, Gupta, and Roubaud, 2019).
- Following Kizys, Tzouvanas, and Donadelli (2021), the 22-day ($\tau = 22$) rolling-window standard deviation of country c's return from the global market return m on day t is used. Smaller values of $CS_{i,t}$ signal stronger evidence of herding behaviour, whereas larger values signal weaker evidence.
- $G_{c,t}$ is a set of government response variables that country c took on day t. The column vector of $\mathbf{\Theta}$ measures the impact of different government responses on investor herding behaviour. If a coefficient in this vector is negative (or positive), then the government responses amplify (or reduce) herding behaviour.
- α_0 represents constant terms; $u_{c,t}$ represents error terms; and π_c represents country fixed effects dummy variables.
- Heteroskedastic robust standard errors are applied.

To answer the final research question, the minimum spanning tree (MST) method is used to identify the leading stock markets that connect other markets in the region. This method is popular in analysing the interdependency of stock markets (e.g. Aslam et al., 2020; Gilmore, Lucey, and Boscia, 2010; Han et al., 2019; Ji and Fan, 2016; Mantegna, 1999; Memon and Yao, 2019; Nguyen, Nguyen, and Nguyen, 2019; Rešovskỳ, Horváth, Gazda, and Siničáková, 2013; Wu, 2020;[3] Wu, Zhang, and Zhang, 2019) and the impact of economic and financial crises (e.g. Mahamood, Bahaludin, and Abdullah, 2019; Memon and Yao, 2019; Yang, Li, and Zhang, 2014).

[3] This study uses MST to explore the financial integration situation amongst the stock markets of ASEAN members, China, Japan, and Korea.

The MST extracts the most important relationships between financial markets and expresses them in the simplest manner, which is easy to visualise with a connected graph. This graph is constructed so that each node, which corresponds to a specific financial index, and the distances between nodes (i.e. edges) are obtained by calculating pairwise correlations. The correlation coefficient between two indices *i* and *j* at time *T* as $\rho_{i,j}^T$ is calculated by:

$$\rho_{i,j}^T = \frac{\sum_{t=1}^{T}(r_{i,t} - \overline{r}_i)(r_{j,t} - \overline{r}_j)}{\sqrt{\sum_{t=1}^{T}(r_{i,t} - \overline{r}_i)^2 \sum_{t=1}^{T}(r_{j,t} - \overline{r}_j)^2}} \qquad (5)$$

This coefficient is then converted to a distance variable using a simple distance function:

$$d_{i,j} = f(\rho_{i,j}) = \sqrt{2(1 - \rho_{i,j}^T)} \qquad (6)$$

where $d_{i,j}$ denotes the distance between node *i* and *j* at time *T*, which satisfies the three axioms of Euclidean distance: (i) $d_{i,j} = 0$ if and only if *i* = *j*; (ii) $d_{i,j} = d_{j,i}$; and (3) $d_{i,j} \leq d_{ik} + d_{k,j}$. The distance d_{ij} varies from 0 to 2, corresponding to correlation values ranging from −1 to +1. A smaller value of $d_{i,j}$ implies that the two stock markets are more correlated and compact.

The MST chooses only the *N - 1* strongest links (or shortest paths) amongst all *N(N - 1)/2* possible links for *K* nodes in the network (Stanley and Mantegna, 2000). To construct the graph, the MST starts with the pair of nodes with the shortest distance (or the highest correlation). Next, the second-smallest distance is identified and added to the MST. Successive nodes are added with the condition that no closed loops are created. The MST is thus a graph that connects all *N* nodes of the graph with *N* − *1* edges so that the sum of all edge weights is a minimum.

This graph is constructed before and after the pandemic announcement in the presence/absence of local policy interventions. To investigate whether the regional stock markets are still strongly linked in the absence of common driving forces from the global stock market, the influences of world stock market dynamics on local stock market returns are filtered out by estimating:

$$\Delta Y_{c,t} = \lambda_c + \mu_{c,t}\Delta Y_{m,t} + \xi_{c,t} \qquad (7)$$

where:

- $\Delta Y_{c,t}$ and $\Delta Y_{m,t}$ denote the daily growth rate of a stock index or the stock market return of country *c* and the global market return at time *t*.
- λ_c is the constant of country *c*.
- $\xi_{c,t}$ is the error term of country *c*, presenting the part of total returns attributed to factors other than common global impacts. These filtered returns control for the daily changes in the systematic risks caused by international factors, such as oil prices, as a result of external demand shocks or major international events with strong spill-over effects across borders (Ashraf, 2020a).[4] This, therefore, helps distinguish between the impact of COVID-19 measures from external demand shocks.

4. Data

The model covers 11 South-East and East Asia countries and areas that have been affected by the COVID-19 pandemic and have larger financial markets, including China, Hong Kong, Indonesia, Japan, Korea, Malaysia, Philippines, Singapore, Taiwan, Thailand, and Viet Nam. One or two major stock indices were chosen from each country, and stock volatility from all stock indices are computed to run Equation (2). Table 1 presents the details of these selections.

Because stock market index data are not available on Saturdays and Fridays, they are input using:

$$Y_{c,t} = (Y_{c,t-1}^2 \times Y_{c,t+2})^{\frac{1}{3}} \text{ for Saturdays.}$$

$$Y_{c,t} = (Y_{c,t-2} \times Y_{c,t+1}^2)^{\frac{1}{3}} \text{ for Sundays.} \qquad (8)$$

[4] For example, the United States Federal Reserve announced a 0% interest rate policy on 15 March 2020 and an unlimited quantitative easing policy 8 days later.

Table 1: Major Stock Indices in South-East and East Asia

Country/Area	**Stock Market (aggregated)**
China	**Shanghai Composite Index** (an index of all stocks traded at the Shanghai Stock Exchange); **Shenzhen Stock Exchange** (a stock exchange based in Shenzhen)
Hong Kong	**Hang Seng Index** (a market capitalisation-weighted index of the largest companies that trade on the Hong Kong Exchange, covering about 65% of its total market capitalisation)
Indonesia	**Jakarta Stock Exchange Composite Index** (an index of all stocks traded on the Indonesia Stock Exchange)
Japan	**TOPIX** (a market capitalisation-weighted index including all stocks on the Tokyo Stock Exchange)
Malaysia	**FTSE Bursa Malaysia Index Series** (covers all eligible companies listed on the Bursa Malaysia Main Board and measures the performance of the major capital segments of the Malaysian market)
Philippines	**PSEi Composite Index** (the stock index on the Philippine Stock Exchange on which all stocks are traded)
Singapore	**FTSE Singapore Index** (representing 98% of Singapore market capitalisation)
Korea	**KOSPI** (a series of indices that track the overall Korean Exchange and its components)
Taiwan	**Taiwan Weighted** (an index for companies traded on the Taiwan Stock Exchange, covering all listed stocks excluding preferred stocks, full-delivery stocks, and newly listed stocks, which are listed for less than 1 calendar month)
Thailand	**SET** (calculated from the prices of all common stocks on the main board of the Stock Exchange of Thailand)
Viet Nam	**VNI Index** (a capitalisation-weighted index of all companies listed on the Ho Chi Minh City Stock Exchange); **HNX Index** (a capitalisation-weighted price index comprising stocks traded on the Hanoi Stock Exchange)
Global	**Dow Jones Global Indexes** (providing 95% market capitalisation coverage of stocks globally, including those in developed and emerging regions)

Source: Investing.com (2021).

Data of confirmed COVID-19 cases for each country are gathered from Johns Hopkins University (2021). Daily data of government responses are from the Blavatnik School of Government (BSG) at the University of Oxford (2021), which collected information on a range of government policies from 1 January 2020 until 30 December 30 2020,[5] assigned a score to each policy, and aggregated them into an overall government response index. The impact of 13 specific measures were also examined, including (i) school closures, (ii) workplace closures, (iii) public event cancellation, (iv) gathering size restrictions, (v) public transport closures, (vi) stay-at-home orders, (vii) internal movement restrictions, (viii) international travel restrictions, (ix) income support programmes, (x) debt/contract relief for households, (xi) testing policies,[6] (xii) contact tracing, and (xiii) mask wearing.[7]

Each measure's levels are regrouped to both utilise additional information on whether the policy is targeted or general and to ensure an adequate number of observations (i.e. at least 10%). Details of these measures are presented in Table A1, and the correlation amongst measures is shown in Table A2 of the appendix.

From the measures listed in Table A1, the aggregated index is computed using this simple addition method:

$$I_t^1 = \frac{1}{13}\sum_{j=1}^{13} I_{j,t} \qquad (9)$$

where $I_{j,t} = \frac{v_{j,t}}{N_j}$ (x) is the sub-index score with a range between 0 and 1 for a measure *j* on a given day *t*; $v_{j,t}$ is the recorded value of the measure *j*; and N_j is the maximum value of the measure *j*.

Another aggregate index (I_t^2) is also computed using the Principal Component Analysis method. This mathematical algorithm reduces the dimensionality of the data while retaining most of the data set variation. These two indices are very close

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5 The sample for Equation (1) covers the period from the first day of 100 confirmed cases in 2020 to 30 December 2020, while the sample for Equation (2) covers the period from the first case reported in each country to 30 December 2020.

6 During this period, the public information campaign is coordinated in all countries. Therefore, the measures exclude this policy.

7 See Hale, Petherick, Phillips, and Webster (2020) for more details.

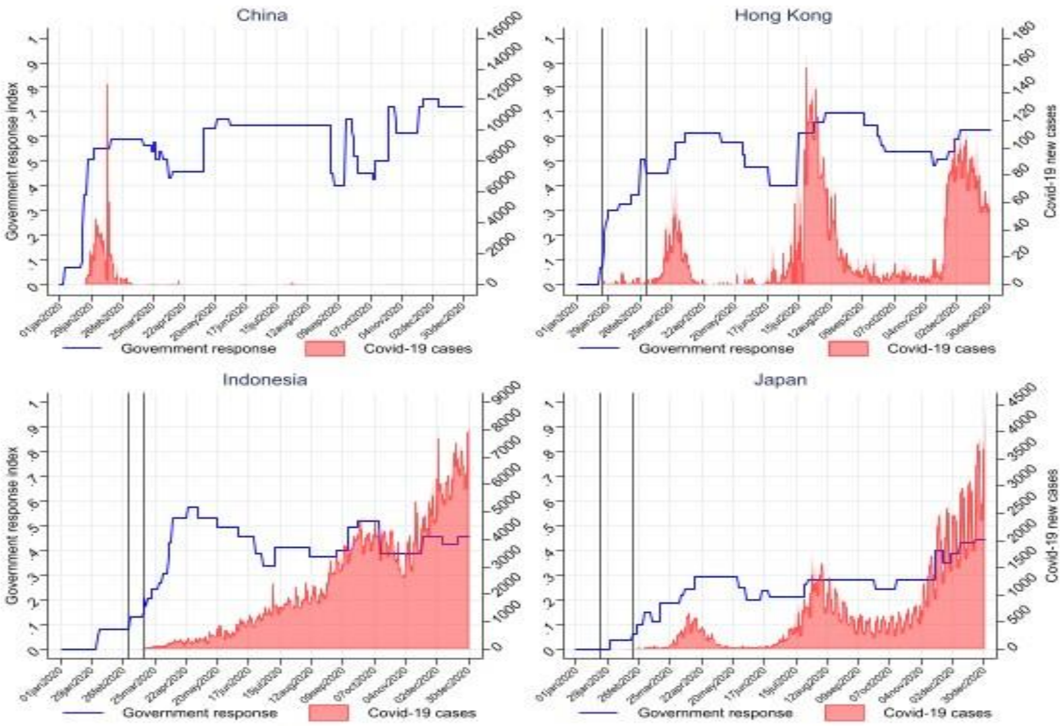
to each other, with a linear correlation of 98% (Figure A1 in the appendix).[8] Higher values of the aggregate indices represent stricter government interventions.

5. COVID-19 Government Interventions and Stock Market Fluctuations in the Region

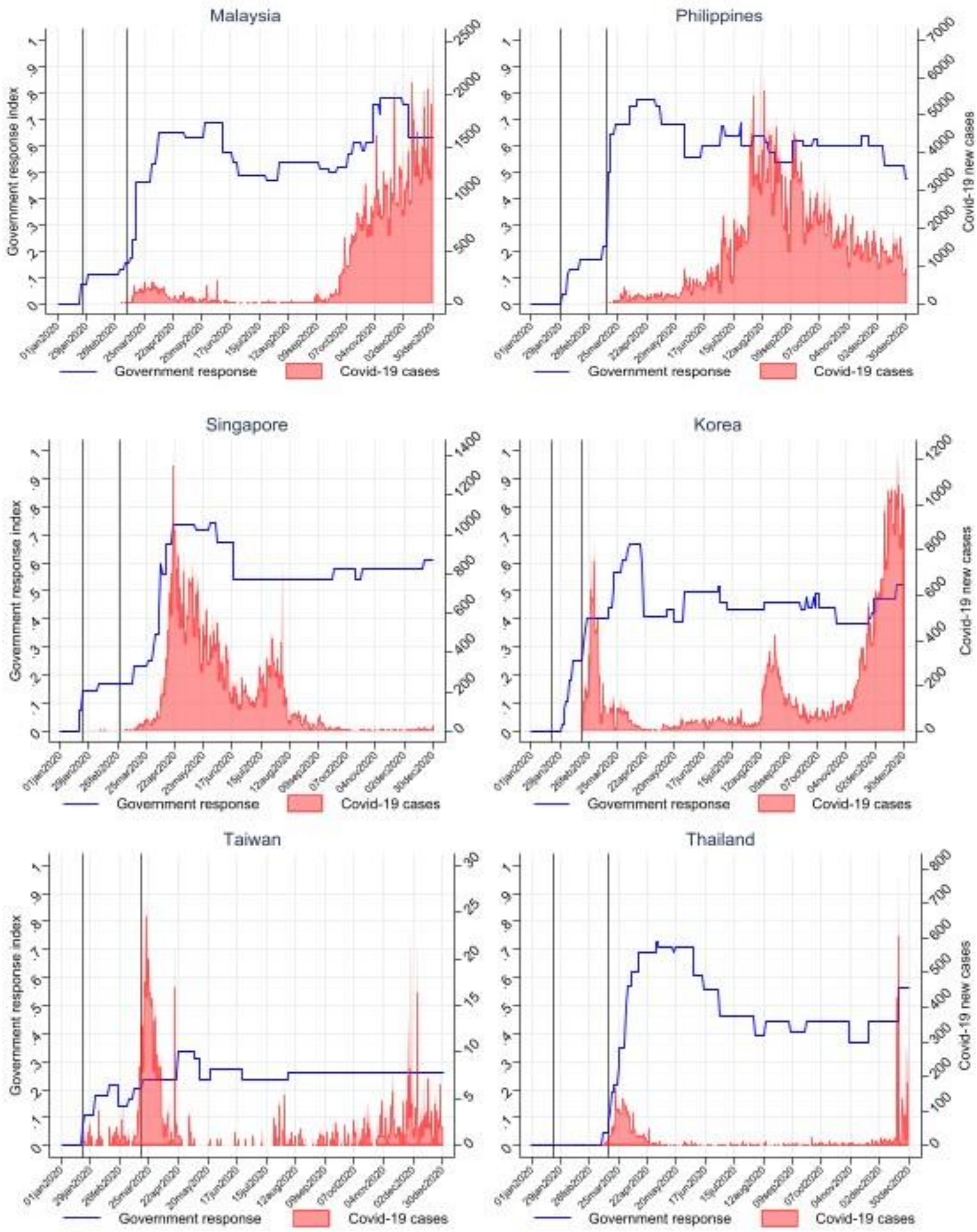
5.1. COVID-19 Government Interventions

Figure 1 demonstrates the variations in daily new COVID-19 cases and the overall government response index, which is aggregated using Equation (9) in 11 countries and areas during 2020. Details of the timeline for different government measures are shown in Figure A1 in the appendix, while a summary of government interventions across countries is presented in Table A3 of the appendix.

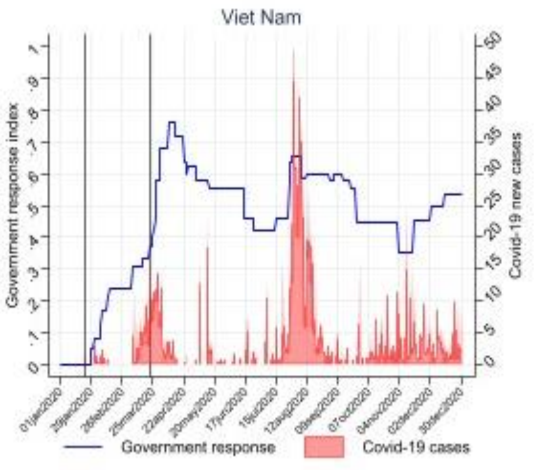
Figure 1: Overall Government Response Index and Daily New COVID-19 Cases in East and South-East Asia, 2020



[8] The available aggregated index is computed from the original categories of government measures.



Malaysia
Philippines
Singapore
Korea
Taiwan
Thailand
Government response index
Covid-19 new cases
Government response
Covid-19 cases



Notes:

1. The government response index is computed using Equation (9).
2. The two black, straight lines in each sub-figure show the dates when the first COVID-19 case and the first 100 confirmed cases occurred in each country.

Sources: Authors' calculations from BSG (2021) and JHU (2021).

The responses in each country indicate how rapid, systematic interventions could substantially contain COVID-19 transmission. In the beginning, clearer variation can be seen across countries. However, these disparities may be less pronounced across time, as each country stepped up its response based on circumstances.

Figure 1 indicates that China, the Philippines, Singapore, Taiwan, Thailand, and Viet Nam have been experiencing declining trends, low numbers, or no new COVID cases. Indonesia, Japan, and Malaysia, however, are experiencing increasing trends of 2,000–8,000 new cases per day. Hong Kong and Korea have fluctuating patterns, but the number of new cases per day in both is less than 1,200, lower than Indonesia, Japan, and Malaysia. In terms of per capita numbers, China, Taiwan, and Viet Nam have recorded the lowest total numbers per 1 million population (Table A3 in the appendix).

China and Hong Kong enacted lockdown or movement control orders since January 2020; followed by Korea and Viet Nam in February 2020; while Indonesia, Japan, and Singapore implemented movement restrictions in March 2020. Viet Nam responded very quickly by cancelling all flights from and to Wuhan when the first COVID-19 case was confirmed in Viet Nam on 23 January and closed most borders 2 weeks after that. China, Hong Kong, Korea, and Viet Nam, which adopted earlier lockdown or movement control orders, have performed better in managing the virus's community transmissions. However, for Hong Kong, there was a spike in the numbers of infection cases at the end of 2020 (Table A3 and Figure A1 in the appendix).

Countries have also learned from prior epidemic experience. Taiwan – with the highest global mortality rate from the severe acute respiratory syndrome (SARS) epidemic in 2003 at 21.2% – established a streamlined disaster management system for pandemics and epidemics that integrates information from health care systems, the immigration department, and custom authorities as part of the Taiwan Centers for Disease Control mandate (Fitzgerald and Wong, 2020). Taiwan is also equipped with contact tracing protocols to manage medical equipment availability. It has thus been able to suppress the transmission of COVID-19 without a national or regional lockdown, although Taiwan quickly ended travel to and from Wuhan on 23 January. Similarly, Korea's Disease Control and Prevention Agency helped quickly strengthen that country's border and contract tracing system like Taiwan. Korea also has one of the most comprehensive COVID-19 testing programmes in the world (Penn, 2020).

Prior epidemic experience and current culture also influence people in Asia to be more receptive to wearing face masks than their Western counterparts. Face masks are mandatory in six Asian countries (i.e. Hong Kong, Indonesia, Malaysia, Philippines, Singapore, and Thailand) and are recommended or required in specific places in China (e.g. Wuhan) and in Japan, Taiwan, and Viet Nam. In Taiwan, the government has even banned the export of masks as they are considered essential items for the population; it also increased the country's mask production in April (Wang, 2020).

Imperial College London created a COVID-19 Behaviour Tracker, which includes mask use compliance. Singapore recorded the highest compliance rate, with 93% of respondents indicating that they always use face masks outside of their homes. In comparison, Malaysia recorded the lowest compliance rate at 76%. These differences may also be reflected in Figure 1, which shows that Singapore has been experiencing fewer new cases while Malaysia has been experiencing the opposite trend. This fact has encouraged the Ministry of Health of Malaysia to recommend postponing all large-scale events and mass gatherings related to religious or cultural ceremonies in the country.

However, the association between mask use and growing case numbers is mixed. Although mask wearing is only recommended in Japan, the data there showed that the mask use compliance rate is high, with 83% of respondents indicating that they prefer to wear masks. However, as indicated earlier, Japan's new infection rate has been increasing, with some stating that it is a third wave.

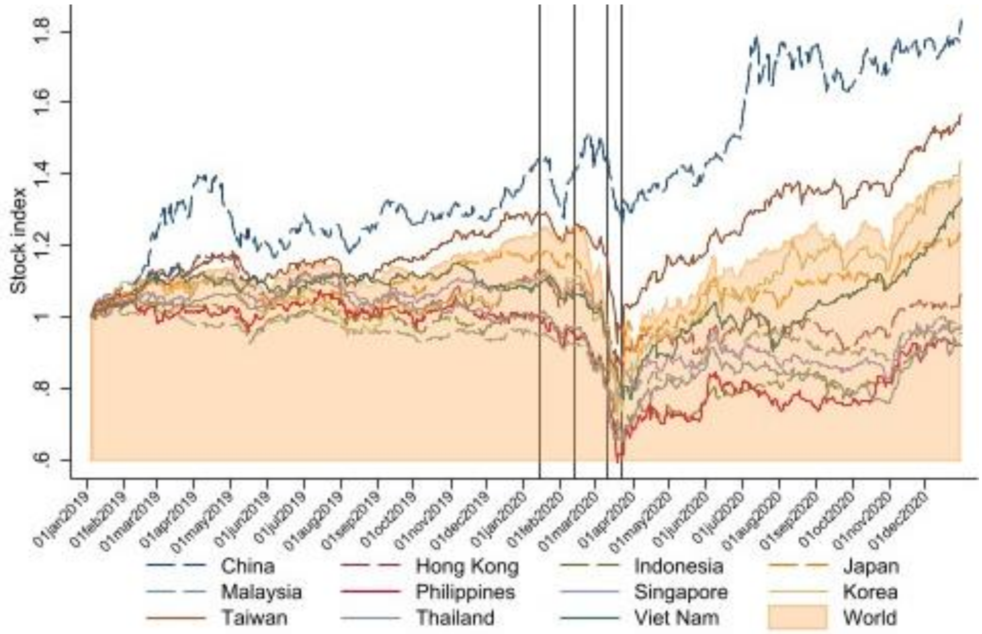
In some countries, such as Indonesia, it has been challenging to ensure that the COVID-19 response works due to limited health care facilities, low testing rates, and inconsistency between the central and regional governments in their policies (Fitzgerald and Wong, 2020; Noer, 2020). Despite high mask use compliance at 80% (Table A3 of the appendix), there is still a lack of participation from the community in preventive actions, particularly poor enforcement of large-scale social restrictions (Sutarsa, Wirawan, and Astuti, 2020). People returned to their hometowns during Eid al-Fitr celebrations in May 2020 or during the end-of-year holiday, which has further grown the number of cases in this country.

Thus, although some countries have performed worse than others, preliminary observations show that policy interventions, combined with citizen efforts, have helped manage the spread of COVID-19 in the region.

5.2. Stock Market Returns and Government Interventions

Figure 2 shows the variations in main stock indices in East and South-East Asia before and during the COVID-19 pandemic. From this figure, investors from the region and worldwide have been affected by the outbreak news since January 2020. The first three straight lines in Figure 2 mark 13 January, when the first COVID-19 case was identified outside of China; 14 February, when the Director-General of WHO gave a brief on the COVID-19 outbreak; and 11 March, when WHO declared COVID-19 a global pandemic. Right after these announcements, stock market prices dropped immediately. Especially on 12 March, stock markets worldwide suffered the most extraordinary single-day fall since the stock market crashed in 1987. As fears and news about the virus continued with new cases of infection increasing exponentially and the virus rapidly spreading worldwide, the stock market hit its trough on 23 March (i.e. the fourth straight line in Figure 2) when all stock indices fell to their lows.

Figure 2: Variations in Stock Markets in South-East and East Asia before and during the COVID-19 Pandemic, 2019–2020



Notes:

1. The indices are normalised at the value of 1 on the trading day of 4 January 2019. Each country tends to have one major stock market. As shown in Table 1, two main stock markets are selected in China and Viet Nam. Therefore, the averages of these two markets in each country are taken.
2. Missing values of stock market indices using Equation (8) are input.

Sources: Authors' calculations from Investing.com (2021).

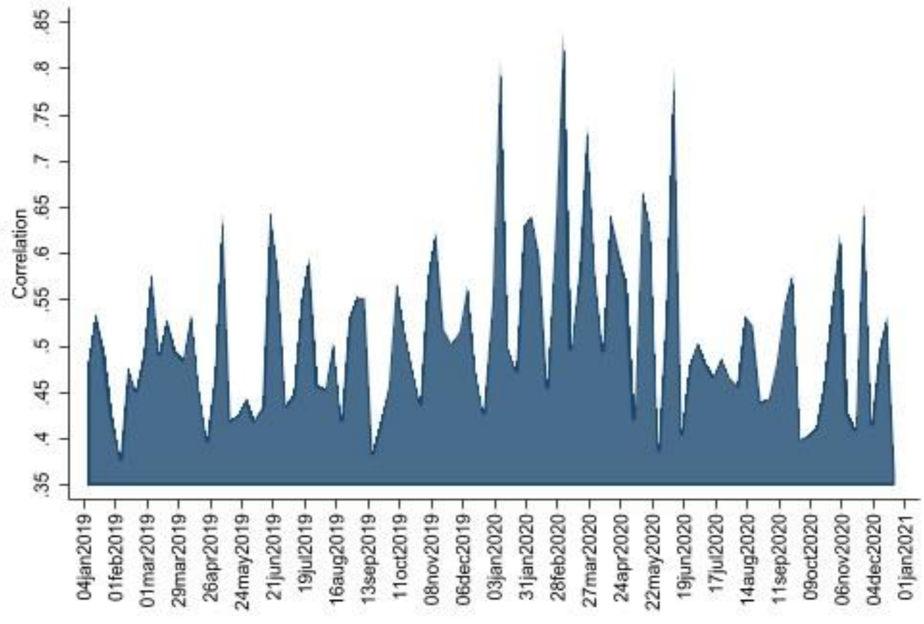
On 23 March, the United States Federal Reserve Board undertook several actions to provide liquidity to banks and businesses. It dropped the Federal Funds Rate to virtually 0%. As the lender of last resort, it reinstituted several global financial crisis-era programmes to support smooth market functioning further and to facilitate credit availability to businesses and households. The region's stock markets and the Dow Jones Global Indexes thus began rising.

During the second half of 2020, stock indices become more diverted from the global one, which suggests some impact of government interventions in each country, combined with economic support policies to lessen the pandemic's negative impact on the economy. China and Taiwan's stock markets performed much better than those of other Asian countries and worldwide, possibly because both countries controlled the pandemic successfully during this period. Similarly, Viet Nam, which also controlled the pandemic effectively, has experienced more rapid growth in its stock markets since August 2020 when daily cases of COVID-19 begun staying low.

Thus, in Figure 2, investor herding behaviour is observed in the first half of 2020, when the pandemic began. Although various countries have faced different situations regarding COVID-19, their stock markets had similar movements during this period, which seemed to be driven by the evolving reactions of other investors to the pandemic news.

Therefore, to investigate the regional integration of stock markets, the global factor is removed by regressing the individual stock returns on the global one and obtaining the residuals, which show the part from the total returns attributed to factors other than common global impacts. These filtered returns are then used to investigate the relationships amongst local stock market returns, free from the disturbances of common global stock market impacts in the region.

Figure 3: Weekly Return Correlations amongst East and South-East Asia Markets



Sources: Authors' calculations from Investing.com (2021).

The correlations are verified to illustrate the systematic reaction to the COVID-19 pandemic. Figure 3 plots weekly return correlations amongst the region, showing that correlations are relatively low (i.e. between 0.4 and 0.6) in 2019. They became characterised by more frequent and larger price swings during the onset of the pandemic, with the correlation ranging between 0.5 and 0.8. At that time, all countries tended to experience social distancing for the first time, and investor sentiment also seemed to oscillate between ups and downs throughout April and May. This likely points towards the optimism found in government measures in these countries.

Later in the pandemic, the correlation returns to the previous trend. This supports the intuition observed in Figure 2, with herding behaviour shown more clearly at the beginning of the pandemic when people were trying to learn about this shock. Most investors could not handle it immediately and thus followed other people's actions. In the second half of the year, however, government responses to the pandemic may have mitigated herding behaviour. For example, income support and debt relief can contribute to investors' information sets, which can potentially trigger no-herding or anti-herding effects.

6. Results

6.1. Impact of Government Responses on Pandemic Spread

The impact of the overall government response index is first examined, measured by Equation (9), through the growth rate of COVID-19 cases, or $\Delta C_{c,t}$ in Equation (1), in multiples of 7-day rolling windows. The results are reported in Table A4 in the appendix. The estimated coefficients of the overall government response index are negative and significant in almost all models, except for the first one, implying the need to use the government measure variable with a longer lag to allow enough time for the pandemic to respond to a policy intervention. When comparing other models, the highest values of R^2 and adjusted R^2 are observed in the third model, which supports the selection of 2 weeks as the most effective period for the pandemic to respond to interventions.

Table 2 reports results on different samples and dependent variables measured by various methods. The estimated coefficient of the overall government response index is negative and significant; an increase in the index by 10 points reduces the 14-day growth rate of new COVID-19 cases by 44 percentage points for the first aggregated intervention index or 32 percentage points for the second index. This coefficient increases slightly (48 percentage points in the first index and 35 in the second index) when China is excluded from the sample. The robustness in the results supports the hypothesis that stricter interventions help mitigate the severity of COVID-19 pandemic significantly.

Table 2: Estimated Impact of Overall Government Response Index on COVID-19 by Different Samples and Dependent Variables

	Addition	**Addition**	**PCA**	**PCA**
Government response index	–4.414***	–4.790***	–3.232***	–3.506***
	(0.262)	(0.266)	(0.194)	(0.194)
Constant	0.222	0.601***	0.034	0.379***
	(0.150)	(0.139)	(0.156)	(0.144)
14-day cases in the last 2 weeks	Yes	Yes	Yes	Yes
Daily time	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes
Including China	Yes	No	Yes	No
Number of observations	3,307	2,990	3,307	2,990
F-statistics	46.69***	45.37***	45.46***	43.96***
Adjusted R^2	0.205	0.220	0.205	0.217

PCA = Principal Component Analysis.

Notes:

1. The dependent variables in all columns are the growth rates of COVID-19 new cases over the past 14 days, starting from the first 100 cases.
2. The government response index is calculated by simple addition using Equation (6) (columns 1 and 2) or PCA (columns 3 to 4) from different policy measures reported on the last day 14.
3. The samples in columns 1 and 3 include all 11 countries, while the samples of columns 2 and 4 exclude China of which data are not available for the beginning of its outbreak.
4. All models control for the 14-day new cases reported in the last 2 weeks, daily time and country fixed effects.
5. Standard errors are in parenthesis: $^{***}p \leq 0.01, ^{**}p \leq 0.05, ^{*}p \leq 0.10$. Heteroskedastic-robust standard errors are applied.

Source: Authors' calculations from BSG (2021) and JHU (2021).

To determine the interventions that reduce COVID-19 transmission, the aggregated index is broken down into a set of measure categories, which are listed in Table A1 in the appendix, through various dummy variables and running the regression Equation (1). The importance of a measure is also examined by decomposing goodness of fit (R^2) according to Shapley and Owen values (Huettner et al., 2012). Table 3 reports the results of Equation (1) for the whole sample (the year 2020) and two sub-samples (from January to June and from July to December 2020). The contribution of each government intervention is also presented in this table with the estimated coefficients. A policy having a negative and statistically significant coefficient – as well as a higher contribution – means a more important role in reducing COVID-19.

Table 3: Estimated Impact of Specific Government Interventions on COVID-19 in the Region, 2020

	Full Year	**%**	**First Half**	**%**	**Second Half**	**%**
School closure		**5.44**		**5.13**		**5.35**
Require closing some levels	0.368***	1.95	1.856***	3.18	–0.008	1.04
	(0.086)		(0.395)		(0.051)	
Require closing all levels, targeted	0.185*	0.39	1.544***	0.98	–0.311***	2.73
	(0.109)		(0.299)		(0.101)	
Require closing all levels, general	–0.131	3.11	1.590***	0.98	–0.291***	1.58
	(0.139)		(0.368)		(0.102)	
Workplace closure		**4.48**		**3.98**		**7.75**
Recommend closing workplace	–0.399***	0.80	–1.709***	1.65	–0.031	1.21
	(0.111)		(0.300)		(0.124)	
Require closing some sectors, targeted	–0.065	0.57	–0.361	0.61	–0.134	1.31
	(0.145)		(0.396)		(0.170)	

	Full Year	%	First Half	%	Second Half	%
Require closing some sectors, general	–0.058	0.82	–0.290	0.63	0.032	1.34
	(0.149)		(0.220)		(0.162)	
Require closing all-but-essential sectors	0.056	2.29	–0.300	1.10	–0.087	3.89
	(0.159)		(0.274)		(0.187)	
Public event cancellation		**3.50**		**2.33**		**9.02**
Recommend cancelling public event	–0.067	0.62	–0.390	0.39	–1.060***	1.94
	(0.179)		(0.452)		(0.212)	
Require cancelling public event, targeted	0.038	0.58	0.178	1.19	–1.239***	4.74
	(0.193)		(0.489)		(0.205)	
Require cancelling public event, general	–0.851***	2.30	–0.688	0.74	–1.438***	2.34
	(0.190)		(0.531)		(0.234)	
Gathering restriction		**8.75**		**9.51**		**10.32**
Restriction on gatherings 101–1,000 people	–0.419***	1.02	–0.775**	0.55	–0.914***	2.07
	(0.130)		(0.320)		(0.241)	
Restriction on gatherings 11–100 people	0.115	1.94	–0.546	1.30	–0.372**	3.79
	(0.155)		(0.350)		(0.188)	
Restriction on gatherings of 10 people or less, targeted	–0.826***	2.69	–2.487***	3.52	–0.678***	2.69
	(0.182)		(0.815)		(0.209)	
Restriction on gatherings of 10 people or less, general	–1.559***	3.10	–2.817***	4.14	0.000	1.76
	(0.235)		(0.461)		(.)	
Public transport closure		**3.62**		**5.37**		**5.20**
Recommend closing public transport	0.487***	1.55	1.607***	3.12	0.126***	2.00

	Full Year	%	First Half	%	Second Half	%
	(0.088)		(0.257)		(0.047)	
Require closing public transport	-0.215	2.07	–0.306	2.25	0.168**	3.20
	(0.144)		(0.391)		(0.080)	
Stay-at-home requirement		**4.23**		**5.29**		**7.32**
Recommend not leaving house	– 0.708***	2.45	– 1.123***	2.35	–0.873***	4.48
	(0.115)		(0.252)		(0.085)	
Require not leaving house with more exceptions	– 0.717***	0.84	-0.047	1.05	-0.740***	2.05
	(0.163)		(0.491)		(0.082)	
Require not leaving house with minimal exceptions	0.099	0.95	1.286**	1.89	–0.232***	0.79
	(0.176)		(0.575)		(0.094)	
Internal travel control		**3.23**		**3.83**		**5.36**
Recommend not to travel between regions	0.294***	0.91	1.490***	0.76	0.188***	3.55
	(0.082)		(0.352)		(0.067)	
Require internal travel controls, targeted	0.333***	1.03	1.159**	1.56	0.384***	1.28
	(0.108)		(0.512)		(0.084)	
Require internal travel controls, general	1.132***	1.29	1.899***	1.51	0.572***	0.52
	(0.182)		(0.352)		(0.139)	
International travel ban		**5.76**		**8.83**		**0.82**
Ban on arrivals from some countries	0.080	1.72	0.385	4.14	–0.076*	0.44
	(0.068)		(0.301)		(0.044)	
Ban on arrivals from all countries	– 0.595***	4.04	– 1.972***	4.69	–0.147**	0.38
	(0.125)		(0.320)		(0.071)	
Income support		**4.88**		**8.25**		**4.25**

	Full Year	%	First Half	%	Second Half	%
Support less than 50% of lost salary, targeted	–0.589***	1.11	–1.839***	1.28	–0.231***	0.98
	(0.157)		(0.340)		(0.082)	
Support less than 50% of lost salary, general	–1.303***	2.49	–2.748***	5.46	0.299***	0.83
	(0.144)		(0.268)		(0.106)	
Support 50% or more of lost salary	–0.573***	1.28	–1.250***	1.51	0.098	2.45
	(0.162)		(0.308)		(0.186)	
Debt relief		**2.58**		**1.05**		**1.09**
Relief to specific debt	0.392***	1.54	–0.257	0.46	0.506***	0.61
	(0.145)		(0.259)		(0.116)	
Relief to broad debt	0.352**	1.04	–0.500***	0.59	0.378***	0.48
	(0.146)		(0.187)		(0.118)	
Testing policy		**1.76**		**2.64**		**6.34**
Test those with symptoms	–0.185	0.81	–0.331	1.01	2.046***	4.02
	(0.143)		(0.278)		(0.250)	
Open public testing	0.093	0.95	–0.255	1.63	1.298***	2.32
	(0.175)		(0.309)		(0.238)	
Contact tracing		**1.16**		**1.65**		**1.64**
Comprehensive contact tracing	–0.118	1.16	0.219	1.65	0.441***	1.64
	(0.099)		(0.336)		(0.066)	
Facial covering		**3.49**		**7.91**		**5.96**
Require facial covering in some public spaces	–0.473***	1.16	–0.066	1.44	–0.593***	3.60
	(0.116)		(0.234)		(0.102)	
Require facial covering in all public spaces	–0.761***	1.45	–2.653***	5.58	–0.474***	1.17
	(0.164)		(0.596)		(0.103)	
Require facial covering in all spaces at all time	–0.812***	0.88	–1.132*	0.89	–0.346**	1.19

	Full Year	%	First Half	%	Second Half	%
	(0.305)		(0.653)		(0.172)	
Constant	–0.600**		–2.892***		–0.853**	
	(0.254)		(0.602)		(0.366)	
14-day cases in the last 2 weeks	Yes	2.82	Yes	4.22	Yes	1.22
Daily time	Yes	11.88	Yes	5.29	Yes	6.78
Country fixed effects	Yes	32.42	Yes	24.72	Yes	21.57
Number of observations	3,307		1,283		2,024	
F-statistics	24.46***		22.29***		43.54***	
Adjusted R^2	0.338		0.460		0.374	

Notes:

1. The dependent variables in all columns are the growth rates of new COVID-19 cases over the past 14 days, starting from the first 100 cases (columns 1, 3, 5).
2. All government measures are reported on the date of the last 2 weeks.
3. All models control for the 14-day new cases reported in the last 2 weeks, daily time, and country fixed effects.
4. Standard errors are in parenthesis. Contribution of each factor to ^2$ are in columns of percentage. $^{***}p \leq 0.01$, $^{**}p \leq 0.05$, $^{*}p \leq 0.10$. Heteroskedastic-robust standard errors are applied.

Source: Authors' calculations from BSG (2021) and JHU (2021).

The overall R^2 of the model is 0.338 when examining the entire period. More than 30% – or 11% of the entire variation in $\Delta C_{c,t}$ – is attributed to specific country fixed effects, which capture the degree of compliance of the population in each country. This means that the local context in each country moderately influenced the effectiveness of an intervention. Government measures play the most important roles, accounting for approximately half of the model's explained variance. When examining two sub-samples in the first and second halves of 2020, changes in the COVID-19 growth rates are explained by the model, with R^2 = 0.460 or 0.374, respectively, and by the changes in government measures (66% and 70% of explained variance).

Further decomposition of the R^2 share of the COVID-19 growth rates reveals that the most effective interventions were restricting places where people gather in smaller or large numbers for an extended period, denoting a 9%–10% share of the overall R^2. Smaller group restrictions seem to have worked better during the first half of 2020. In the second half of 2020, cancellation of public events also contributed a marginally similar magnitude (9%) to R^2. Stricter and broader coverage of a ban on public events became more useful to delay the spread of the virus. Similarly, a mask requirement proves a moderate role in combating a resurgence throughout the year, with attribution of 6%–8% to R^2. These results are in line with Kenyon (2020) and Leffler et al. (2020), who found that COVID-19 transmission was 7.5 times higher in countries without a mask mandate.

Moderate support is found for the effectiveness of total border closures in flattening the COVID-19 growth curve where international travelling was a central factor in spreading disease during the SARS epidemic (Brockmann and Helbing, 2013). However, earlier in the COVID-19 pandemic, border shutdowns were much more effective, explaining about 5% of R^2, rather than later (i.e. less than 1%). This finding is similar to some studies (e.g. Russell et al., 2021) that found that travel restrictions in the early part of the epidemic helped delay its spread, possibly because many more cases resulted from local transmission compared to imported cases later in the pandemic. By contrast, this fact can explain why some policies seem to work more effectively in the second half of 2020. For example, school closure or stay-at-home orders have negative and statistically significant coefficients at almost all levels and contribute 5.3%–7.3% to R^2 later in the pandemic. Similar findings on school closure measures are found in Liu et al. (2021) and Auger et al. (2020).

For lockdowns or stay-at-home orders, recommendations – not bans – become more effective in mitigating virus spread in both periods. Recommendations on workplace closures demonstrate a similar finding. These interventions, known as risk communication strategies, are non-binding government advice in contrast to mandatory social distancing measures that are often enforced by the police, military, and/or sanctions. The outcome supporting the effectiveness of these interventions is in line with Haug et al. (2020) and are considered less costly.

Government income support programmes helped mitigate the COVID-19 pandemic in the first half of 2020 as evidenced by negative, large, and statistically significant coefficients and the considerable contribution to R^2 of 8.3%. Debt relief also played a similar role, although at a smaller scale during this period. Both measures impacted the socio-economic sphere (Gentilini et al., 2020) and positively affected public health. With these measures, facilitating people's access to COVID-

19 tests or allowing them to self-isolate without fear of losing their jobs or part of their salaries may have helped reduce virus spread (Haug et al., 2020).

However, this changed in the second half of 2020, with positive and statistically significant coefficients. One reason can be both support programmes were implemented at all times during this period; there were only 6% and 1% observations in the sub-samples without a government support programme (Table A1 in the appendix), making it difficult to differentiate the impact between scenarios with and without a government support programme. Another reason stems from a more severe unemployment and underemployment issue; government support levels were much lower than expected, pushing vulnerable peoples to break restriction rules.

Other policies, including those involving COVID-19 testing and contact tracing, are associated with higher COVID-19 growth rates in the second half of 2020, as these coefficients are statistically significant and positive. A reasonable explanation of R^2 is in regard to testing policies, that is, better coverage in tests and more comprehensive contact tracing rules later in the pandemic may have led to a better chance of identifying COVID-19 cases and, hence, a short-term increase in confirmed cases. Internal travel control and public transport closures also show positive correlations with COVID-19 growth rates in both periods, reflecting their ineffectiveness, in line with Islam et al. (2020). A heightened public risk awareness associated with commuting (e.g. people being more likely to wear masks) may have contributed to this finding (Liu and Zhang, 2020).

6.2. Impact of Government Responses on the Stock Market Index

The effects of government responses to COVID-19 on herding behaviour are tested by running Equation (2). This regression assumes that the effects of government and regulatory responses do not vary across different parts of the distribution of $CS_{c,t}$ values, which may be overly restrictive during the pandemic when abrupt changes in herding behaviour in international stock markets become common. To relax this assumption, a quantile regression model was employed, which was introduced by Koenker and Bassett (1978) and used to study herding behaviour in Gębka and Wohar (2013) and Kizys, Tzouvanas, and Donadelli (2021). While the original method estimates the average relation between the dependent and explanatory variables, a quantile regression allows estimating such a relation at specific quantiles of the distribution of the dependent variable.

Concretely, coefficients that describe 5%, 25%, 50%, 75%, and 95% of the conditional distribution are thus investigated.

Table 4: Impact of Government Interventions on the Regional Stock Market

	CSSD	**CSSD**	**CSSD**	**CSAD**	**CSAD**	**CSAD**
Daily world stock market return	0.496***	0.465***	0.209***	0.348***	0.330***	0.139***
	(0.025)	(0.029)	(0.030)	(0.018)	(0.021)	(0.020)
Daily world stock market return, squared	–0.031***	–0.031***	–0.068***	–0.021***	–0.022***	–0.048***
	(0.004)	(0.004)	(0.012)	(0.003)	(0.003)	(0.008)
Government response index	0.787***	1.304***	0.423***	0.564***	0.918***	0.305***
	(0.066)	(0.077)	(0.097)	(0.047)	(0.054)	(0.068)
Constant	0.680***	0.371***	0.759***	0.477***	0.314***	0.539***
	(0.047)	(0.070)	(0.064)	(0.033)	(0.049)	(0.044)
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Period	Year 2020	1–6/2020	7–12/2020	Year 2020	1–6/2020	7–12/2020
Number of observations	3,784	1,760	2,024	3,784	1,760	2,024
F-statistics	74.22***	57.67***	47.26***	72.33***	55.72***	58.55***
Adjusted R^2	0.262	0.258	0.225	0.256	0.248	0.263

CSAD = cross-sectional absolute deviation, CSSD = cross-sectional standard deviation.

Notes:

1. The coefficients are estimated using Equation (2).
2. CSSD is computed using Equation (3).
3. CSAD is computed using Equation (4).
4. The government response index is measured by Equation (9).
5. Standard errors are in parenthesis. $^{***}p \leq 0.01,^{**} p \leq 0.05,^{*} p \leq 0.10$. Heteroskedastic-robust standard errors are applied.

Source: Authors' calculations from BSG (2021) and Investing.com (2021).

Table 4 reports estimation results. The results from the first and second rows in all models indicate the existence of herding behaviour, as the variable R_m^2 exerts a negative and statistically significant effect on both CSSD and CSAD.

The coefficients of the government response index in all models are positive and statistically significant. This entails that a more stringent government response – which translates into larger values of the index – is associated with larger values of CSSD and CSAD. For instance, the estimated coefficient of α_3 in model 1 is 0.787, implying that that a 10-point increase in the stringency degree of government response raises the daily cross-sectional standard deviation by approximately eight percentage points. This supports the notion that more stringent government responses mitigate investor herding behaviour, especially early in the pandemic. These findings are in line with the hypothesis of Avery and Zemsky (1998) and the empirical results by Kizys, Tzouvanas, and Donadelli (2021) of which government responses can reduce multidimensional uncertainty surrounding the pandemic, effectively limiting investor herding behaviour.

Table 5: Impact of Government Interventions on Regional Stock Markets Using Quartile Regression

	All	**q05**	**q25**	**q50**	**q75**	**q95**
Daily world stock market return	0.496***	0.095***	0.170***	0.233***	0.537***	1.301***
	(0.025)	(0.019)	(0.017)	(0.024)	(0.064)	(0.108)
Daily world stock market return, squared	–0.031***	0.002	–0.002	0.010	–0.022*	–0.121***
	(0.004)	(0.003)	(0.004)	(0.009)	(0.013)	(0.011)
Government response index	0.787***	0.419***	0.604***	0.740***	0.999***	1.908***
	(0.066)	(0.055)	(0.027)	(0.035)	(0.053)	(0.331)
Constant	0.680***	0.342***	0.402***	0.492***	0.455***	0.426
	(0.047)	(0.066)	(0.018)	(0.027)	(0.050)	(0.275)
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	3,784	3,784	3,784	3,784	3,784	3,784
R^2	0.265	0.118	0.135	0.163	0.207	0.191

CSSD = cross-sectional standard deviation, q = quantile.

Notes:

1. The coefficients are estimated using Equation (2).
2. The dependent variable is the CSSD and is computed using Equation (3).
3. The government response index is measured by Equation (9).
4. Standard errors are in parenthesis: $^{***}p \leq 0.01$, $^{**}p \leq 0.05$, $^{*}p \leq 0.10$. The heteroskedastic-robust standard errors are applied.

Source: Our calculation from BSG (2021) and Investing.com (2021).

Table 5 summarises the results of the quantile regression. In this table, only the results for CSSD are reported at the 5%, 25%, 50%, 75%, and 95% quantiles of the conditional distribution. Lower quantiles denote lower $CSSD$ and thus higher levels of herding behaviour, whereas upper quantiles indicate higher deviations from the market return and thus lower levels of herding behaviour (Gębka and Wohar, 2013). The effects of the government intervention index are always positive and significant, taking on larger values in markets with lower levels of herding behaviour. This means that more stringent government responses are conducive to lower herding behaviour, and government responses are more effective at lower levels of herding behaviour.

Table 6: Stringency Index Components on Herding Behaviour in the Region, 2020

	Full Year	**%**	**First Half**	**%**	**Second Half**	**%**
World stock market return		**19.80**		**13.52**		**3.03**
Daily world stock market return	0.222***	14.27	0.204***	9.69	0.117***	2.12
	(0.022)		(0.026)		(0.025)	
Daily world stock market return, squared	–0.010***	5.52	–0.012***	3.83	–0.034***	0.91
	(0.004)		(0.004)		(0.010)	
School closure		**10.20**		**4.50**		**4.60**
Require closing some levels	0.032	0.62	–0.457***	0.75	0.031*	1.66
	(0.031)		(0.079)		(0.018)	
Require closing all levels, targeted	0.139***	1.01	0.162**	0.52	0.078***	1.26
	(0.040)		(0.081)		(0.028)	
Require closing all levels, general	0.388***	8.57	0.330***	3.23	0.064*	1.68
	(0.044)		(0.074)		(0.039)	
Workplace closure		**4.69**		**10.60**		**4.86**
Recommend closing workplace	0.189***	0.93	0.655***	6.71	–0.092***	1.31

	Full Year	%	First Half	%	Second Half	%
	(0.067)		(0.107)		(0.038)	
Require closing some sectors, targeted	–0.041	0.62	–0.368***	0.53	–0.123**	1.22
	(0.076)		(0.115)		(0.052)	
Require closing some sectors, general	–0.253***	2.16	–0.631***	2.54	–0.062	0.82
	(0.071)		(0.094)		(0.054)	
Require closing all-but-essential sectors	–0.104	0.97	–0.438***	0.81	–0.255***	1.50
	(0.083)		(0.111)		(0.058)	
Public event cancellation		**14.32**		**22.01**		**8.99**
Recommend cancelling public event	0.737***	3.16	0.655***	3.66	–0.504***	2.45
	(0.066)		(0.081)		(0.059)	
Require cancelling public event, targeted	1.033***	7.17	1.863***	13.21	–0.208***	4.91
	(0.078)		(0.113)		(0.054)	
Require cancelling public event, general	0.854***	3.99	1.317***	5.14	0.007	1.62
	(0.071)		(0.120)		(0.053)	
Gathering restriction		**3.55**		**6.73**		**13.72**
Restriction on gatherings of 101–1,000 people	0.204***	0.54	0.343***	3.29	0.444***	1.23
	(0.083)		(0.114)		(0.095)	
Restriction on gatherings of 11–100 people	0.494***	1.14	0.625***	0.99	0.116*	2.20
	(0.075)		(0.111)		(0.071)	
Restriction on gatherings of 10 people or less, targeted	0.183**	0.85	–0.549***	2.01	0.683***	8.32
	(0.082)		(0.181)		(0.083)	
Restriction on gatherings of 10 people or less, general	0.079	1.02	0.156	0.44	0.000	1.97

	Full Year	**%**	**First Half**	**%**	**Second Half**	**%**
	(0.087)		(0.121)		(.)	
Public transport closure		**1.25**		**1.69**		**3.72**
Recommend closing public transport	0.030	0.59	0.036	0.74	0.044*	0.38
	(0.036)		(0.076)		(0.024)	
Require closing public transport	0.174***	0.66	0.280***	0.95	–0.103***	3.34
	(0.055)		(0.090)		(0.035)	
Stay-at-home requirement		**3.02**		**3.61**		**6.36**
Recommend not leaving house	-0.127***	1.06	–0.388***	1.30	–0.180***	2.19
	(0.042)		(0.084)		(0.036)	
Require not leaving house with more exceptions	–0.049	0.83	–0.056	0.79	–0.035	0.89
	(0.052)		(0.124)		(0.032)	
Require not leaving house with minimal exceptions	0.193***	1.13	0.420***	1.52	0.082**	3.27
	(0.063)		(0.138)		(0.037)	
Internal travel control		**1.95**		**3.12**		**5.64**
Recommend not to travel between regions	–0.103**	0.28	0.184**	1.67	0.270***	3.38
	(0.043)		(0.092)		(0.029)	
Require internal travel controls, targeted	–0.301***	0.63	–0.629***	0.92	0.067***	1.21
	(0.052)		(0.133)		(0.024)	
Require internal travel controls, general	–0.137***	1.04	–0.350***	0.53	–0.152***	1.04
	(0.053)		(0.109)		(0.046)	
International travel ban		**1.18**		**3.08**		**0.56**
Ban on arrivals from some countries	–0.066**	0.51	–0.448***	1.57	–0.015	0.22
	(0.029)		(0.063)		(0.017)	

	Full Year	%	First Half	%	Second Half	%
Ban on arrivals from all countries	–0.225***	0.67	–0.886***	1.51	–0.015	0.35
	(0.042)		(0.080)		(0.029)	
Income support		**15.07**		**9.19**		**6.88**
Support less than 50% of lost salary, targeted	–0.120***	2.32	-0.305***	1.87	0.438***	3.48
	(0.049)		(0.073)		(0.055)	
Support less than 50% of lost salary, general	–0.746***	8.67	–0.492***	6.00	–0.129*	1.17
	(0.062)		(0.071)		(0.069)	
Support 50% or more of lost salary	–0.551***	4.09	0.103	1.32	0.234***	2.24
	(0.084)		(0.115)		(0.076)	
Debt relief		**7.00**		**2.79**		**2.05**
Relief to specific debt	–0.169***	3.22	0.457***	0.82	0.338***	0.90
	(0.051)		(0.100)		(0.053)	
Relief to broad debt	0.013	3.77	–0.328***	1.97	0.393***	1.15
	(0.054)		(0.073)		(0.056)	
Testing policy		**4.22**		**6.95**		**9.39**
Test those with symptoms	0.144***	2.43	0.381***	5.13	1.056***	5.21
	(0.044)		(0.068)		(0.074)	
Open public testing	–0.125**	1.79	–0.323***	1.82	0.858***	4.18
	(0.052)		(0.087)		(0.067)	
Contact tracing		**1.00**		**1.97**		**2.43**
Comprehensive contact tracing	0.233***	1.00	0.483***	1.97	–0.235***	2.43
	(0.050)		(0.075)		(0.038)	
Facial covering		**7.66**		**4.47**		**7.79**
Require facial covering in some public spaces	–0.032	1.17	0.797***	1.62	0.047**	0.77

	Full Year	%	First Half	%	Second Half	%
	(0.048)		(0.111)		(0.020)	
Require facial covering in all public spaces	–0.395***	2.60	–0.307**	0.87	0.110***	0.89
	(0.048)		(0.150)		(0.027)	
Require facial covering in all spaces at all time	–0.537***	3.89	–0.600***	1.98	–0.575***	6.13
	(0.064)		(0.102)		(0.071)	
Constant	0.765***		0.312***		0.590***	
	(0.058)		(0.073)		(0.127)	
Country fixed effects	Yes	5.10	Yes	5.77	Yes	19.99
Number of observations	3,784		1,760		2,024	
F-statistics	64.21***		74.26***		61.90***	
Adjusted R^2	0.522		0.628		0.494	

CSSD = cross-sectional standard deviation.
Notes:

1. The coefficients are estimated using Equation (2).
2. The dependent variable is computed using Equation (3).
3. Government response components are listed in Appendix 1 and used directly rather than sets of dummies.
4. Standard errors are in parenthesis: $^{***}p \leq 0.01, ^{**}p \leq 0.05, ^{*}p \leq 0.10$. Heteroskedastic-robust standard errors are applied.

Source: Authors' calculations from BSG (2021) and Investing.com (2021).

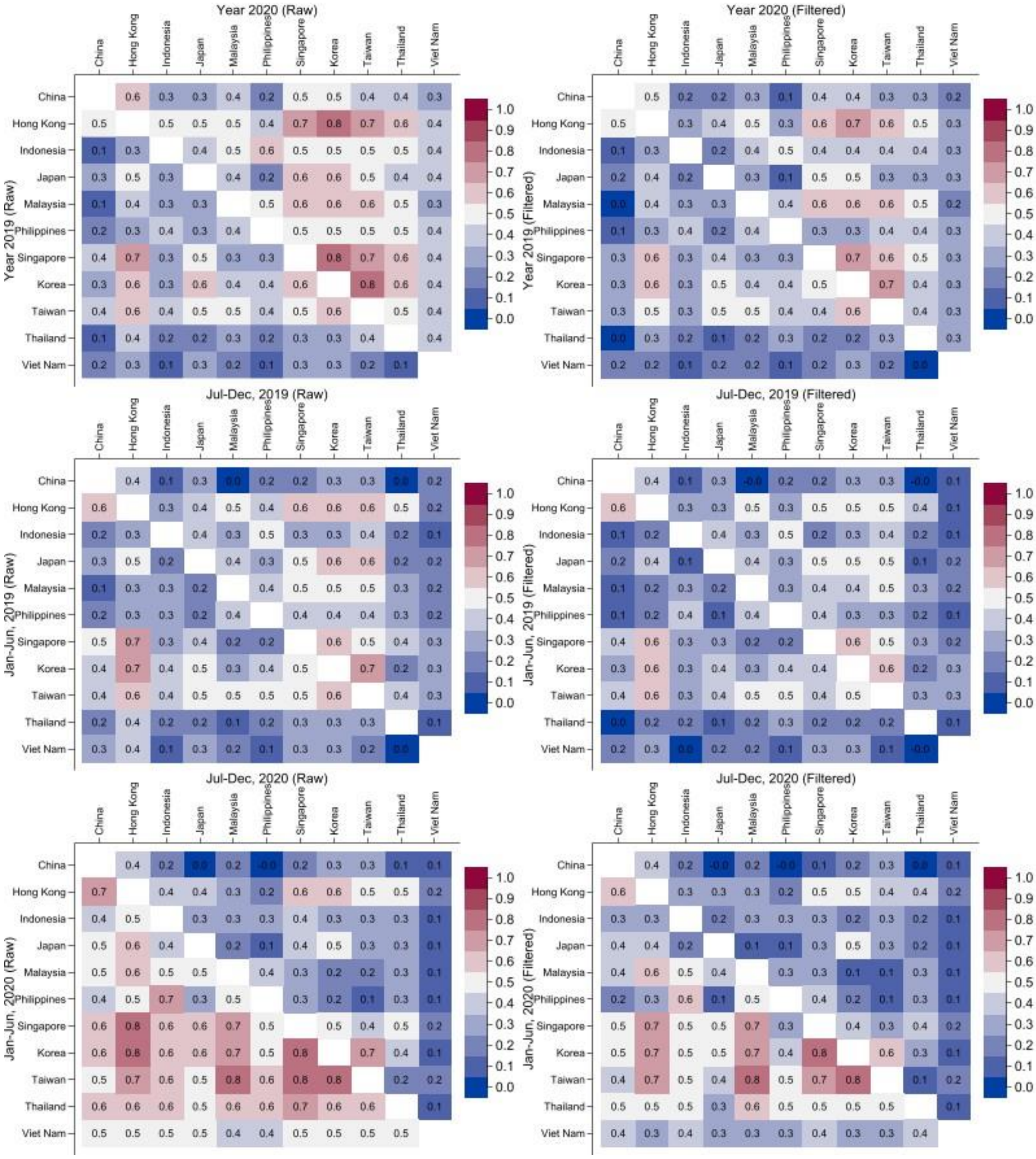
The government index is then decomposed into 13 components, and the results of Equation (2) is presented in Table 6. In this table, similar to Table 3, three columns are added of the contribution of each component to R^2. Investors tended to follow others' actions much more when the pandemic started rather than later (with a contribution of almost 14% to R^2 in the first half of 2020, compared to nearly 3% in the second half). Looking at the interventions, when governments closed schools at all levels, restricted gatherings, locked down or required people to stay home with minimal exceptions, recommended not travelling between regions within a country, and tested those with symptoms, investor herding decreased. Government income support programmes also helped mitigate investor herding behaviour seen later in the pandemic. This is because these measures aim to minimise the transmission of COVID-19 within countries, which is perceived by investors as positive news for both public health and long-term growth prospects. However, other interventions, including public event cancellations, required workplace closures, mask mandates, and contact tracing policies seem to have induced herding behaviour in the second half of 2020. Meanwhile, international travel bans tended to cause herding behaviour during the onset of the pandemic but no longer had a statistically significant impact in the second half of 2020.

6.3. COVID-19 and Stock Market Integration

In this section, a simple correlation analysis is extended to an MST, which was introduced in the methodology section to visualise the interdependence amongst regional stock markets. Leading stock markets – which play critical roles in connecting other markets in the network – are identified by the MST. The analysis is conducted for the full sample and two sub-periods, January to June 2020 and July to December 2020.

A correlation matrix by Pearson's rank correlation coefficients is constructed for the raw returns of regional stock markets, without filtering the effects of the world stock market. Then, Equation (7) is estimated to remove the impact of the global factor and to construct another correlation matrix for the filtered returns, that is, residuals from Equation (7).

Figure 5: Correlation of Regional Stock Markets before and during the Pandemic



Note: The actual returns are located on the left, while the filtered returns – residuals from estimation of Equation (7) – are on the right.
Source: Authors' calculations from Investing.com (2021).

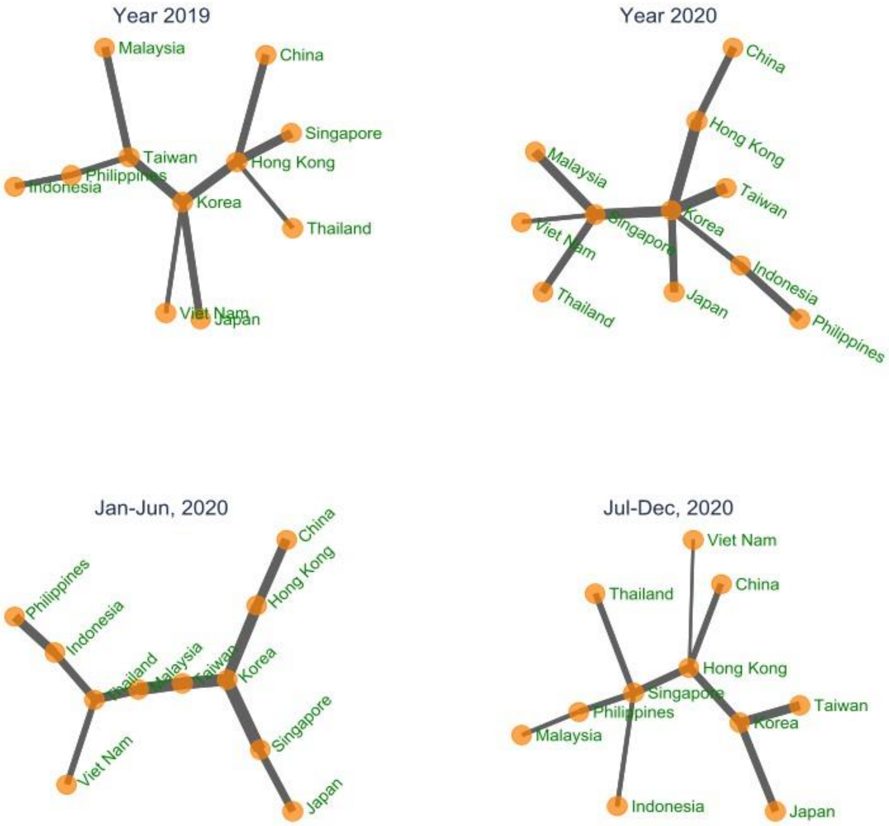
Figure 5 uses heat maps to visualise the pairwise dependences before the pandemic (2019) and during the pandemic (2020) and between the first and second halves of 2020. Darker red reflects higher correlation, while darker blue shows lower correlation. Diagonal elements represent self-correlations equalling 1 and are not shown. No negative correlations are found in the regional stock markets in the period.

Looking at the raw returns, China and Viet Nam are generally blue, reflecting a lower level of aggregated correlation with all other markets. In contrast, Hong Kong, Korea, Singapore, and Taiwan markets are redder, indicating that they are the most correlated markets and that their correlation is always highest, irrespective of sample period. However, the stock markets became more integrated when the COVID-19 crisis emerged (i.e. with more red). This trend is the same but at a smaller scale when the global factors are filtered.

When dividing the period into two halves, the early part of pandemic experienced more correlated stock markets, with darker red amongst raw returns. Pairwise linear correlations become higher between four main stock markets (i.e. 80% amongst Hong Kong, Korea, Singapore, and Taiwan) and between these markets with Malaysia. However, the correlation becomes lower later in the pandemic with darker blue. Comparing 2019, the correlations between two sub-periods look closer, different from 2020. These findings imply a short-term impact of a sudden shock on stock market integration in the region, but this impact tends to reduce quickly. Although the filtering process does not change these rankings, it systemically reduces the magnitude of pairwise correlations.

The distance matrix is then correlated for all pairwise markets using Equation (6), and an MST is constructed for the system. Figure 6 shows the four tree diagrams, presenting the full sample in each year and two sub-periods of 2020, based on filtered returns.

Figure 6: Minimum Spanning Tree Plots before and during the Pandemic



Note: The thicker lines mean a stronger correlation.
Source: Authors' calculations from Investing.com (2021).

The stock market with the highest degree of centrality is highlighted as the central node. Also, the shorter the pairwise distance, the thicker the edge between them. As seen in the top left of Figure 6, before the pandemic, Hong Kong, Korea, and Taiwan occupy central positions and are most connected. Korea is also connected with Japan and Viet Nam; Hong Kong is linked to China, Singapore, and Thailand; and Taiwan is linked to Malaysia and the Philippines. Indonesia, the Philippines, Thailand, and Viet Nam seem to have weaker connections.

Japan and China have insignificant roles in the network, although they are amongst the world's most important financial markets. These markets have low centrality and lower strength, which can be seen as more resilient to external shocks and may depend more on domestic conditions. This implies that market size is not a critical factor affecting a market's level of integration in the region.

The structure of regional stock markets has changed since the COVID-19 pandemic, although it maintains some pre-pandemic characteristics. Generally, the whole network seems more interconnected and centralised, with evidence of thicker edges in all connections. Korea became the main hub in the regional stock market network with five degrees of connections, an increase from four before the pandemic. It has expanded its network to Singapore, while changing its weak link from Viet Nam to Indonesia. Besides Korea, Singapore replaced Taiwan to become another central market during the pandemic. It is more connected with Malaysia, Thailand, and Viet Nam. Hong Kong is decoupled from Singapore and Thailand, despite their moderate correlations. This implies that some other correlations increased more than those pairs, making them less important during the crisis.

Regional network integration is different between the onset and later period of the pandemic. The whole network seems less compact early in the crisis, although higher connections are observed. The central role of Korea was maintained and strengthened by thicker-edge evidence, although the degrees of connection fall from four before the pandemic to three early in the pandemic. Meanwhile, Thailand appears to be important in this sub-period and emerge as a new central node, linking to three other markets in the region (i.e. Indonesia, Malaysia, and Viet Nam). More intermediate markets link these two hubs (i.e. Korea and Thailand) to others, including Singapore, Hong Kong, Indonesia, Malaysia, Singapore, and Taiwan. This may reflect that investors looked for an opportunity to diversify their portfolios during the crisis to mitigate the possibility of a domino effect, in which more interlinked stock markets carry higher risks.

Later in the pandemic, Hong Kong became the most connected market, with four degrees of connection, along with Korea and Singapore. The network seems to return to the one observed before the pandemic, except for Singapore, which replaces Taiwan to become a central market in the region. All edges are thinner compared to those in the onset of the pandemic, implying weaker regional connections. Indonesia and Malaysia, two countries hard hit by COVID-19 later in the pandemic, are less connected than before.

7. Conclusion

This study found that government interventions helped mitigate the severity of the COVID-19 pandemic significantly. Specifically, an increase in the government intervention index by 10 points reduced the 14-day growth rate of new COVID-19 cases by 32–44 percentage points. The impact is even higher when excluding China from the sample. During 2020, government measures played an important role, interpreting approximately half of the explained variation in the COVID-19 growth rates, almost 70% of R^2 for each sub-period of 2020. The local context also moderately influenced the effectiveness of interventions.

The model further revealed that the most effective interventions are gathering restrictions, public event cancellations, and facial covering requirements. Total border closures also showed moderate effectiveness in flattening COVID-19 growth, especially during the onset of the pandemic. Other policies, such as school closures or stay-at-home orders, worked effectively later in the pandemic, possibly because there were more cases due to local transmission. Some risk communication strategies, including recommendations on not leaving the house or closing workplaces, are suggested to be less costly but more effective as well.

In models examining the impact of government interventions on regional stock markets, herding behaviour was found, especially during the onset of the COVID-19 pandemic. This behaviour could be more serious without government intervention. More stringent government responses are conducive to lower herding behaviour, and government responses are more effective at lower levels of herding behaviour. The most effective interventions include school closures, gathering restrictions, stay-at-home requirements, recommendations on not travelling between regions within a country, and testing policies for those with symptoms. Government income support programmes also helped mitigate investor herding behaviour later in the pandemic.

Higher stock market integration was found during the onset of the pandemic compared to the periods before the pandemic and later in the pandemic. These findings imply the short-term impact of a sudden shock from COVID-19. Hong Kong, Korea, and Taiwan occupied the central positions before the pandemic and were most connected with each other. During the onset of the pandemic, Korea's central role was maintained and strengthened, while Thailand temporarily emerged as a new central node. The regional network seems less compact during this sub-period, although higher connections were observed, implying that investors tended to diversify their portfolios during the crisis to mitigate the possibility of a domino effect.

Later in the pandemic, Hong Kong became the most connected market, along with those of Korea and Singapore. The network seemed to return to that observed before the pandemic, except for Singapore, which replaced Taiwan as a central market in the region. However, connections within the region became weaker, especially for Indonesia and Malaysia. In all times, Indonesia, the Philippines, Thailand, and Viet Nam seemed to have fewer connections with regional stock markets. Japan and China also showed insignificant roles in the regional stock network.

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Table A1: Government Measures and Their Distributions, 2020

(%)

Indicator	Categories	2020	1st half	2nd half
School closure	0 - No requirement	38.5	20.8	49.7
	1 - Require closing some levels	19.8	10.9	25.4
	2 - Require closing all levels, targeted	13.9	13.6	14.1
	3 - Require closing all levels, general	27.8	54.6	10.8
Workplace closure	0 - No recommendation	14.5	20.0	11.0
	1 - Recommend closing workplace	19.3	13.0	23.3
	2 - Require closing some sectors, targeted	18.7	8.5	25.1
	3 - Require closing some sectors, general	28.6	29.0	28.3
	4 - Require closing all-but-essential sectors	18.9	29.5	12.2
Public event cancellation	0 - No recommendation	9.5	5.1	12.4
	1 - Recommend cancelling public event	25.6	22.2	27.7
	2 - Require cancelling public event, targeted	27.1	23.5	29.4
	3 - Require cancelling public event, general	37.8	49.3	30.5
Gathering restriction	0 - No restriction	21.6	27.0	18.2
	1 - Restriction on gatherings 101–1,000 people	15.6	13.1	17.1
	2 - Restriction on gatherings 11–100 people	15.4	19.6	12.7
	3 - Restriction on gatherings of 10 people or less, targeted	27.4	20.1	32.0

	4 - Restriction on gatherings of 10 people or less, general	20.1	20.2	20.0
Public transport closure	0 - No recommendation	60.1	60.5	59.8
	1 - Recommend closing public transport	23.8	24.5	23.4
	2 - Require closing public transport	16.1	15.0	16.8
Stay-at-home requirement	0 - No recommendation	25.7	31.6	22.0
	1 - Recommend not leaving house	42.4	37.6	45.4
	2 - Require not leaving house with more exceptions	22.3	18.2	24.9
	3 - Require not leaving house with minimal exceptions	9.6	12.5	7.7
Internal travel control	0 - No recommendation	31.1	29.8	31.9
	1 - Recommend not to travel between regions	37.6	27.2	44.2
	2 - Require internal travel controls, targeted	20.0	17.0	21.8
	3 - Require internal travel controls, general	11.4	26.0	2.1
International travel ban	0 - No ban	21.0	12.5	26.4
	1 - Ban on arrivals from some countries	53.9	40.9	62.2
	2 - Ban on arrivals from all countries	25.0	46.5	11.4
Income support	0 - No policy	15.9	32.1	5.7
	1 - Support less than 50% of lost salary, targeted	22.3	17.9	25.1
	2 - Support less than 50% of lost salary, general	39.1	30.6	44.5
	3 - Support 50% or more of lost salary	22.6	19.3	24.7
Debt relief	0 - No policy	13.5	33.4	0.8

	1 - Relief to specific debt	41.8	26.7	51.4
	2 - Relief to broad debt	44.7	39.9	47.8
Testing policy	0 - None or test those with symptoms meeting specific criteria	17.7	23.3	14.1
	1 - Test those with symptoms	37.9	43.2	34.5
	2 - Open public testing	44.5	33.5	51.4
Contact tracing	0 - No comprehensive contact tracing	18.7	20.9	17.4
	1 - Comprehensive contact tracing	81.3	79.1	82.6
Facial covering	0 - No requirement	26.5	48.0	12.9
	1 - Require facial covering in some public spaces	34.2	28.3	37.9
	2 - Require facial covering in all public spaces	20.5	9.3	27.6
	3 - Require facial covering in all spaces at all times	18.8	14.4	21.6
Observations		3,307	1,283	2,024

Notes: The sample starts when the first 100 cases were detected in each country, except for China.
Sources: BSG (2021).

Table A2: Correlation amongst Government Intervention Measures

		1	2	3	4	5	6	7	8	9	10	11	12	13
School closure	1	1.000												
Workplace closure	2	0.517***	1.000											
Public event cancellation	3	0.452***	0.599***	1.000										
Gathering restriction	4	0.328***	0.642***	0.623***	1.000									
Public transport closure	5	0.305***	0.492***	0.114***	0.371***	1.000								
Stay-at-home requirement	6	0.374***	0.556***	0.226***	0.519***	0.608***	1.000							
Internal travel control	7	0.362***	0.530***	0.316***	0.204***	0.514***	0.462***	1.000						
International travel ban	8	0.228***	0.024	0.057***	–0.017	–0.019	–0.064***	–0.006	1.000					
Income support	9	–0.208***	0.024	0.169***	0.112***	–0.170***	–0.171***	–0.160***	–0.068***	1.000				

Debt relief	10	–0.052***	–0.006	0.149***	0.037**	-0.167***	–0.059***	–0.156***	-0.114***	0.604***	1.000			
Testing policy	11	–0.136***	–0.029*	0.074***	–0.032*	-0.104***	–0.119***	–0.057***	-0.046***	0.168***	–0.006	1.000		
Contact tracing	12	0.017	0.176***	0.219***	0.215***	0.163***	0.041**	–0.023	-0.042**	0.288***	–0.030*	0.629***	1.000	
Facial covering	13	–0.051***	0.292***	0.182***	0.441***	0.147***	0.254***	0.125***	-0.236***	0.108***	0.177***	–0.198***	–0.048***	1.000

Notes: The sample starts when the first 100 cases were detected in each country (except for China), including 3,307 observations.
Sources: BSG (2021).

Table A3: Comparison of COVID-19 Cases, Tests, and Response Measures across Countries

Countries	Total Cases (per 1 million) as of 3 Jan 21	Tests (per 1 million) as of 3 Jan 21	Previous Pandemic Experience	Social Restrictions and Closures	Mask Wearing as of 3 Aug 2020	Compliance in Mask Wearing per July 2020[a] (%)
Viet Nam	15	14,641	SARS, H1N1 influenza	Closing borders with China in Feb 2020, national lockdown began 1 Apr, school/workplace closures, restrictions on mass gatherings	Required in certain places or regions	68
Taiwan	34	5,336	SARS	1.5 metre physical distancing in indoor and 1 metre in an outdoor settings, international borders closed to foreigners with some exceptions (such restrictions have been relaxed), no nationwide or local lockdowns	Required in certain places or regions	59
China	61	111,163	SARS, H1N1 influenza	Strict social distancing from 23 Jan 2020 in Wuhan followed by national 14 Feb 2020, limited movement of >500 million persons across 80 cities, school/workplace closures, restrictions on mass gatherings, lockdowns	Recommended	67

Countries	Total Cases (per 1 million) as of 3 Jan 21	Tests (per 1 million) as of 3 Jan 21	Previous Pandemic Experience	Social Restrictions and Closures	Mask Wearing as of 3 Aug 2020	Compliance in Mask Wearing per July 2020[a] (%)
Thailand	106	17,426	H1N1 influenza	State of emergency declared 26 Mar, with foreigners banned except with special permits, school/workplace closures, restrictions on mass gatherings, lockdowns	Mandatory	82
Hong Kong	1,185	656,724	SARS, H1N1 influenza	1 metre physical distancing, lockdowns or movement control from Jan 2020	Mandatory from 27 Jul	85 [b]
Republic of Korea	1,233	84,631	SARS, H1N1 influenza	2 metres physical distancing, school/workplace closures, restrictions on mass gatherings, lockdowns	Required in certain places or regions	84 [b]
Japan	1,885	38,961	H1N1 influenza	2 metres physical distancing, lockdowns or movement control from Mar 2020, school/workplace closures, restrictions on mass gatherings	Recommended	83
Indonesia	2,758	27,018	H1N1 influenza	Public health emergency declared on 31 Mar, allowing regional governments to impose restrictions like closing schools and workplaces	Mandatory from 5 Apr	80

Countries	Total Cases (per 1 million) as of 3 Jan 21	Tests (per 1 million) as of 3 Jan 21	Previous Pandemic Experience	Social Restrictions and Closures	Mask Wearing as of 3 Aug 2020	Compliance in Mask Wearing per July 2020[a] (%)
				and limiting religious and public gatherings and partial lockdowns		
Malaysia	3,603	103,499	SARS, H1N1 influenza	Movement control order declared on 18 Mar, school/workplace closures, restrictions on mass gatherings, lockdowns	Mandatory in public spaces since 1 Aug	76
Philippines	4,323	61,506	H1N1 influenza	Strict quarantine and travel ban measures from 12 Mar except for buy food/medicine	Mandatory, and face shields in public spaces since 15 Dec	92
Singapore	9,987	923,848	SARS, H1N1 influenza	1 metre physical distancing, school/workplace closures, restrictions on mass gatherings, lockdowns	Mandatory since 14 Apr	93

SARS = severe acute respiratory syndrome.
Notes:
[a] Those who responded 'always'
[b] 9–15 Nov 2020, while for other countries, this is based on the survey between 6-12 July.
Sources: Fitzgerald and Wong (2020); Hale, Petherick, Phillips, Webster (2020); Han et al. (2020); OECD (2020); Patel and Sridhar (2020); Penn (2020); Find (2021); Worldometer (2021).

Table A4: Estimated Impact of the Overall Government Response Index on COVID-19 Transmission in Multiples of 7-Day Windows

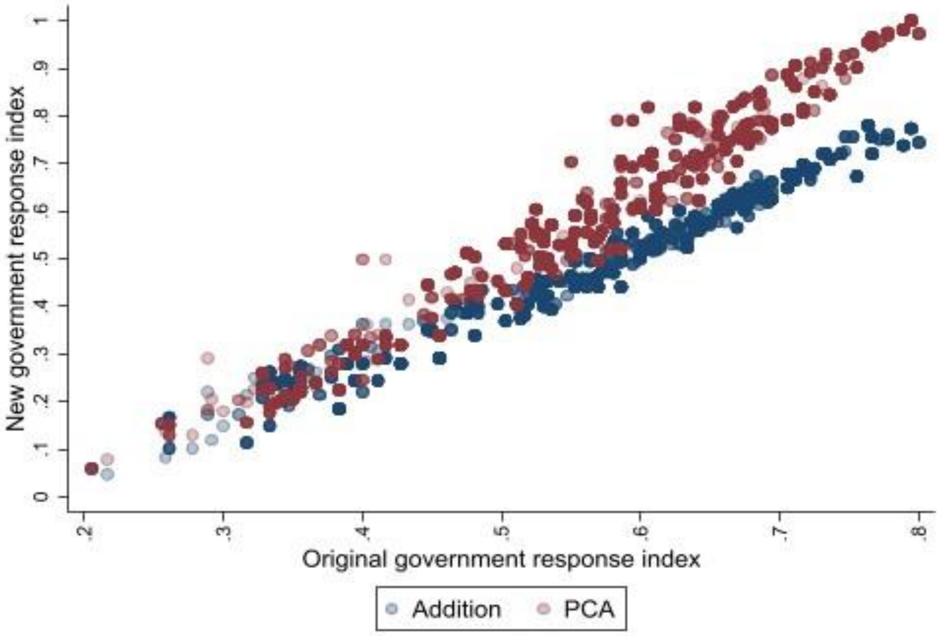
	$C_{c,t-1}$	$C_{c,t-7}$	$C_{c,t-14}$	$C_{c,t-21}$	$C_{c,t-28}$	$C_{c,t-35}$
Response at time *t - 1*	–0.090					
	(0.346)					
Response at time *t - 7*		–2.234***				
		(0.195)				
Response at time *t - 14*			–4.414***			
			(0.262)			
Response at time *t - 21*				–6.717***		
				(0.402)		
Response at time *t - 28*					–8.070***	
					(0.383)	
Response at time *t - 35*						–9.331***
						(0.455)
Constant	–0.200	–0.307*	0.222	0.522***	0.895***	1.393***
	(0.172)	(0.168)	(0.150)	(0.179)	(0.193)	(0.194)
14-day cases in the last two weeks	Yes	Yes	Yes	Yes	Yes	Yes
Daily time	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	3,006	3,295	3,307	3,287	3,266	3,234
F-statistics	4.12***	33.33***	46.69***	36.30***	48.33***	45.83***
Adjusted R^2	0.006	0.094	0.205	0.181	0.182	0.182

Notes:

1. The dependent variables from columns (1) to (6) are the growth rates of COVID-19 new cases over the dates 1, 7, 14, 21, 28, and 35 days earlier, respectively.
2. Response at time *t – 1, t – 7, t – 14, t – 21, t – 28,* and *t – 35* are the overall government response index, which is aggregated from policy measures reported on the dates 1, 7, 14, 21, 28, and 35 days earlier, respectively. This index ranges between 0 and 1.
3. Standard errors are in parenthesis: $^{***}p \leq 0.01,^{**}p \leq 0.05,^{*}p \leq 0.10$. Heteroskedastic-robust standard errors are applied.

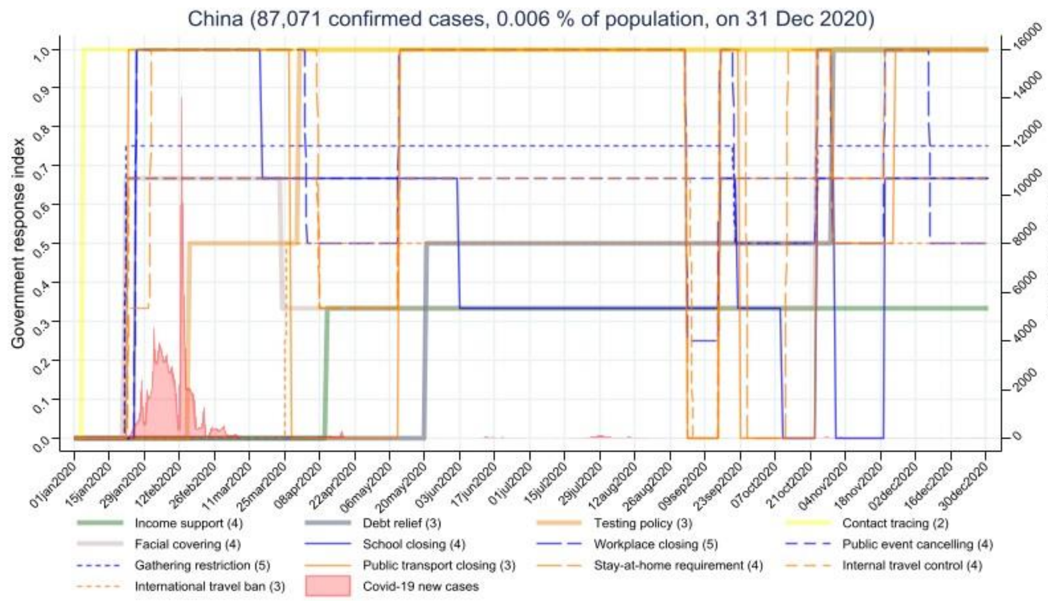
Source: BGS (2021)

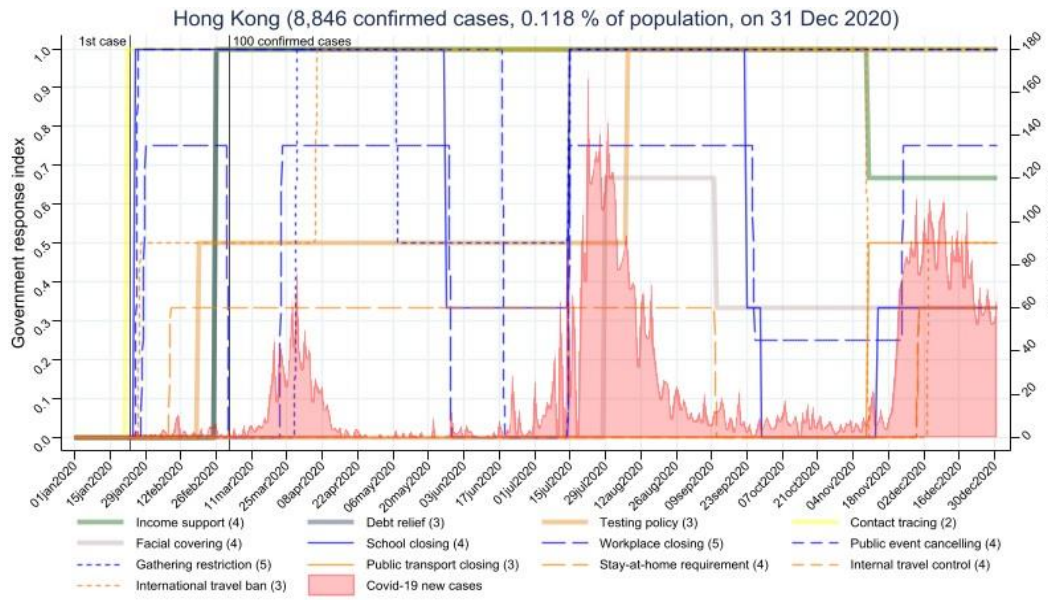
Figure A1: Correlation between Different Measures of Overall Government Response Index

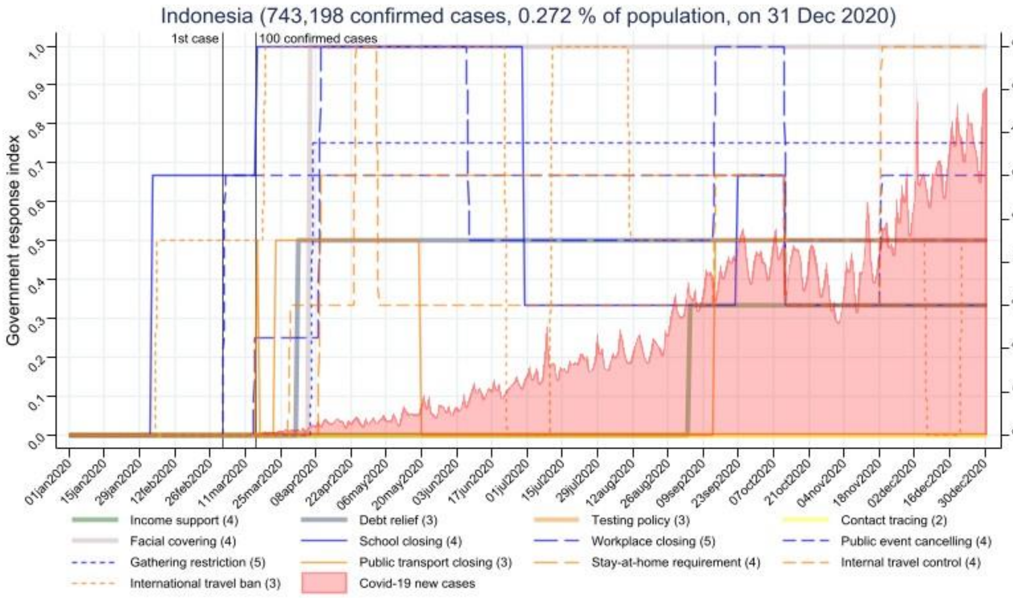


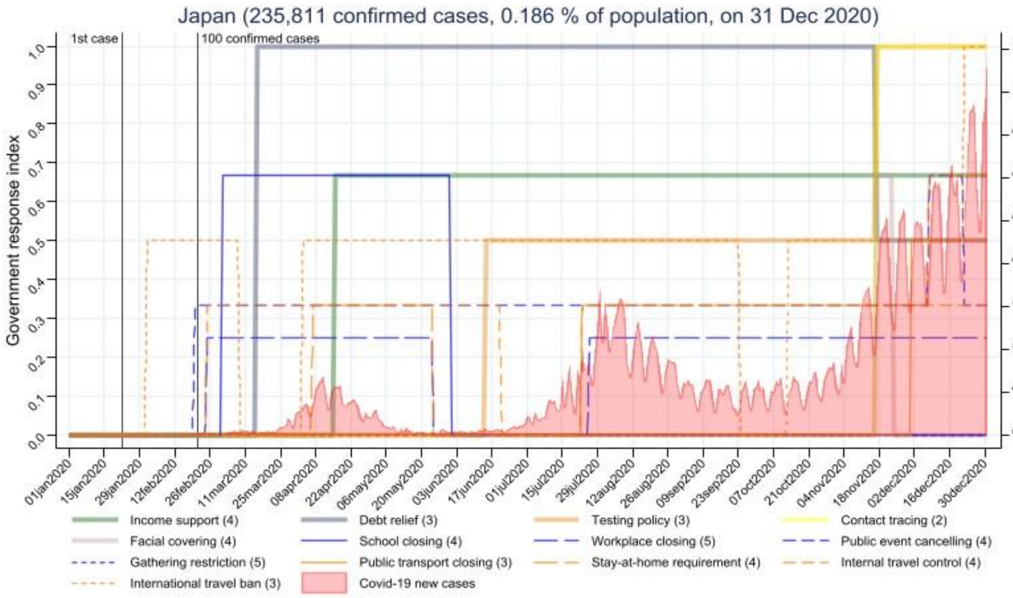
Sources: BSG (2021).

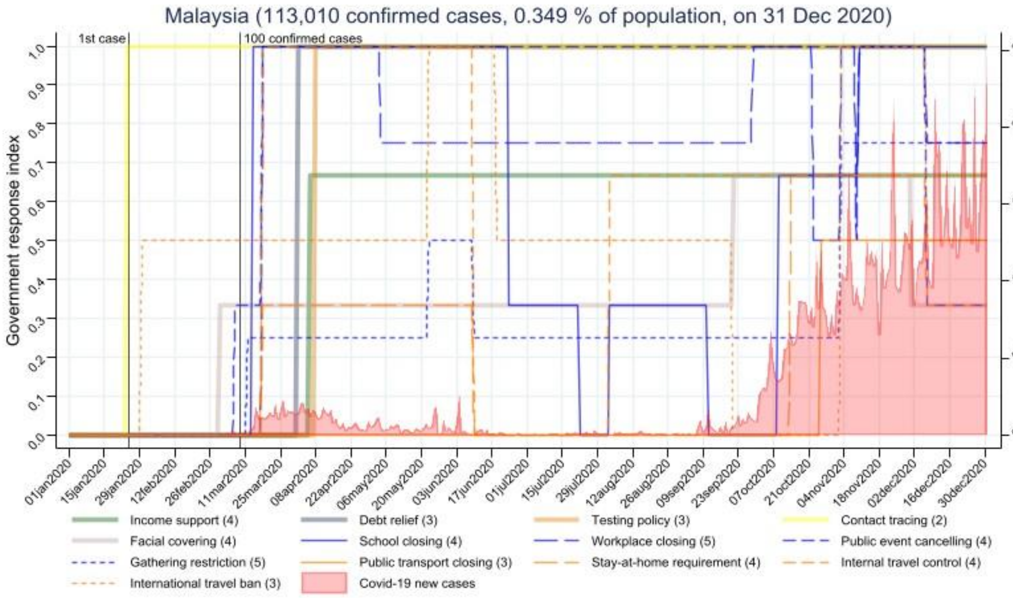
Figure A2: Daily New COVID-19 Cases and Government Intervention Measures, 2020

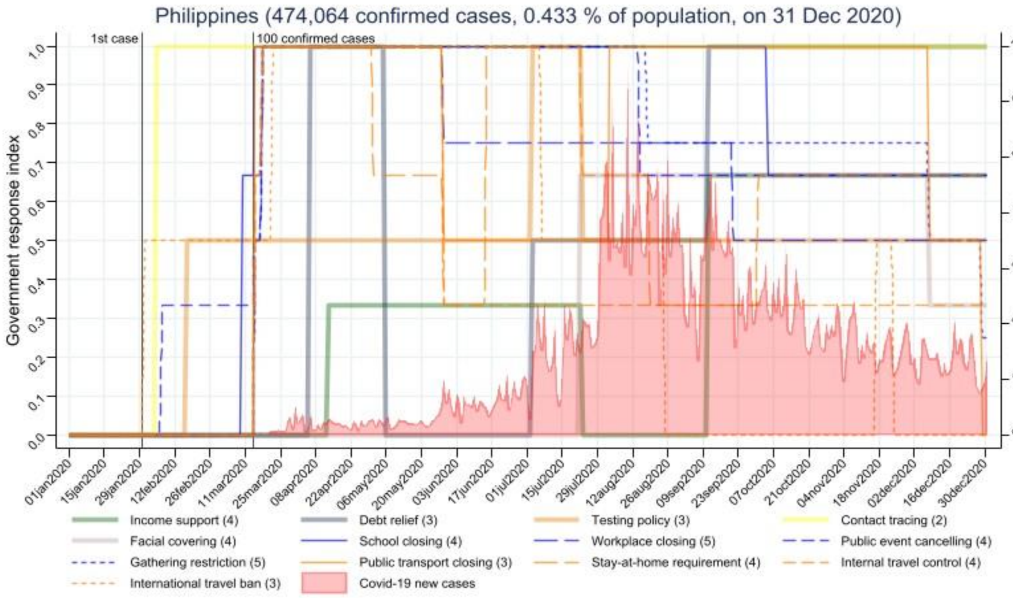


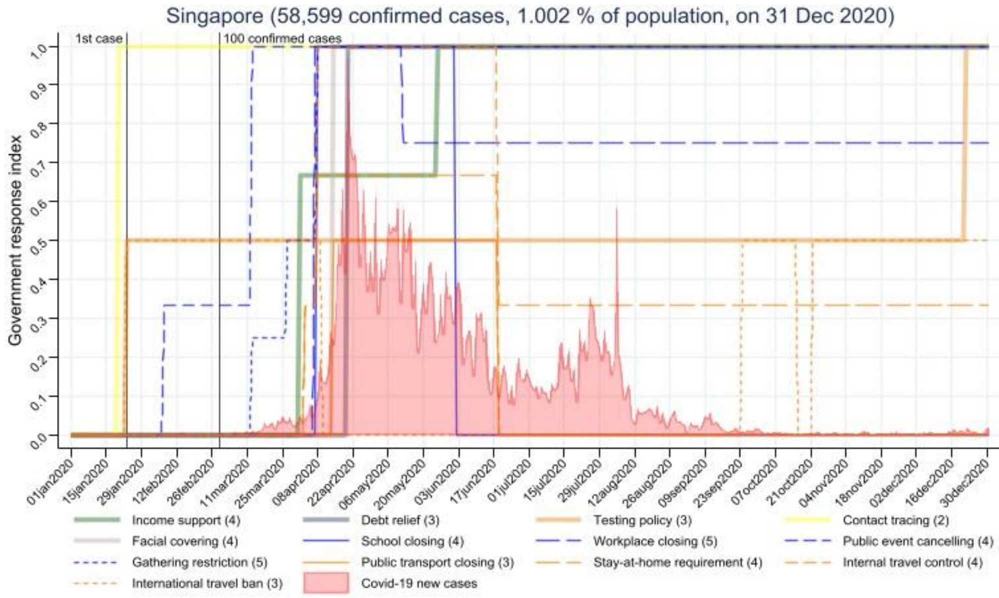


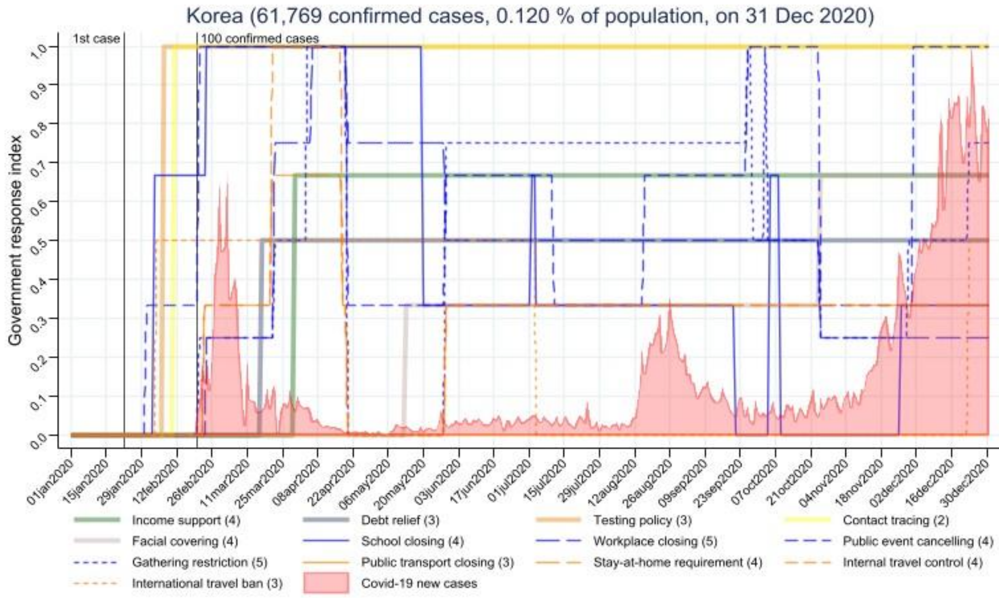

Indonesia (743,198 confirmed cases, 0.272 % of population, on 31 Dec 2020)
1st case
100 confirmed cases
Government response index
Covid-19 new cases
Income support (4)
Debt relief (3)
Testing policy (3)
Contact tracing (2)
Facial covering (4)
School closing (4)
Workplace closing (5)
Public event cancelling (4)
Gathering restriction (5)
Public transport closing (3)
Stay-at-home requirement (4)
Internal travel control (4)
International travel ban (3)
Covid-19 new cases

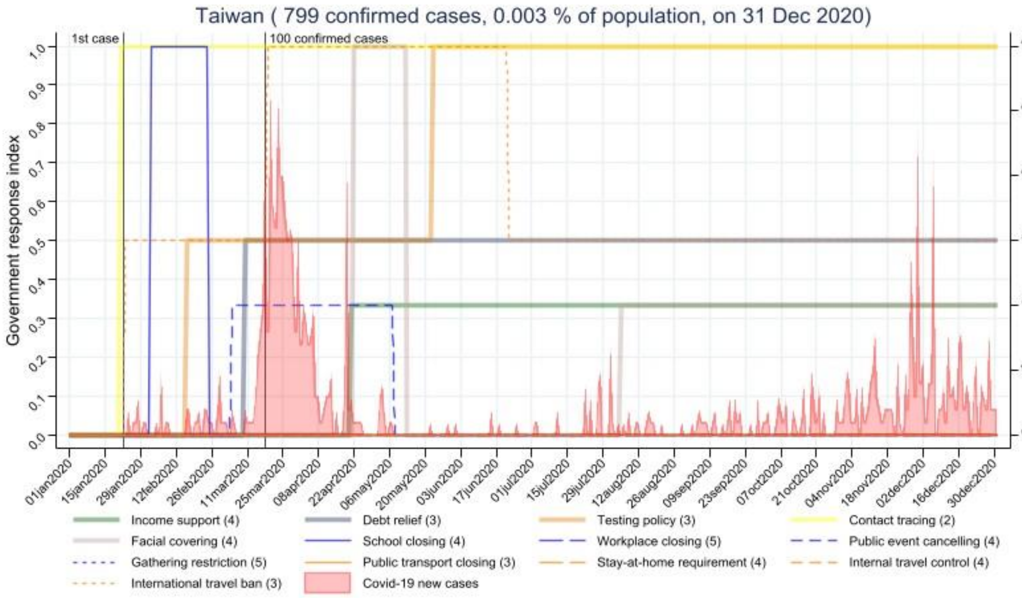

Japan (235,811 confirmed cases, 0.186 % of population, on 31 Dec 2020)
1st case
100 confirmed cases
Government response index
Covid-19 new cases
Income support (4)
Debt relief (3)
Testing policy (3)
Contact tracing (2)
Facial covering (4)
School closing (4)
Workplace closing (5)
Public event cancelling (4)
Gathering restriction (5)
Public transport closing (3)
Stay-at-home requirement (4)
Internal travel control (4)
International travel ban (3)
Covid-19 new cases


Malaysia (113,010 confirmed cases, 0.349 % of population, on 31 Dec 2020)
1st case
100 confirmed cases
Government response index
Covid-19 new cases
Income support (4)
Debt relief (3)
Testing policy (3)
Contact tracing (2)
Facial covering (4)
School closing (4)
Workplace closing (5)
Public event cancelling (4)
Gathering restriction (5)
Public transport closing (3)
Stay-at-home requirement (4)
Internal travel control (4)
International travel ban (3)
Covid-19 new cases

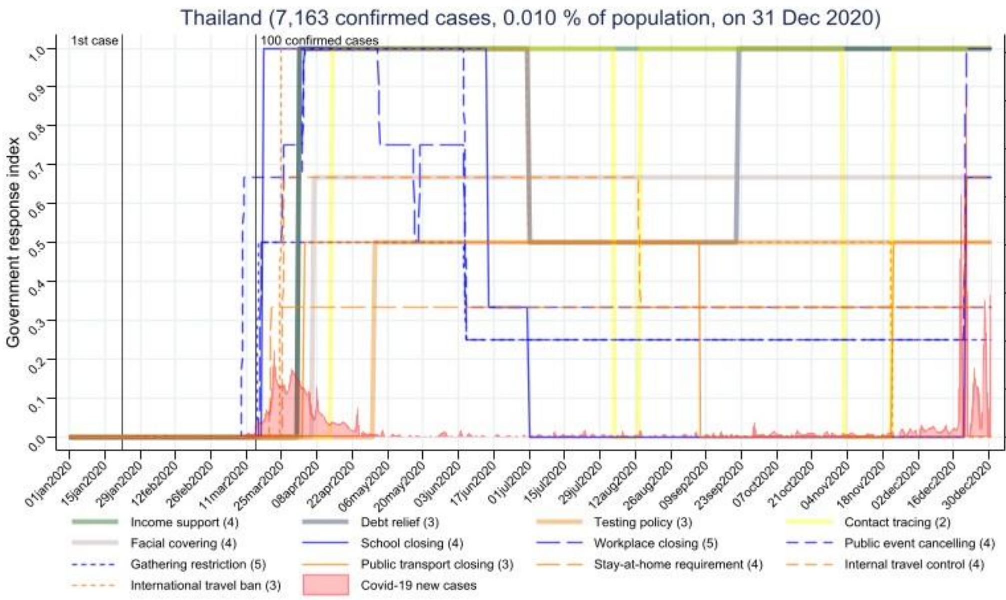

Philippines (474,064 confirmed cases, 0.433 % of population, on 31 Dec 2020)
1st case
100 confirmed cases
Government response index
Covid-19 new cases
Income support (4)
Debt relief (3)
Testing policy (3)
Contact tracing (2)
Facial covering (4)
School closing (4)
Workplace closing (5)
Public event cancelling (4)
Gathering restriction (5)
Public transport closing (3)
Stay-at-home requirement (4)
Internal travel control (4)
International travel ban (3)
Covid-19 new cases


Singapore (58,599 confirmed cases, 1.002 % of population, on 31 Dec 2020)
1st case
100 confirmed cases
Government response index
Covid-19 new cases
Income support (4)
Debt relief (3)
Testing policy (3)
Contact tracing (2)
Facial covering (4)
School closing (4)
Workplace closing (5)
Public event cancelling (4)
Gathering restriction (5)
Public transport closing (3)
Stay-at-home requirement (4)
Internal travel control (4)
International travel ban (3)
Covid-19 new cases

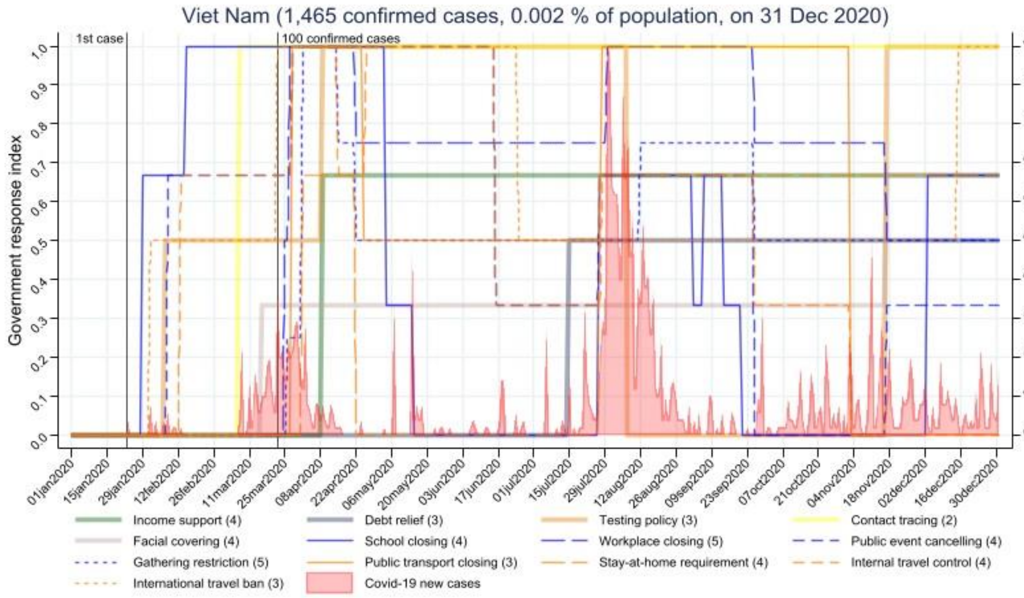

Korea (61,769 confirmed cases, 0.120 % of population, on 31 Dec 2020)
1st case
100 confirmed cases
Government response index
Covid-19 new cases
Income support (4)
Debt relief (3)
Testing policy (3)
Contact tracing (2)
Facial covering (4)
School closing (4)
Workplace closing (5)
Public event cancelling (4)
Gathering restriction (5)
Public transport closing (3)
Stay-at-home requirement (4)
Internal travel control (4)
International travel ban (3)
Covid-19 new cases



Taiwan (799 confirmed cases, 0.003 % of population, on 31 Dec 2020)
1st case
100 confirmed cases
Government response index
Covid-19 new cases
Income support (4)
Debt relief (3)
Testing policy (3)
Contact tracing (2)
Facial covering (4)
School closing (4)
Workplace closing (5)
Public event cancelling (4)
Gathering restriction (5)
Public transport closing (3)
Stay-at-home requirement (4)
Internal travel control (4)
International travel ban (3)
Covid-19 new cases



Thailand (7,163 confirmed cases, 0.010 % of population, on 31 Dec 2020)
1st case
100 confirmed cases
Government response index
Covid-19 new cases
Income support (4)
Debt relief (3)
Testing policy (3)
Contact tracing (2)
Facial covering (4)
School closing (4)
Workplace closing (5)
Public event cancelling (4)
Gathering restriction (5)
Public transport closing (3)
Stay-at-home requirement (4)
Internal travel control (4)
International travel ban (3)
Covid-19 new cases



Notes: Government measures are normalised using Equation (10).
Sources: BGS (2021).

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