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The impact of COVID-19 on stock markets

Qing He^a, Junyi Liu^b, Sizhu Wang^c and Jishuang Yu^c

^aChina Financial Policy Research Centre and School of Finance, Renmin University of China, Beijing, P.R. China; ^bDepartment of Economics, Soka University of America, Aliso Viejo, USA; ^cSchool of Finance, Renmin University of China, Beijing, P.R. China

ABSTRACT

This paper attempts to explore the direct effects and spill-overs of COVID-19 on stock markets. Using conventional *t*-tests and non-parametric Mann–Whitney tests, we empirically analyse daily return data from stock markets in the People’s Republic of China, Italy, South Korea, France, Spain, Germany, Japan and the United States of America. Our empirical results show that (i) COVID-19 has a negative but short-term impact on stock markets of affected countries and that (ii) the impact of COVID-19 on stock markets has bidirectional spill-over effects between Asian countries and European and American countries. However, there is no evidence that COVID-19 negatively affects these countries’ stock markets more than it does the global average. The findings contribute to the research on economic impact of the pandemic by providing empirical evidence that COVID-19 has spill-over effects on stock markets of other countries. The results also provide a basis for assessing trends in international stock markets when the situation is alleviated worldwide.

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COVID-19; coronavirus disease; stock markets; spill-over effects

Introduction

An unanticipated disease called coronavirus disease 2019 (COVID-19) has spread worldwide since the end of 2019. In December 2019, Wuhan, a central city in China, reported the first COVID-19 case. On 3 January 2020, the Wuhan Health Committee reported 44 cases of viral pneumonia of unknown cause. Due to mass migration during the Chinese New Year and Wuhan’s geographic location as an important transportation hub in China, the disease has spread silently to other provinces in China since early January 2020. On 19 January, the first three confirmed cases outside Wuhan were reported, one in Guangdong and two in Beijing. Since 10 am on 23 January, bus, metro, ferry and long-distance passenger transportation in Wuhan had been suspended. As a further precaution, all outbound trains and flights were stopped. The Chinese government continues to adopt various public health policies, such as travel restrictions, curfews and school closures to prevent the spread of the epidemic. On 30 January 2020, the World Health Organisation (WHO) issued its first global alert

regarding COVID-19 (WHO 2020a). As the number of confirmed cases soared throughout the world, the WHO announced it as a pandemic on 11 March 2020 (WHO 2020b). So far, the countries with the largest number of confirmed cases in the world include the People's Republic of China, Italy, South Korea, France, Spain, Germany, Japan and the United States of America. The outbreak centre has been gradually shifted from China to Europe and the USA. In March 2020, some researchers and media outlets reported how this terrible disease would affect the economy of the affected countries. Duan, Wang, and Yang (2020) point out that those small and medium-sized enterprises, which play a significant role in China, have been severely affected due to decline in social consumption and rigid expenditure on rents, wages and interests. This could further affect the stability of the banking system. When the China A-share market reopened on 3 February, the Shanghai Securities Composite Index declined by nearly 8% in response. The initial impact of this event so far on the stock markets of the countries with the highest number of confirmed cases is examined in this paper.

Since the public transit in Wuhan was suspended on 23 January, there have been several articles in the popular press indicating that COVID-19 is having a tremendous impact on the economies of the affected countries. A report titled 'Spread and Stutter' in *The Economist* (2020a) emphasises that COVID-19 is a grave threat to the poise of global markets. 'The Right Medicine for the World Economy' (*The Economist* 2020c) also states that as fears grow about the impact of the COVID-19 virus, stock markets have slumped. Now there are signs that the virus is moving from traders' screens to the real economy. In the same month, 'Sneezy Money' (*The Economist* 2020b) notes that 'One of the ways virus damages the economy is to interfere with the supply of labour, goods and services. But more serious is its spill-over effect. Goldman Sachs estimates that global GDP will contract at an annualised rate of 2.5% in the first quarter'. Another article entitled 'Tracking the Economic Impact of COVID-19 in Real Time' (*The Economist* 2020d) also points out that the modelling by academics at the Australian National University suggests that the GDP in America and Europe would be 2% lower than it would have been in the absence of a pandemic and perhaps as much as 8% lower if the rate of deaths is many times higher than expected. Stock markets are pricing in fear.

Black Swan events, including terrorist attacks and epidemics, will cause shock, fear and panic among international investors and result in a sharp panic-selling response (Burch, Emery, and Fuerst 2016). An expanding body of literature, such as Carter and Simkins (2004), Chen and Siems (2004), Nikkinen et al. (2008), Kollias et al. (2011), and Papakyriakou, Sakkas, and Taoushianis (2019), has addressed the impact of terrorists on the international stock markets. As Chen and Siems (2004) point out, terrorist attacks are unexpected events which seriously affect normal life and result in panic-selling ensues. Epidemics will inevitably have the same effect. Nippani and Washer (2004) focus on stock indices of eight seriously affected countries during the SARS period and find that SARS had no negative impact on the affected countries' stock markets with the exception of those based in China and Vietnam. Chen, Jang, and Kim (2007) study the impact of the SARS outbreak on the performance of hotel stocks in exchanges of the Chinese mainland and Taiwan and find a significant negative impact.

The unfortunate situation created by COVID-19 gives us a unique opportunity to gauge the impact of an unexpected and dreaded disease on the economy of affected nations while globalisation continues under debates. The COVID-19 virus first broke out in China and exerted a direct influence on China's stock market. Fluctuations in China's stock market may have spill-over effects on others due to the breadth and depth of interdependence among contemporary economies. In China, the spread of the disease is gradually being curtailed, but it continues to spread in other countries, some of which might adversely influence back on China's stock market.

To this end, we establish domestic and non-domestic COVID-19 timelines with news reports and then examine the separate impacts that COVID-19 has had on the stock markets of the People's Republic of China, Italy, South Korea, France, Spain, Germany, Japan and the USA as represented by their leading stock indices. The impact of COVID-19 on these stock indices is explored by examining the mean returns of the indices in the disease-affected period vis-à-vis a pre-event period using *t*-tests and Mann–Whitney non-parametric tests. Furthermore, the stock indices of these affected countries are compared with the S&P 1200 Global Index. The latter comparison is to determine if the affected stock markets' performance is significantly below the global average.

We find that COVID-19 had a negative and limited impact on the stock markets of China and other Asian countries in the early stage of the epidemic. With the spill-over effect on European and American countries, the indices underperformed after the epidemic, as opposed to the comparison period, in the middle and late stages. The evidence found in the non-domestic timeline suggests that the development of COVID-19 has had a negative impact on the European and USA stock markets, a condition that will intensify in the short term as the virus spreads.

The impact of COVID-19 on the European and USA stock markets has a backflow effect on the Asian stock markets, especially on China's stock market. Even as the spread of the disease in China has been gradually stabilised, it has started to break out in other countries. In the midst of this global spread, China's stock market has borne a glancing blow due to the spill-over effect. But if we exclude the case of China in the short event window of the domestic timeline, there is no evidence that COVID-19 has a negative impact on the major stock indices in these countries compared to the S&P 1200 Global Index.

Our paper makes contributions to the literature and international investment in three aspects. First, it documents the latest impact of COVID-19 on stock markets of the first group of countries where the epidemic started. Second, it investigates the spill-over effects of China's stock market on those countries and the spill-over effects of their stock markets back on China by defining domestic and non-domestic COVID-19 timelines. Last, it provides a reference for assessing trends in international stock markets after the pandemic subsides.

The rest of the paper is organised as follows. The following section presents the data and methodology. The next section describes and analyses the empirical results. The last section concludes.

Data and methodology

To examine the impact of COVID-19, the following stock indices are chosen: the CSI 300 Index to represent the People's Republic of China, the FTSE MIB Index to represent Italy, the Korea Composite Index to represent South Korea, the CAC-40 Index to represent France, the SMSI Index to represent Spain, the DAX Index to represent Germany, the Nikkei 225 Index to represent Japan, and the S&P 500 Index to represent the USA. The above indices are arguably the most representative indices of these countries' stock markets in the world press. The data for the daily closing value and daily return of each of these indices for the period of 1 June 2019 to 16 March 2020 are collected from the web portal 'Investing.com' (cn.investing.com).

We use the stock indices of these eight countries, which are considered the representative cases in the study, to warrant some explanations. First of all, because the WHO did not report the list of countries and regions most affected by the epidemic, we initially select eight countries and regions with the largest number of confirmed cases in the world on 16 March 2020. Secondly, Japan and the Diamond Princess cruise line calculated the number of confirmed cases separately, but considering that the Diamond Princess pulled up alongside a Japanese dock and all its members entered Japan, the two parts of the data are added together to calculate the number of confirmed cases in Japan. Finally, because there is no stock index in Iran, and other commodity indices cannot be compared horizontally in this paper, Iran is removed from the list of countries. The USA, which ranks ninth in the number of confirmed cases in the time when this paper is being written, is added. The final list of countries studied in this paper contains the People's Republic of China, Italy, South Korea, France, Spain, Germany, Japan and the USA.

Several sources of COVID-19 news, which first appeared in the press at the close of 2019, are examined to find the exact chronology of the occurrence of COVID-19. On 3 January 2020, 44 cases of viral pneumonia of unknown cause, known as COVID-19 later, were reported by the Wuhan Health Committee. On 23 January, a strict blockade was imposed in Wuhan to prevent the spread of the epidemic to other areas. This is considered a sign of the start of an outbreak in China. The WHO issued the first global alert on 30 January, which meant that the international epidemic situation has shown a slow deterioration trend. Other warnings and announcements followed in subsequent weeks. With the joint efforts of various segments of the Chinese society, the closure of the last mobile cabin hospital in Wuhan on 10 March suggests that the epidemic situation in China has eased. However, on 11 March, COVID-19 was still characterised as a pandemic by the WHO. So far, the centre of COVID-19 has gradually moved from China to Europe, with confirmed cases increasing and outbreaks beginning to erupt.

Considering the time difference between the whole process of outbreak and mitigation in China and that in the world, it is unlikely that a study at this stage of events will be able to distinguish its actual impact on the stock market. In this paper, we have two timelines for the outbreak of COVID-19 in China and the outbreak in other countries, and the stock indices in the two parallel timelines are studied respectively. This approach lets us explore the spill-over effect of the outbreak in China on the international community, as well as the spill-over effect of the outbreak in other countries on China. Due to the fact that the pandemic has not been alleviated worldwide yet, we

can only base our empirical research on the outbreak stage in the assigned timeline, while also providing a reference for the trend of stock markets when the situation is alleviated worldwide.

For the China's timeline, the entire period of study is divided into several sub-periods in order to examine the impact of COVID-19, and the main time points are related to the important events of the epidemic within China. The first sub-period examined is from 3 January 2020 to 22 January 2020. We identify this sub-period as the pre-event window. We hypothesise that there is a negative impact on the stock indices of the seriously affected countries. More specifically, we suspect that China's indices could bear some of the worst blows because of newspaper reports of COVID-19.

We mark the actual event period as the beginning when Wuhan announced the closure of public spaces, i.e. 23 January 2020. As mobile cabin hospitals specialise in treating novel coronavirus infected patients with mild symptoms and suspected cases, the closure of the last mobile cabin hospital in Wuhan on 10 March implies that the large-scale transmission in China had come to an end, which can be regarded as a sign of domestic epidemic mitigation. The period from 23 January 2020 to 10 March 2020 is thus called the 'long event window', and it examines the impact of the whole battle against COVID-19 in China. A 'short event window' is also looked at to assess the immediate impact of the closure of Wuhan city, and this runs from 23 January 2020 to 3 February 2020, ten days after the event. Our hypothesis for both the short event window and long event window is that COVID-19 has a negative impact on the stock market index of China and spill-over effects on other indices.

The performance of the stock market indices mentioned above are from 1 June 2019 to 2 January 2020. The daily returns of these stock indices are grouped into the pre-event window, short event window and long event window for comparison. Simple heteroscedastic *t*-tests and the non-parametric Mann-Whitney (1947) tests are conducted. The performance of these indices during the three periods are also compared with the performance of the S&P 1200 Global Index. For example, to compare the performance of the FTSE MIB Index with the global index in the short event window, the daily returns of the two indices are from 23 January 2020 to 3 February 2020. We infer that if the FTSE MIB Index were more negatively affected than the rest of the world, it would underperform the world index.

For the timeline of the selected countries in this paper, the above segmentation and testing approaches also apply. The entire period of study is divided into several sub-periods, and the main time points are related to the important events of the epidemic outside China. The 'pre-event window' is from 30 January 2020 to 10 March 2020. This represents the period from the appearance of symptoms outside China to the outbreak of the pandemic in the world. Since the pandemic is not over yet, the data collected are up to 22 March 2020. The period from 11 March 2020 to 22 March 2020 is called the 'short event window', and it examines the impact of the battle with COVID-19 outside China since the outbreak. The hypothesis for the short event window is that COVID-19 has a negative impact on the stock market indices of the whole world. At present, we can only forecast the situation in the long event window of the timeline of selected countries according to the domestic timeline. The performance of the stock

market indices mentioned above is compared from 1 June 2019 to 29 January 2020. The heteroscedastic t -tests and non-parametric Mann–Whitney tests are used.

Empirical results

We start by looking at the results of the domestic timeline. The mean returns, standard deviations, t -statistics and statistical significance levels for the pre-, short, and long event windows of the domestic timeline using the t -tests are presented in Table 1. The table also includes a column showing the number of trading days for each window. According to Chen and Siems (2004), the t -statistics essentially test the significance of the economic impact of an event on the capital market as measured by the deviation of index returns from their average. If the event had no consequence, one would expect an insignificant return deviation.

Panel A shows that each index had a positive average daily return over the comparison period, indicating these stock markets were performing well before the outbreak of

Table 1. Differences in mean returns of domestic timeline.

Index	Number of trading days	Event group's mean and std. dev.	Event group's t -value
Panel A: comparison period from 1 June 2019 to 2 January 2020			
CSI 300	146	0.10% (0.91%)	
FTSE MIB	148	0.13% (0.95%)	
Korea Composite	145	0.05% (0.78%)	
CAC-40	151	0.10% (0.84%)	
SMSI	151	0.04% (0.79%)	
DAX	147	0.09% (0.85%)	
Nikkei 225	144	0.10% (0.80%)	
S&P 500	149	0.12% (0.77%)	
Panel B: pre-event window from 3 January 2020 to 22 January 2020			
CSI 300	14	0.03% (0.83%)	−0.51
FTSE MIB	14	−0.04% (0.61%)	−0.64
Korea Composite	14	0.03% (0.88%)	−1.15
CAC-40	14	−0.04% (0.41%)	−0.61
SMSI	14	−0.10% (0.44%)	−0.66
DAX	14	−0.07% (0.65%)	−0.10
Nikkei 225	12	0.14% (1.22%)	0.16
S&P 500	13	0.15% (0.47%)	0.16
Panel C: short event window from 23 January 2020 to 3 February 2020			
CSI 300	2	−5.49% (3.38%)	−8.28**
FTSE MIB	8	−0.12% (1.78%)	−0.68
Korea Composite	6	−1.12% (1.25%)	−3.47**
CAC-40	8	−0.37% (1.31%)	−1.50
SMSI	8	−0.23% (1.08%)	−0.93
DAX	8	−0.43% (1.40%)	−1.64
Nikkei 225	8	−0.56% (1.09%)	−2.12*
S&P 500	8	−0.27% (1.03%)	−1.36
Panel D: long event window from 23 January 2020 to 10 March 2020			
CSI 300	28	−0.02% (2.33%)	−0.44
FTSE MIB	34	−0.79% (2.60%)	−3.46**
Korea Composite	32	−0.44% (1.69%)	−2.45*
CAC-40	34	−0.74% (2.07%)	−3.82**
SMSI	34	−0.71% (2.05%)	−3.51**
DAX	34	−0.73% (2.01%)	−3.72**
Nikkei 225	32	−0.58% (1.60%)	−3.51**
S&P 500	33	−0.40% (2.46%)	−2.14*

Notes: Std. dev. in parentheses. *Significant at the 5% level; **significant at the 1% level.

COVID-19 in China. The hypothesis tested is whether the outbreak has a significant negative effect on stock market returns.

Panel B compares the mean returns of the pre-event window with the comparison period. It appears that half of these indices were adversely affected shortly before the outbreak, but not in a statistically significant way.

In the short event window seen in Panel C, the CSI 300 Index and the Korea Composite Index have a mean return that underperformed the comparison period at the 1% level of significance, while the Nikkei 225 Index underperformed its comparison period at the 5% level. The outbreak of COVID-19 in Asian countries seems to offer a satisfactory explanatory basis for this market reaction.

The results over the long event window are shown in Panel D. Except for the CSI 300 Index, all other indices underperformed the comparison period. The Korea Composite Index and the S&P 500 Index have mean returns that differ from the comparison period at the 5% level of significance. The FTSE MIB Index, the CAC-40 Index, the SMSI Index, the DAX Index and the Nikkei 225 Index all underperformed the comparison period at the 1% level.

It is also interesting to note that, the stock market of China, as the first country to be hit by the outbreak of COVID-19, was not severely affected. Thus, China's stock market shows a high degree of resilience compared to the rest of the world by rebounding performance following its initial plunge. Our empirical results indicate that the outbreak of COVID-19 had a negative but limited impact on stock markets.

Furthermore, huge drops are observed in the stock markets of the countries that had not yet been severely affected by the virus. A tentative explanation for this seemingly counterintuitive finding is that the impact of COVID-19 in the stock markets of Asian countries has spill-over effects on European and American countries. The spill-overs appear to be related to the spread of COVID-19 and the shock, fear and panic among international investors.

The results from non-parametric Mann–Whitney tests are presented in [Table 2](#) and partly consistent with those in [Table 1](#). Perme and Manevski (2019) point out that the Mann–Whitney tests' null hypothesis is that the two random variables share the distribution. It is often seen as the non-parametric alternative of the t -test.

In the pre-event window shown in Panel B, the median returns for the indices are not statistically different from the comparison period. In the short event window shown in Panel C, the CSI 300 Index (1% level) and the Korea Composite Index (5% level) underperformed the comparison period.

In the long event window shown in Panel D, the Nikkei 225 Index underperformed its comparison period at the 5% level of significance. The other six countries underperformed, as opposed to the comparison period, but not in a way that was statistically significant. Surprisingly, the CSI 300 Index outperformed the indices in the reference period. Our findings confirm that COVID-19 had negative but limited impact on stock markets. Though psychological factors cannot be directly observed, it is possible that the elapsed time had a calming effect, as investors were able to take additional time to absorb the news of the outbreak and avoid panicking. It is also possible that Chinese investors boosted stocks out of a heightened sense of patriotism.

Table 2. Differences in median returns of domestic timeline.

Index	Number of days	Median return	W-value
Panel A: comparison period from 1 June 2019 to 2 January 2020			
CSI 300	146	0.06%	
FTSE MIB	148	0.11%	
Korea Composite	145	0.07%	
CAC-40	151	0.15%	
SMSI	151	0.05%	
DAX	147	0.58%	
Nikkei 225	144	0.12%	
S&P 500	149	0.09%	
Panel B: pre-event window from 3 January 2020 to 22 January 2020			
CSI 300	14	−0.11%	11,823
FTSE MIB	14	−0.25%	12,229
Korea Composite	14	0.49%	11,401
CAC-40	14	−0.02%	12,759
SMSI	14	−0.23%	12,764
DAX	14	0.01%	11,957
Nikkei 225	12	0.32%	11,239
S&P 500	13	0.19%	12,145
Panel C: short event window from 23 January 2020 to 3 February 2020			
CSI 300	2	−5.49%	11,023**
FTSE MIB	8	0.29%	11,631
Korea Composite	6	−1.14%	11,269*
CAC-40	8	−0.14%	12,155
SMSI	8	0.49%	12,030
DAX	8	−0.40%	11,584
Nikkei 225	8	−0.77%	11,222
S&P 500	8	0.01%	11,875
Panel D: long event window from 23 January 2020 to 10 March 2020			
CSI 300	28	0.35%	12,564
FTSE MIB	34	0.06%	13,851
Korea Composite	32	−0.15%	13,275
CAC-40	34	−0.21%	14,524
SMSI	34	0.03%	14,302
DAX	34	−0.21%	13,891
Nikkei 225	32	−0.47%	13,287*
S&P 500	33	−0.16%	14,096

Note: *significant at the 5% level; **significant at the 1% level.

The returns on each of these indices are compared to the S&P 1200 Global Index returns for the pre-, short and long event windows. Such a comparison shows which of these indices performed negatively as compared with the global average for the affected periods. Table 3 compares the event period returns for the eight countries with the S&P 1200 Global Index using *t*-tests (Panel A) and non-parametric Mann–Whitney tests (Panel B).

Looking at the grand picture of all event period results reported in Table 3, there is no strong evidence that these major indices of the stock markets differ significantly from the S&P 1200 Global Index. The only market with a statistically significant negative mean return over three event horizons was China's over the short event window. The mean return was −5.49%, significant at the 1% level under the *t*-tests (Panel A) and at the 5% level under the Mann–Whitney tests (Panel B). This can be explained by the fact that China was the first country in the world to be hit by the outbreak and that the first site of an outbreak suffers a comparatively stronger negative impact compared with the global average. The findings further confirm the significantly negative but limited impact of COVID-19 on stock markets.

Table 3. Returns relative to global index of domestic timeline.

Index	Pre-event period 3 January 2020 –22 January 2020		Short event window 23 January 2020– 3 February 2020		Long event window 23 January 2020 –10 March 2020	
	Mean	t-value	Mean	t-value	Mean	t-value
Panel A: <i>t</i> -test on daily returns relative to S&P 1200						
S&P 1200	0.10% (0.33%)		–0.34% (0.77%)		–0.46% (1.90%)	
CSI 300	0.03% (0.83%)	0.56	–5.49% (3.38%)	4.67**	–0.02% (2.33%)	–0.82
FTSE MIB	–0.04% (0.61%)	0.76	–0.12% (1.78%)	–0.33	–0.79% (2.60%)	0.61
Korea Composite	0.03% (0.88%)	–0.79	–1.12% (1.25%)	1.44	–0.44% (1.69%)	–0.05
CAC-40	–0.04% (0.41%)	0.99	–0.37% (1.31%)	0.32	–0.74% (2.07%)	0.59
SMSI	–0.10% (0.44%)	1.35	–0.23% (1.08%)	–0.12	–0.71% (2.05%)	0.52
DAX	–0.07% (0.65%)	0.17	–0.43% (1.40%)	0.16	–0.73% (2.01%)	0.57
Nikkei 225	0.14% (1.22%)	–0.11	–0.56% (1.09%)	0.46	–0.58% (1.60%)	0.29
S&P 500	0.15% (0.47%)	–0.31	–0.27% (1.03%)	–0.15	–0.40% (2.46%)	–0.11
Panel B: Mann–Whitney test						
	Median	W-value	Median	W-value	Median	W-value
S&P 1200	0.08%		–0.23%		–0.23%	
CSI 300	–0.11%	193	–5.49%	3*	0.35%	987
FTSE MIB	–0.25%	188	0.29%	74	0.06%	1,199
Korea Composite	0.49%	229	–1.14%	37	–0.15%	1,078
CAC-40	–0.02%	175	–0.14%	46	–0.21%	1,175
SMSI	–0.23%	162	0.49%	47	0.03%	1,192
DAX	0.01%	196	–0.40%	69	–0.21%	1,163
Nikkei 225	0.32%	175	–0.77%	64	–0.47%	1,059
S&P 500	0.19%	189	0.01%	72	–0.16%	1,136

Notes: Std. dev. in parentheses. *Significant at the 5% level; **significant at the 1% level.

Before we turn to the timeline of the selected countries, we first sum up our empirical investigation in the domestic timeline at the first stage. The evidence suggests that COVID-19 had a negative but limited direct impact on the stock markets of Asian countries. Furthermore, it appears that such impact has the spill-over effects on European and American countries. Except in China, none of these indices significantly underperformed the S&P 1200 Global Index in either event period.

We now proceed with the second stage of our investigation focussing on the impact of outbreak of COVID-19 in selected countries. Given the similarity between the outbreak of COVID-19 in China and in other countries, conclusions obtained from the domestic timeline may be further confirmed in the foreign timeline. Two further research questions are investigated:

- Does the outbreak of COVID-19 significantly affect stock markets in selected countries?
- Does the impact of COVID-19 on stock markets in Europe and the USA have a spill-over effect on stock markets of China?

The mean returns, standard deviations, *t*-statistics and statistical significance levels of the foreign timeline using the *t*-tests are presented in Table 4. Panel A shows that each index has a positive median daily return during the comparison period. In the pre-event window shown in Panel B, except for the CSI 300 Index, the other stock indices have been significantly negatively affected. The MIB Index, the CAC-40 Index, the SMSI Index, the DAX Index (at the 1% level) and the Korea Composite Index, the

Table 4. Differences in mean returns of foreign timeline.

Index	Number of trading days	Event group's mean and std. dev.	Event group's <i>t</i> -value
Panel A: comparison period from 1 June 2019 to 29 January 2020			
CSI 300	161	0.07% (0.93%)	
FTSE MIB	167	0.12% (1.00%)	
Korea Composite	162	0.05% (0.83%)	
CAC-40	170	0.08% (0.84%)	
SMSI	170	0.03% (0.78%)	
DAX	166	0.08% (0.86%)	
Nikkei 225	161	0.08% (0.85%)	
S&P 500	167	0.11% (0.76%)	
Panel B: pre-event window from 30 January 2020 to 10 March 2020			
CSI 300	27	0.10% (2.29%)	0.13
FTSE MIB	29	-1.00% (2.68%)	-4.14**
Korea Composite	29	-0.35% (1.69%)	-1.98*
CAC-40	29	-0.84% (2.15%)	-4.08**
SMSI	29	-0.82% (2.16%)	-3.90**
DAX	29	-0.81% (2.08%)	-3.98**
Nikkei 225	27	-0.59% (1.69%)	-3.19*
S&P 500	28	-0.42% (2.65%)	-2.12*
Panel C: short event window from 11 March 2020 to 22 March 2020			
CSI 300	8	-1.37% (1.69%)	-4.05**
FTSE MIB	8	-1.50% (7.46%)	-2.54**
Korea Composite	8	-2.69% (4.50%)	-6.17**
CAC-40	8	-1.83% (6.22%)	-3.56**
SMSI	8	-1.77% (6.64%)	-3.25**
DAX	8	-2.07% (5.61%)	-4.20**
Nikkei 225	7	-2.55% (2.08%)	-7.43**
S&P 500	8	-2.52% (7.32%)	-4.40**

Notes: Std. dev. in parentheses. *Significant at the 5% level; **significant at the 1% level.

Nikkei 225 Index and the S&P 500 Index (at the 5% level) underperformed the comparison period.

These results differ from the results obtained from Panel C in Table 1, which could tentatively be interpreted that the negative impact over the pre-event period is derived from the spill-over effects of COVID-19 in Asian countries. It is worth mentioning that the CSI 300 Index has a good performance over the pre-event period, which is consistent with the results shown in Panel D of Tables 1 and 2.

The results of the short event window are shown in Panel C. All indices underperformed the comparison period at the 1% level of significance, even further deteriorated compared with the pre-event period. Recent articles explain why the stock market has plummeted. A report titled 'What is the Root Cause of the Continued Collapse of US Stocks?' (Wang 2020) points out that the external trigger of the sharp decline of USA stocks is the market panic caused by the COVID-19 epidemic and Saudi Arabia's oil price war, depicting COVID-19 as the straw that broke the camel's back. The findings imply that the COVID-19 epidemic bears direct responsibility for part of the sharp decline, which confirms the conclusion that the outbreak of COVID-19 significantly affected the stock markets.

It is worth noting that the CSI 300 Index underperformed the comparison period at the 1% level as well, despite the fact that the COVID-19 epidemic has eased in China. It would appear that the impact of COVID-19 on stock markets in Europe and the USA has a spill-over effect on Chinese stock markets. From the findings shown in

Table 5. Differences in median returns of foreign timeline.

Index	Number of days	Median return	W-value
Panel A: comparison period from 1 June 2019 to 29 January 2020			
CSI 300	161	0.06%	
FTSE MIB	167	-0.25%	
Korea Composite	162	0.07%	
CAC-40	170	0.14%	
SMSI	170	0.00%	
DAX	166	0.14%	
Nikkei 225	161	-0.47%	
S&P 500	167	0.09%	
Panel B: pre-event window from 30 January 2020 to 10 March 2020			
CSI 300	27	-0.35%	14,886
FTSE MIB	29	-0.05%	16,876
Korea Composite	29	-0.06%	15,857
CAC-40	29	-0.23%	17,540
SMSI	29	0.01%	17,302
DAX	29	-0.27%	16,831*
Nikkei 225	27	-0.39%	15,652
S&P 500	28	-0.23%	16,770
Panel C: short event window from 11 March 2020 to 22 March 2020			
CSI 300	8	-1.37%	14,107**
FTSE MIB	8	-1.02%	14,604
Korea Composite	8	-3.31%	14,334**
CAC-40	8	-0.63%	15,193
SMSI	8	-0.20%	15,197
DAX	8	-0.21%	14,517
Nikkei 225	7	-2.27%	14,077**
S&P 500	8	-4.61%	14,912

Note: *Significant at the 5% level; **significant at the 1% level.

Tables 1 and 4, the bidirectional spill-over effect caused by the outbreak of COVID-19 is confirmed.

Table 5 shows the returns of the pre- and short event windows in the timeline of the selected countries compared with the comparison period using the non-parametric Mann–Whitney tests. In the pre-event window shown in Panel B, the DAX Index underperformed the comparison period at the 5% level of significance. In the short event window shown in Panel C, the CSI 300 Index, the Korea Composite Index and the Nikkei 225 Index (1% level) underperformed the comparison period.

Considering that the pandemic has not peaked while this paper is being written, the empirical results of the domestic timeline for the long event window provide a reference for the trend of stock markets when COVID-19 eventually subsides. According to the results in Panel D of Tables 1 and 2, we can predict that, if the pandemic were to be controlled within two months, the impact of COVID-19 on stock markets would be limited. Andersen (2020) also notes that in the research papers of formally modelling pandemic scenarios, many find a large short-run economic impact, but none of them finds a significant long-run impact, even in a very severe scenario.

There may be several factors that make a potential pandemic-generated economic slowdown different from usual recessions. First, recent recessions have been accompanied by large-scale reallocation of labour and other resources across sectors. By contrast, workers unemployed or put on furlough because of coronavirus are likely to resume their former positions. In other words, the former pattern of economic activity

Table 6. Returns relative to global index of foreign timeline.

Index	Pre-event period		Short event window	
	30 January 2020–10 March 2020		11 March 2020–22 March 2020	
Panel A: <i>t</i> -test on daily returns relative to S&P 1200				
	Mean	<i>t</i> -value	Mean	<i>t</i> -value
S&P 1200	−0.02% (0.60%)		−2.84% (8.23%)	
CSI 300	0.10% (2.29%)	−1.00	−1.37% (1.69%)	−0.50
FTSE MIB	−1.00% (2.68%)	0.83	−1.50% (7.46%)	−0.34
Korea Composite	−0.35% (1.69%)	−0.25	−2.69% (4.50%)	−0.04
CAC-40	−0.84% (2.15%)	0.65	−1.83% (6.22%)	−0.28
SMSI	−0.82% (2.16%)	0.62	−1.77% (6.64%)	−0.29
DAX	−0.81% (2.08%)	0.61	−2.07% (5.61%)	−0.22
Nikkei 225	−0.59% (1.69%)	0.21	−2.55% (2.08%)	−0.09
S&P 500	−0.42% (2.65%)	−0.10	−2.52% (7.32%)	−0.08
Panel B: Mann–Whitney test				
	Median	<i>W</i> -value	Median	<i>W</i> -value
S&P 1200	−0.23%		−1.60%	
CSI 300	−0.35%	868	−1.37%	68
FTSE MIB	−0.05%	849	1.02%	67
Korea Composite	−0.06%	873	−3.31%	68
CAC-40	−0.23%	845	0.63%	66
SMSI	0.01%	856	0.20%	65
DAX	−0.27%	837	0.21%	68
Nikkei 225	−0.39%	763	−2.27%	66
S&P 500	−0.23%	821	−4.61%	69

Notes: Std. dev. in parentheses. *Significant at the 5% level; **significant at the 1% level.

can be resumed, whereas usual recessions and their aftermath entail a reconfiguration of economic activity. Second, a general recession is often prolonged by a lack of confidence on the part of investors, firms and consumers. It seems logical, however, that these groups would regain their confidence in the markets once the pandemic recedes.

Table 6 compares the daily returns with the S&P 1200 Global Index in the timeline of the selected countries using *t*-tests (Panel A) and non-parametric Mann–Whitney tests (Panel B). From the findings reported in Table 6, it appears that no unequivocal picture seems to emerge when it comes to the market's reaction in the foreign timeline compared with the S&P 1200 Global Index. Over the pre- and short event windows, the S&P 1200 Global Index has a return that is not significantly different from the eight indices; this is consistent with the results obtained from Table 3. There is no evidence that COVID-19 has a negative impact on the major stock indices in these countries compared with the S&P 1200 Global Index.

Overall, the study of the timeline of the selected countries indicates that COVID-19 negatively affected stock markets. Specifically, the development of the COVID-19 pandemic has had a negative impact on the European and American stock markets and, as the virus spreads, the negative impact will be also further intensified. We postulate, however, that the impact on stock markets will be short-term rather than long-term. Once again, it is worth noting that the impact of COVID-19 on the European and American stock markets has a spill-over effect on the Asian stock market. When we combine our study of the foreign timeline with our study of the domestic one, the bidirectional spill-over effect caused by the outbreak of COVID-19 is confirmed.

Conclusion

This paper studies the direct and spill-over effects of COVID-19 on stock markets. The development of the epidemic up to the date when this paper was written is divided into two parallel timelines: the domestic timeline and the foreign timeline. Using conventional *t*-tests and non-parametric Mann–Whitney tests, an empirical analysis is conducted based on daily return data of stock markets in the People’s Republic of China, Italy, South Korea, France, Spain, Germany, Japan and the USA.

Despite the facts that COVID-19 is fiercely hurting the world with its outbreak not reaching a turning point and that the foreign timeline is still extending, the following conclusions can be drawn. Evidence from the domestic timeline and the timeline of the selected countries suggests that COVID-19 has a negative but short-term impact on the stock markets of the eight affected countries. The impact of COVID-19 on stock markets has bidirectional spill-over effects between Asian countries and European and American countries. Furthermore, except for China in the short event window of the domestic timeline, there is no evidence that COVID-19 has a negative impact on the major stock indices in these countries compared to the S&P 1200 Global Index.

These findings contribute to the research in economic impacts of the pandemic by providing empirical evidence that COVID-19 has bidirectional spill-over effects on the Chinese economy and seven other countries that are affected by the outbreak. Admittedly, though, since there is no a pandemic mitigation period in the other countries yet while this paper is being written, this study merely provide a reference for the trend of capital markets when the COVID-19 pandemic subsides worldwide.

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