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Coronavirus disease outbreak and supply chain disruption: Evidence from Taiwanese firms in China

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ABSTRACT

This study applies an empirical analysis to examine whether supply chain disruption is caused by the outbreak of the coronavirus disease (COVID-19) that was first reported in Wuhan, China, on December 31, 2019. The study’s findings indicate a link between the COVID-19 outbreak and the disruption of logistics and supply chains along with negative cumulative abnormal returns within Taiwanese firms manufacturing products in China and marketing them globally. This is the first study to examine the outbreak of the COVID-19 and the disruption of the supply chain and its effect on the stock market. The empirical results provide insights for business management in reconsidering their global supply chain strategies for the risk of disruption caused by similar epidemics occurs in the future.

1. Introduction

The coronavirus disease, (COVID-19), was first reported in Wuhan, China, on December 31, 2019 (World Health Organization, 2019a Situation report-1). The outbreak of the disease has caused chaos and weakened the economy of China especially at the end of 2019 and January, 2020. The sudden spread of the disease to nearby countries has made people aware of its effects on their daily lives, especially for those firms located in China. Additionally, various local governments have introduced measures in businesses to prevent further spread of the disease at workplaces. Any employer’s failure to comply with these measures may result in administrative penalties as stated by the Implementing Measures Law of the People’s Republic of China, (PRC), on the prevention and treatment of infectious diseases and the PRC Emergency Response Law. Accordingly, most firms have been forced to temporarily shut down their current facilities in compliance with these measures set by the government, forcing employees to stay home until further notice to resume work.

China, also known as the world’s factory, has complied with action plans to shut down most of its factories to avoid the spread of COVID-19. The government’s action plans to curb further spread of the disease will eventually disrupt the entire logistics and supply chain system. The advantages of geographical and cultural backgrounds between China and Taiwan enable most Taiwanese firms to migrate into China to either continue manufacturing or discuss a cost-saving strategy that will sustain their businesses since the total amount of money remitted from Taiwan to China as of 2018 was NTD2.5 billion (KEYPO, 2020, Appendix, Figure A.3). The COVID-19 outbreak also affected Taiwanese manufacturing firms in China.

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Motivated by the panic selling perspective, the following three major behaviors were likely to be observed in the stock market. First, the sudden, wide-scale selling of securities causes a significant decline in stock prices. Chen et al. (2009) showed that stock prices are correlated with a variety of rational and international events. Second, it is often triggered by an event that significantly reduces trust in investors in a security market. Finally, stock market authorities are likely to manipulate trading curbs and halts to limit panic selling. Specifically, major global events or crises have impacted the global economy and financial market (Popkova et al., 2021). Previous studies have focused on the impact of macroeconomic factors on stock returns (Fama, 1981; Fama and French, 1988; Abdullah and Hayworth, 1993). Schell et al. (2020) investigated six Public Health Risk Emergency of International Concern (PHEIC) announcements made by the World Health Organization on, April 22, 2008, to March 12, 2020, and the COVID-19 outbreak shows a significant negative reaction on the stock market. Additionally, the global financial market risks have increased substantially in response to the COVID-19 outbreak; the evidence shows that regional market integration/collaboration is likely to appear in the face of this major crisis and may have a significant impact on the stock market (Zhang et al., 2020; Ashraf, 2020).

Liu et al. (2020) examined the short-term impact of the coronavirus outbreak on 21 leading stock markets. They confirmed that the outbreak directly affects stock markets worldwide, especially for those countries in Asia experienced more negative abnormal returns as compared to other countries.

Hence, this study examines the impact of the COVID-19 outbreak on Taiwanese firms located in China. To the best of our knowledge, this is the first study to examine the relationship between the effect of COVID-19 and supply chain system with stock market reaction. Our study particularly shows the supply chain disruption along with panic selling in stock markets in relation to the regarding COVID-19. Additionally, we find significant evidence on the relation between the COVID-19 outbreak and the negative cumulative abnormal returns (CARs) on stock performance within the Taiwanese firms manufacturing products in China and marketing them globally. Consistent with Goodell and Huynh (2020), the results suggest that the COVID-19 outbreak had a major impact on the financial market, among which the tourism industry has been identified as having negative abnormal returns. Our empirical evidence provides insights to entrepreneurs, fund managers and investors on business or investment strategies by globalization as well as lowers the risk of supply chain disruption if a similar epidemic occurs in the future.

The remainder of this paper is organized as follows. Section 2 discusses relevant literature, Section 3 presents data and methodology, Section 4 discusses the empirical results of the findings, and Section 5 concludes the study.

2. Relevant literature

2.1. Major events and stock market responses

Ideally, in an efficient market, a stock price fully represents all available information in the stock market (Jensen et al., 1996). Besides, previous studies have indicated that the stock market is significantly correlated with sudden events. Chen and Siems (2004) show that the U.S. capital markets responded to various terrorism attack events, which had a significant negative impact on the markets (Curatola et al., 2016). Charles and Darné (2006) examined the impact of attacks on international stock markets on September 11, 2001 by estimating abnormal price changes. Previous studies have examined whether stock events have a sustainable effect on stock prices. Rajiv et al. (1993) studied both nuclear and non-nuclear utilities’ reactions on the stock market using the event parameter measures approach. You et al. (2017) report that the effects of oil shocks and economic policy uncertainty are highly correlated with stock markets in different market conditions (Zhang, 2017). The results indicated negative price reactions to the accident or event as well as small and transitory effects.

Kaplanski and Levy (2010) suggest that the bad mood and anxiety individuals who are afraid of loss and uncertainty of investment return, can lead to an impact on investment decisions and subsequently affect returns on assets. In 2007, the world suffered a severe acute respiratory syndrome (SARS) outbreak that significantly impacted the global economy. Chen et al. (2007) showed that on and after the day of the SARS outbreak, stock prices showed significant negative CARs and indicated the influence of the SARS outbreak on stock performance.

Ichev and Mariné (2018) examined the 2014–2016 Ebola outbreak in the U.S. and West African Countries (WAC) and found that following the Ebola event, the financial market had a significant negative return. In this regard, the effectiveness of the several diseases has been verified by previous studies. It has shown that stock price movement is significantly correlated with the outbreak of the disease.

2.2. Extent of COVID-19 infection in each province in China

However, stock market returns are highly correlated with major events or crises. The sudden shock of the report dated February 10, 2020 (World Health Organization, 2019b Situation report-21), the number of infections and mortality rates in each province in China, are shown in Appendix Table A.1 (the geographical representation of the virus infection and mortality population rates). The impact of the COVID-19 outbreak is mainly reflected in three aspects. First, China’s manufacturing industries cannot start production, which will inevitably affect the development of upstream and downstream enterprises in the relevant international industrial chain to manufacture goods for production or marketing, eventually leading to the contraction of the global supply chain. Second, due to the implementation of traffic control in some regions in China, and the reduction of flights between some countries and China, and the nationwide postponement of China’s flights will result in limited scope for development, which will also affect the international supply chain. Third, the COVID-19 outbreak has delayed the main parts of international business communication, exhibition, and trade and investment. In contrast, some parts of the international supply chain were forced to wait for opening or approval time, leading to a
delay or postponement of the global supply chain.

The advantages of geographical and cultural backgrounds between China and Taiwan enable Taiwanese firms to migrate into China to either continue manufacturing or discuss a cost-saving strategy that will sustain their businesses for a decade. Additionally, the sum of the accumulated amount of money remitted from Taiwan (as in Appendix A.3) has shown that the total amount was at NTD 2.5 billion as of 2019. With the increasing amount of capital inflow and the manufacturing facility bases located in China, this study aims to examine the Taiwanese firms and find significant evidence of the relationship between the COVID-19 outbreak and negative cumulative mean abnormal returns on stock volatility.

2.3. Impact of the COVID-19 outbreak on the stock market

Following the global spread of the COVID-19 outbreak, the economic effect of COVID-19 has grown rapidly in many research aspects; McKibbin and Fernando (2020) explore the correlation between the global market and the outbreak of COVID-19; Abdullah et al. (2020) explore the total cases of death caused by COVID-19 and indicate that the negative stock returns in all companies are correlated with the COVID-19 outbreak. Events may significantly affect stock market returns (David et al., 2021). This study aims to verify whether the COVID-19 outbreak has a significant impact on the stock market and whether it causes a tremendous decrease in the firms’ stock prices. This study focuses on the listed companies in Taiwan that have already migrated and invested in China over the past decade. We examine the negative effect documented by Akhtar et al. (2011) and determine whether stock returns react more strongly to negative or positive events. The study of negative effects is also supported by Kaplanski and Levy (2010). They show that the stock market losses through aviation disasters are substantially larger than those of the actual costs of the disasters. At the same time, Edmans et al. (2007) indicate that a country’s unexpected loss in a sporting event causes a significant negative reaction in the stock market, which is not mirrored by a significant reaction to an unexpected win.

This COVID-19 outbreak has caused a disastrous crisis in the global supply chain as most Chinese factories are shutdown to prevent the spread of infection. The reduction of flights between some countries and China, and the nationwide postponement of Chinese flights have also contributed to the crisis in the global supply chain. The global supply chain however, has no set emergency countermeasures meant for such situations. For example, after the 9/11 terrorist attack, the U.S. consumption was in doldrums and many factories were permanently shut down, all of which caused temporary stagnation of the economy of U.S. economy. Another example is the shutting down of the Sanlu group in China, after the Sanlu milk powder incident was exposed resulting in the bankruptcy and disintegration of the supply chain. Such crises are usually caused by unpredictable and unexpected risks, which often have a huge impact on enterprises and society at large. It is often difficult to recover from the consequences.

The shock impact from the COVID-19 outbreak has forced certain local governments to put in place strict measures in businesses to prevent further spread of the COVID-19. This will not only impact production and marketing within local areas but also cause the closure of factories, shortage of material resulting in the disruption of China’s distribution of goods internationally. In particular, based on the infected population statistics from January 1, 2020 to February 25, 2020 (KEYPO, 2020, Appendix, A.2); we believe that there is a variation in the stock return response and the relationship between the COVID-19 and the impact of the sudden outbreak on the stock market. This study distinguishes Taiwanese firms that migrated into China, into two groups. The first group mainly or only manufactures who market their products in China, while the second group manufactures in China and markets their products globally. Hence, we posit the following hypotheses to examine the existence of the accumulated abnormal returns on 1st, 3rd, 5th, and 7th days after the pandemic was announced on December 31, 2019:

**Hypothesis 1.** Compared with the first group of firms, which mainly market their products in China, the second group’s firms’ market is likely to be negatively impacted by the COVID-19 outbreak, resulting in abnormal returns and the disruption of the supply chain system.

3. Data and methodology

3.1. Data

The study uses the daily close-of-day (business day) stock market prices obtained from the Taiwan Economic Journal database (TEJ). For the study, we took 250 trading days to analyze the extent of the impact of COVID-19 infection; January 2, 2019 to July 9, 2020. In this study, EPSC is firm’s earnings per share, income is the firm’s net profit before tax, size is the firm size, and turnover is the ratio of the total number of shares traded to the total number of outstanding shares. Finally, the industry and Taiwan Security Exchange (TSE) were controlled to eliminate the differences between them in the study.

3.2. Methodology

3.2.1. Event study

Several methodologies have been used in modeling event studies for abnormal returns. This study applies the even-study approach,

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1 The Chinese New holiday is from January 24, 2020 to January 31, 2020, hence the stock market remains closed during the holiday period until February 3, 2020 which is its opening date.
which is often used to measure the effectiveness of an economic event on the value (or stock return) of a firm (Campbell et al., 1997; Nicolau, 2002) to examine the COVID-19’s effect on the stock volatility of Taiwanese firms located in China. We took a group of Taiwanese listed companies and divided them into two major groups. Group 1 consisted of firms manufacturing and marketing in China, while Group 2 consisted of firms manufacturing in China but marketing globally. The study aims to test whether the COVID-19 outbreak has a significant negative effect on stock markets by causing abnormal stock returns using the regression analysis method.

Based on Brown and Warner (1985) who utilized the mean-adjusted-returns approach, this study computes the daily excess returns of AR by:

\[ AR_t = R_t - \bar{R} \]  

Where \( AR_t \) is the CARs for stock prices at time \( t \), \( R_t \) is the actual observed rate of return for the stock, and \( \bar{R} \) is the mean return of daily return stock in the (-250,-10) estimation period, such that:

\[ \bar{R} = \frac{1}{240} \sum_{t=-250}^{-10} R_t \]  

To examine the COVID-19’s effect on the firms located in China, and consequently causing the CARs on stock prices in the 1st, 3rd, 5th, and 7th days after the pandemic was announced on December 31, 2019. According to Kollias et al. (2011), longer event windows are examined by computing the cumulative abnormal returns (CARs) ten (\( t = 10 \)), five (\( t = 5 \)), three (\( t = 3 \)), and one (\( t = 1 \)) days following the event. The CARs were estimated using the following equation:

\[ CAR_t = \frac{1}{\sqrt{m}} \sum_{i=t_1}^{t_2} COVID - 19 \]  

We consider the returns (\( R_t \)), earnings per share (EPSC), the size of the firm (size), and the total amount of the firm’s sales (turnover) as variables to test the relationship with EPS, as it represents the contribution of the firm’s earnings ability. Table 1 shows the results of the descriptive statistics for each panel. Overall, all four panels show that the mean of the actual rate of returns is negative. In particular, panel D’s earnings per share is less than 0, which indicates that the effect of the COVID-19 outbreak is likely to impact the stock returns on the firm’s EPSC once it becomes less than 0.

The statistics on any day (\( t \)) test in the event window for all stocks (\( n \)) is constructed to determine whether or not CARs are significant, as shown in Eq. (4):

\[ t - \text{statistic} = \frac{1}{\sqrt{n}} \sum_{i=1}^{n} CAR_i \]  

The t-statistic as the test statistic follows a standard normal distribution (Campbell et al., 1997). If the COVID-19 outbreak causes abnormal returns, the t-statistic should be significantly different from zero. Thus, we test the null hypothesis \( H_0 \) against the alternative

Table 1
Descriptive statistics of all variables.

| Variable | Mean | Std. Dev. | Max  | Min  |
|----------|------|-----------|------|------|
| Panel A: All data (\( N = 1289 \)) | R | -6.004 | 4.102 | 9.988 | -10.000 |
| EPSC | 0.302 | 1.260 | 13.030 | -4.450 |
| SIZE | 15.650 | 1.687 | 22.999 | 10.148 |
| TURNOVER | 0.634 | 1.625 | 21.402 | 0.000 |
| Panel B: EPSC = 0 (\( N = 146 \)) | R | -4.910 | 4.728 | 9.979 | -10.000 |
| EPSC | 0.000 | 0.000 | 0.000 | 0.000 |
| SIZE | 15.760 | 2.242 | 22.077 | 10.148 |
| TURNOVER | 0.599 | 1.990 | 21.402 | 0.000 |
| Panel C: EPSC>0 (\( N = 646 \)) | R | -6.258 | 3.818 | 9.977 | -10.000 |
| EPSC | 0.820 | 1.566 | 13.030 | 0.010 |
| SIZE | 15.966 | 1.669 | 22.999 | 12.322 |
| TURNOVER | 0.668 | 1.520 | 18.961 | 0.000 |
| Panel D: EPSC<0 (\( N = 497 \)) | R | -5.996 | 4.216 | 9.988 | -10.000 |
| EPSC | -0.283 | 0.461 | -0.010 | -4.450 |
| SIZE | 15.206 | 1.403 | 21.816 | 11.179 |
| TURNOVER | 0.601 | 1.642 | 15.807 | 0.000 |

Note: \( R_t \) is the actual observed rate of return for the stock. EPSC is the firm’s earnings per share, Size is the firm size, and TURNOVER is the ratio of total shares traded to the total shares outstanding.
hypothesis H1:

**H0.** The COVID-19 outbreak did not cause negative cumulative abnormal returns, based on stock performance.

**H1.** The COVID-19 outbreak has caused significant negative cumulative abnormal returns based on stock performance.

To test the null hypothesis H0 against the alternative hypothesis H1 by running Eq. (4), Table 2 represents the result of the t-statistic test of the COVID-19 outbreak in all provinces and Hubei province, respectively. The empirical results in Table 3 are $R^2 = -5.253$ in all provinces and $-7.39$ in Hubei, while it $\text{CAR}_1$ is $-5.296$ in all provinces and $-7.513$ in Hubei. The evidence in this analysis has proven that the COVID-19 outbreak has significant negative CARs based on stock performance.

As of now, we have empirically found that the COVID-19 outbreak causes CARs, especially in firms located in Hubei Province. Subsequently, to test the CARs effect, we constructed the following baseline regression Eq. (5):

$$ Y_t = \alpha + \beta_1 \text{EPSC}_t + \beta_2 \text{SIZE}_t + \beta_3 \text{TURNOVER}_t + \delta \text{Ind} + \theta \text{TSE} + \epsilon_t $$

(5)

Here $Y_t = (\text{CAR}_1^i$ and $\text{CAR}_2^i$), $\text{CAR}_1^i$ and $\text{CAR}_2^i$ are the cumulative abnormal returns and the firm’s stock rate of returns of (i) stock at day t respectively. EPSC is the firm’s earnings per share, size is the firm’s size, and turnover is the ratio of the total number of shares traded to the total number of outstanding shares.

4. Empirical result

4.1. Outbreak effect test of COVID-19

The main variable in Eq. (5) of this study’s estimation is $Y_t$. The empirical results show that the coefficient of $(\beta_1)$ is significant and negative, which indicates that the COVID-19’s outbreak effect exists and that CARs are correlated with a firm’s EPSC, resulting in CARs based on stock performance.

Subsequently, we focused on two major groups—group (1) that consists of firms manufacturing and marketing products in China, and group (2) that consists of firms manufacturing products in China and marketing the products globally—to examine whether the CARs exist during the 1st, 3rd, 5th, and 7th days. The empirical results in Table 4 indicate that the coefficient of $(\beta_1)$ is significant and negative, indicating that the effect of the COVID-19 outbreak causes CARs when firms are manufacturing in China and marketing globally. In this analysis, we also test the four variables, namely income, EPSC, size and turnover, and the robustness that will cause differences in CARs group 1 and group 2. The results, however, show that there is no significant connection between the four variables and the CARs.

The empirical results in Table 4 indicate that the coefficient of $(\beta_1)$ is significant and negative, implying that the COVID-19 outbreak affects on the firms that manufacture in China but market globally, causing CARs$^2$. The evidence has provided insights to firms encouraging them to embrace globalization and strategies to lower the risk of supply chain disruption. However, Kleindorfer and Saad (2005) have shown that supply chain risk can be divided into disruption and demand risks. The risk of disruption causes a loss of customers and business opportunities. Therefore, a firm’s profitability decreases based on its stock performance.

According to chaos theory, the butterfly effect is the sensitive dependence on initial conditions in which a small change in one state of a deterministic nonlinear system can result in large differences in a later state. China, the world’s biggest factory is also confronted with the current outbreak of the deadly COVID-19, which was first reported in Wuhan. The world suffers a significant decline in sales, stock markets, oil prices, and the disruption of supply chains and aviation activities, which have a significant impact on trade exchange across globally.

Table 4 shows that the CARs of the group (2) during the 1st, 3rd, 5th, and 7th days are not correlated with EPSC, which implies that the COVID-19 outbreak is the main cause of CARs. Moreover, group (1) is also not significantly correlated with EPSC.

Since the COVID-19 outbreak was first reported in Wuhan, China, on December 31, 2019, the Chinese government initiated a series of temporary regulations to either diminish or prevent further spread of the disease. The regulations include the postponement of schools’ winter break, the extension of the Chinese New Year Holiday, suspension of businesses among others. In other words, the second group of firms is likely to be negatively affected by the COVID-19 outbreak since most of the firms’ buyers are international. The outbreak causes uncertainty among firms as they are unable to maintain factory operations delayed or postponed production and the risk of prolonged supply chain disruption.

Additionally, the efficient market hypothesis shows that the market would respond rationally to extreme tail events. However, financial markets are inefficient, especially for tail events. Generally, our results show that the sudden occurrence of an incident like the COVID-19 outbreak has negative effects on stock markets and the economy at large, as it results in panic selling among other effects. Consequently, the market responded irrationally to extreme tail events, as our hypothesis construction in this study that the COVID-19 outbreak led the government action plans for the business to prevent the spread of the COVID-19 outbreak at the workplace by a temporary shut down. The temporary government action plans have caused disrupted, then gradually affecting global supply chain, of firms manufacturing in China and marketing globally.
5. Conclusion

This study provides clear insights on how stock prices and the supply chain system react to the outbreak of an infectious disease in the short-term, specifically focusing on Taiwan listed companies’ manufacturing in China and distributing their products globally. The findings of this study indicate that Taiwanese companies’ stocks are sensitive to the COVID-19 outbreak and show the fragility of business allocation in the supply chain system and the likelihood of suppressing the supply of goods and stock performance. Therefore, to minimize the possible negative effects of the outbreak on financial performance or capital losses when a similar sudden epidemic occurs, a quick response of preventive measures improve specific negative stock effects is required.

Besides, the COVID-19 outbreak also complied with a series of the action plans set by the Chinese government, which eventually

Table 2

T-test results of all provinces in China.

|          | Panel A: All provinces |          | Panel B: Hubei Province |
|----------|------------------------|----------|------------------------|
|          | Mean       | Std.error | t value    | Mean       | Std.error | t value    |
| R1       | -5.253*** | 0.112     | -46.85     | -7.397*** | 0.281     | -26.25     |
| R3       | -6.840*** | 0.167     | -41.05     | -9.999*** | 0.676     | -14.80     |
| R5       | -5.377*** | 0.165     | -32.70     | -8.623*** | 0.527     | -16.35     |
| R7       | -5.295*** | 0.198     | -26.75     | -8.251*** | 0.558     | -14.80     |
| CAR1     | -5.296*** | 0.114     | -46.70     | -7.513*** | 0.288     | -26.05     |
| CAR3     | -6.882*** | 0.168     | -41.05     | -10.117***| 0.680     | -14.85     |
| CAR5     | -5.425*** | 0.165     | -32.90     | -8.740*** | 0.525     | -16.65     |
| CAR7     | -5.335*** | 0.199     | -26.85     | -8.368*** | 0.558     | -15.00     |

Note:
1. R1 and CAR1 are the firm’s stock rate of returns and accumulative abnormal returns on day i.
2. ***, **, and * denote significance at the 1%, 5%, and 1% levels, respectively; t values are in parentheses.

Table 3

The result of firms’ returns and abnormal returns.

|          | R1       | R3       | R5       | R7       |
|----------|----------|----------|----------|----------|
| EPSC     | -0.232** | -0.465** | -0.508***| -0.605***|
| SIZE     | -0.425***| -0.485***| -0.556***| -0.318*  |
| TURNOVER | 0.281**  | 0.868*** | 0.651*** | 0.940*** |
| Constant | 0.230    | 1.209    | 3.397    | -1.058   |
| Ind fixed| Yes      | Yes      | Yes      | Yes      |
| TSE fixed| Yes      | Yes      | Yes      | Yes      |
| R2       | 0.249    | 0.181    | 0.149    | 0.174    |
| Adjusted R2 | 0.229  | 0.158    | 0.126    | 0.151    |
| N        | 1289     | 1289     | 1289     | 1289     |
| EPSC     | -0.241** | -0.474** | -0.517***| -0.614***|
| SIZE     | -0.428***| -0.488***| -0.560***| -0.321*  |
| TURNOVER | 0.261**  | 0.849*** | 0.631*** | 0.921*** |
| Constant | 0.171    | 1.150    | 3.338    | -1.117   |
| Ind fixed| Yes      | Yes      | Yes      | Yes      |
| TSE fixed| Yes      | Yes      | Yes      | Yes      |
| R2       | 0.252    | 0.181    | 0.149    | 0.174    |
| Adjusted R2 | 0.232  | 0.159    | 0.126    | 0.151    |
| N        | 1289     | 1289     | 1289     | 1289     |

Note:
1. R1 and CAR1 are the firm’s stock rate of returns and accumulative abnormal returns on day i. EPSC, SIZE and TURNOVER are the firm’s earnings per share, the firm’s size and the ratio of total shares traded to the total shares outstanding. The dummy variables of "Ind fixed" and "TSE fixed" have been fixed to avoid any effects from a difference in the Taiwan Security Exchange (TSE) or industry. The t-statistics are adjusted for serial correlation using the Newey-West procedure.
2. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively; t values are in parentheses.

5. Conclusion

This study provides clear insights on how stock prices and the supply chain system react to the outbreak of an infectious disease in the short-term, specifically focusing on Taiwan listed companies’ manufacturing in China and distributing their products globally. The findings of this study indicate that Taiwanese companies’ stocks are sensitive to the COVID-19 outbreak and show the fragility of business allocation in the supply chain system and the likelihood of suppressing the supply of goods and stock performance. Therefore, to minimize the possible negative effects of the outbreak on financial performance or capital losses when a similar sudden epidemic occurs, a quick response of preventive measures improve specific negative stock effects is required.

Besides, the COVID-19 outbreak also complied with a series of the action plans set by the Chinese government, which eventually
resulted in the disruption of the supply chain system in China. This study also provides insights into companies on globalization. Based on the examples of Taiwanese firms, we found that the firms that manufacture their products in China and distribute or market globally are likely to be affected by the COVID-19 outbreak. The outbreak causes firms to disrupt factory operations, hence delaying or postponing production. Since China has come to be known as the world’s factory, the COVID-19 outbreak is likely to disrupt the supply chain system, causing an irrational market response such as panic selling or stock sell-offs. This may not be as durable, Kleindorfer and Saad (2005) have shown that the supply chain risk can be divided into disruption and demand risks. The risk of disruption causes a loss of customers’ business opportunities. From a corporate governance perspective, the top management should sustain the confidence level of investors while suggesting multiple business growth strategies to avoid the sudden occurrence of similar epidemics in the future.

Moreover, business management may also want to re-consider their global supply chain strategies in the future when a risk of supply chain disruption arises due to the occurrence of similar epidemics in the future. The empirical findings of this study also show that to avoid the risk of supply chain disruption there is a need to reconsider the firm’s logistics of the supply chain strategy on this COVID-19 outbreak, move back to the original country or have multiple production locations to minimize a sudden shock of similar epidemic impact and has become the objective and goal of several businesses on the supply chain system for the future.

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### Appendix A. Supplementary data

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