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The impact of COVID-19 on the G7 stock markets: A time-frequency analysis

Mrobeen Ur Rehman a,b, Sang Hoon Kang c,d,*, Nasir Ahmad e, Xuan Vinh Vo f

a Institute of Business Research, University of Economics Ho Chi Minh City, Viet Nam
b South Ural State University, 76, Lenin Prospekt, Chelyabinsk, Russian Federation
c PNU Business School, Pusan National University, Busan, Republic of Korea
d UniSA Business, University of South Australia, Adelaide, Australia
e Independent Researcher
f Institute of Business Research and CFVG, University of Economics Ho Chi Minh City, Viet Nam

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ABSTRACT

We examine the co-movement of the G7 stock returns with the numbers of confirmed COVID-19 cases and causalities based on daily data from December 31, 2019 to November 13, 2020. We employ the wavelet coherence approach to measure the impact of the numbers of confirmed cases and deaths on the G7 stock markets. Our findings reveal that both the number of confirmed COVID-19 cases and the number of deaths exhibit strong coherence with the G7 equity markets, although we find heterogeneous results for the Canadian and Japanese equity markets, in which the numbers of COVID-19 cases and the deaths exhibit only a weak relationship. This evidence is more pronounced in the long-term horizon rather than the short-term horizon. Moreover, the lead-lag relationship entails a mix of lead-lag relations across different countries. We present the implications of these findings for both policymakers and the international investment community.

1. Introduction

The global economic situation has been subjected to a severe disruption due to the COVID-19 pandemic. According to the World Bank’s (2021) recent report on the global economic outlook, global economic growth is projected to contract by 4.3 percent, as compared with the 3 percent decline seen in April 2020, as a result of COVID-19, which indicates that the pandemic will have had a much more significant adverse impact than the global financial crisis of 2008–2009. The group of seven (G7) economies, which are responsible for around 40 percent of the global gross domestic product (GDP), also experienced substantial economic and financial losses as a result of the COVID-19 pandemic. According to the Organization for Economic Co-operation and Development (OECD, 2020), economic growth fell by 11.2 percent in the United Kingdom (UK), 9.1 percent each in France and Italy, 5.5 percent in Germany, 5.4 percent in Canada, 5.3 percent in Japan, and 3.7 percent in the US during 2020.

Prior studies document severe impact of various pandemics (e.g., the 1918–1920 Spanish flu pandemic, the severe acute respiratory

* Corresponding author: PNU Business School, Pusan National University, Jangjeon2-Dong, Geumjeong-Gu, Busan 609-735, Republic of Korea. E-mail addresses: Rehman@ueh.edu.vn (M.U. Rehman), sanghoonkang@pusan.ac.kr (S.H. Kang), vinhx@ueh.edu.vn (X.V. Vo).

1 The novel coronavirus disease 2019 (COVID-19) was first identified in the city of Wuhan in China in December 2019. The World Health Organization (WHO) announced a worldwide emergency on March 11, 2020 following the rapid spread of the virus across 200 counties.

2 http://www.oecd.org/economic-outlook/december-2020/
syndrome [SARS] pandemic, and the COVID-19 pandemic) on the global equity markets. Despite being associated with greater market efficiency and stability, the G7 stock markets, similar to the majority of other equity markets, have experienced increased levels of uncertainty due to the COVID-19 pandemic (Aldawasari & Alnagada, 2020). According to Albulescu (2020) and Onali (2020), the number of confirmed COVID-19 cases and casualties has a significant positive impact on the stock market volatility in the United States (US). Similar results have been documented by Zhang, Hu, and Ji (2020), who found that US stock market volatility increased due to the COVID-19 pandemic. In terms of the G7 equity markets, Aldawasari and Alnagada (2020) reported that the G7 equity markets experienced significant uncertainty due to the COVID-19 pandemic. Pata (2020) examined the impact of COVID-19 on the G7 equity markets and reported that the numbers of COVID-19 cases and deaths had a negative impact on the markets, with the UK’s FTSE 100 exhibiting the greatest decline. Similar results were also reported by Izzeldin, Muradoğlu, Pappas, and Sivaprasad (2021), who found that the number of COVID-19 cases had a negative effect on the G7 equity markets. It appears that the US and UK stock markets were affected to a greater extent than the equity markets in Canada, France, Germany, Italy, and Japan. Moreover, Wang and Emilov (2020) examined the causal impact of the number of COVID-19 cases on the G7 equity market returns and reported that the number of cases resulted in changes in the stock market returns of Canada, France, Germany, Italy, and the US. According to Yousef (2020), an increase in the daily COVID-19 rate caused a significant increase in the returns volatility of the G7 stock markets.

In the present study, to measure the co-movement among the numbers of COVID-19 cases and casualties and the G7 stock returns, we employ wavelet coherence (WTC) approach, as recommended by Torrence and Compo (1998). This approach represents an effective measure when it comes to combining the time and frequency domains, which allows for the analysis of the co-movement between two series across high, medium, and low frequencies. Another advantage of the WTC approach when compared with other techniques concerns the fact that it can be used to quantify both short- and long-run co-movement, which can provide important insights for investors across different investment horizons during crisis periods.

Our work adds to the existing strand of literature by examining the effect of COVID-19 cases and deaths in G7 stock returns. The contribution of G7 countries in the global GDP is by far significant which was badly affected due to the COVID-19 pandemic. Therefore, examining the sensitivity of G7 stock market returns to the COVID-19 affected cases and deaths can provide useful information for investors regarding the downside returns movement. Another contribution of our work is the measurement of sensitivity of COVID-19 cases and deaths on G7 returns across different investment periods and frequencies. Such examination is helpful in measuring co-movement across COVID-19 cases and deaths with G7 returns under different periods ranging from short- to long-run investment horizon and with varying intensities. Such analysis can enable to position their investment across different investment periods based on the magnitude of returns co-movement.

Our results highlight the fact that the number of COVID-19 cases and the associated deaths in each G7 country are significantly related to their respective stock market returns. However, the magnitude of the relationship with regard to the Canadian and Japanese stock markets is not as strong as that seen with regard to the US, UK, and French stock markets. We report significant coherence of the number of COVID-19 cases and the deaths with the Canadian and the Japanese equity markets in the long-run, however no short-run relationship between stock returns and the number of COVID-19 cases and the deaths is observed.

Due to prolonged duration of COVID-19 pandemic since its spread, investors around the world are constantly seeking latest insights and more tailored investment advices which can reflect their risk aversion behavior. The behavior of G7 markets due to COVID-19 cases and deaths can provide useful insights to investors since the majority of these markets are badly affected by the COVID-19 pandemic. Furthermore, our analysis based on time–frequency domain can assist in defining the investment horizon (i.e. from −1 day to −64 day’s period).

The remainder of this paper is organized as follows. Section 2 presents the estimation techniques applied in this study. Section 3 describes the utilized data and presents preliminary descriptive statistics of sample data. Section 4 analyses the estimation results. Finally, section 5 concludes the paper.

2. Methodology

In this study, we are primarily interested in measuring the effect of COVID-19 pandemic on the G7 stock returns in the time and frequency domain (i.e., short-, medium- and long-term). The application of wavelet coherence allows us to capture long- and short-run causal linkages between G7 stock returns and the COVID-19 pandemic by combining the time- and frequency-domain causality linkages. The main innovation behind the idea of wavelet coherence is based on examining the correlation between two series in the form of unified causality based on time–frequency space which is different from the conventional causality tests. Traditional econometric time series tests are capable to measure different time dimensions of variables but are not capable to quantify frequency dimensions of the variables.

To achieve that, we utilize the wavelet coherence (WTC) technique (Torrence & Compo, 1998) a method characterized by localization in both time and frequency domains in turn allows to measure the strength of association between two time-series over sample period across different time frequencies. We define the cross-wavelet between the two series \( x(t) \) and \( y(t) \) as follows:

\[
W_{xy}(\tau, s) = W_x(\tau, s)W^*_y(\tau, s), \quad W^*_y(\tau)
\]

where \( \tau \) refers to the location, \( s \) represents the scale, and \( * \) denotes the complex conjugate. The cross-wavelet shows a high common

\[\text{See Mensi, Rehman, Maitra, Al-Yahyaee, and Vo (2021); Rehman and Kang (2020); Al- Yahyaee et al. (2020)}\]
power by representing the local covariance between the time series at each scale.

To capture the co-movement between the two series, we define the wavelet coherence as:

$$R^2(\tau, s) = \frac{|S(\frac{1}{2}\omega_{xy}(\tau, s))|^2}{S(\frac{1}{2}\omega_x(\tau, s))^2S(\frac{1}{2}\omega_y(\tau, s))^2}$$

(2)

where Q represents the smoothing operator and $0 \leq R^2(\tau, s) \leq 1$. Moreover, values closer to one (zero) indicate the presence of strong (weak) correlation between the two time series. In the next step, we provide information about the positive and negative returns co-movements, as well as the causal relationships between the two series, using the phase difference described by Torrence and Compo (1998) as:

$$\Phi_{xy}(\tau, s) = tan^{-1}\left[\frac{Im[S(\frac{1}{2}\omega_{xy}(\tau, s))]}{Re[S(\frac{1}{2}\omega_{xy}(\tau, s))]}\right], \quad \Phi_{xy} \in [-\pi, \pi]$$

(3)

where $Im$ and $Re$ represent the imaginary and real parts of the smoothed cross-wavelet transformation, respectively. The phase difference is graphically shown by black arrow on the inside regions of wavelet coherence plots. Arrows pointing to the right mean that two series $x(t)$ and $y(t)$ are in phase or moving in a similar way. If arrows point to the left (antiphase), then two series are negatively correlated. Furthermore, the phase difference show the lead/lag relationship between two series $x(t)$ and $y(t)$. For example, arrows points to the right and up suggest that variable $x(t)$ is leading and the two variables are positively correlated; if arrows are pointing to the right and down, $y(t)$ is leading. On the other hand, arrows pointing to the left and up signify that the first series $x(t)$, is lagging and the correlation is negative, while arrows facing the left and down indicate the first series $x(t)$ is leading but with a negative correlation.

3. Data

This study uses the stock returns of the S&P 500 (US), FTSE 100 (UK), TSX (Canada), DAX 30 (Germany), CAC 40 (France), MIB (Italy), and Nikkei 225 (Japan). The data comprise the daily frequencies for the period December 31, 2019 to November 13, 2020. The

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Table 1
Summary descriptive statistics for G7 stock returns and the number of COVID 19 cases and deaths.

|                  | S&P 500 | FTSE 100 | TSX | DAX 30 | CAC 40 | MIB | Nikkei 225 |
|------------------|---------|----------|-----|--------|--------|-----|------------|
| **Panel A: Stock returns** |         |          |     |        |        |     |             |
| Mean             | 0.0333  | -0.0568  | -0.0073 | -0.0041 | -0.0037 | -0.0037 | 0.0226    |
| Max              | 8.956   | 8.666    | 11.29 | 10.41  | 8.056  | 8.549 | 7.731      |
| Min              | -12.76  | -11.51   | -13.17 | -13.05 | -13.09 | -18.54 | -6.273     |
| Std. Dev         | 1.953   | 1.647    | 1.879 | 1.862  | 1.844  | 2.018 | 1.406      |
| Skewness         | -0.939  | -1.174   | -1.529 | -0.968 | -1.262 | -2.955 | 0.263      |
| Kurtosis         | 14.44   | 14.19    | 22.61 | 14.82  | 14.28  | 29.47 | 9.947      |
| J.-B.            | 1748.8  | 1699.7   | 5124.9 | 1867.1 | 1739.3 | 9563.2 | 631.1      |

Notes: An asterisk (*) indicates significance at the 1% levels.

- On the wavelet coherence plots, the red colors represent strong co-movement, whereas the blue colors correspond to weak co-movement.
- The data for all the stock indices are extracted from the Thomson Reuters Data Stream.
data about the number of COVID-19 deaths and confirmed cases in the G7 countries is extracted from the website of the European Centre for Disease Prevention and Control (ECDC).

Table 1 presents descriptive statistics concerning the G7 stock returns (Panel A), the reported COVID-19 cases (Panel B), and the reported COVID-19 casualties (Panel C). Among the various countries, the S&P 500 and Nikkei 225 exhibit positive returns during the COVID-19 period, which highlights the capacity of these stock markets to perform during crisis periods. The FTSE 100 exhibits a maximum loss of ~5.68 percent, which indicates the high vulnerability of this market during financially turbulent periods. The highest level of returns deviation is seen in relation to the MIB, which reflects the massive death toll seen in Italy due to COVID-19 during the first half of 2020. Save for the Nikkei 225, all the stock market returns are negatively skewed with fat tails. The normality hypothesis is rejected for all the return indices.

Fig. 1 presents the return dynamics of the G7 stock markets during the COVID-19 period, with the maximum volatility being evident in March immediately after the WHO issued its emergency announcement and declared the COVID-19 outbreak to be a global pandemic. The returns of all the stock markets fell sharply up to ~10 percent on daily basis (except for the Nikkei 225), although the MIB returns are reported to exhibit daily loss of ~19 percent. In terms of the affected cases, the maximum number is seen in the case of the US, whereas the minimum number of cases is seen in relation to Japan. The results concerning the number of COVID-19 deaths are quite similar, as the US COVID-19 death toll is the highest, followed by France and the UK, whereas the lowest death toll is seen in the case of Japan. Fig. 1 also displays the evolution of the deaths and the numbers of confirmed cases (log value) in the G7 countries, with the US being the most affected country in terms of both cases and deaths. The death toll reached its peak in April 2020; however, the number of COVID-19 cases continued to increase up to November 2020.

4. Empirical findings

Fig. 2 illustrates the results of the wavelet coherence between the G7 stock returns and the numbers of COVID-19 casualties (Panel A) and confirmed COVID-19 cases (Panel B) during the COVID-19 period. The findings provide evidence of the strong co-movement between the US stock returns and the COVID-19 deaths at a high frequency (i.e., ~64-day period from April to June). This high co-movement is reflected by the red-colored contour. Likewise, in terms of the number of confirmed cases in Panel B, strong co-
movement can be seen between the US stock returns and the number of confirmed COVID-19 cases from April to June (i.e., a period of under 32 ~ 64 days). It is also possible to observe the leading behavior of the COVID-19 deaths with regard to the stock returns from August to September for a short-run period of 16 ~ 32 days. In both instances of high co-movement between the US stock returns and the number of deaths, the direction of the black arrows highlights the leading behavior of the US stock returns. Similarly, in terms of the wavelet coherence between the number of reported cases and the US stock returns, the stock market returns lead the way. Similar results have been reported by Yilmazkuday (2020), who found that the number of COVID-19 cases had a negative effect on the S&P 500 returns. In relation to both the number of deaths and the number of confirmed cases of COVID-19, the leading behavior of the US stock returns could be attributed to the fact that the presence of COVID-19 was felt in a large number of countries (e.g., China, Italy, Spain, etc.) before it reached its peak level in the US. Therefore, due to their high integration with the global equity markets, the stock markets in the US received downside spillover before the COVID-19 pandemic reached a severe level inside the US. The present results concerning the US market are supported by the findings of Chowdhury and Abedin (2020), who reported the negative impact of COVID-19 deaths on the S&P 500 returns.

Fig. 1. (continued).
The results concerning the UK stock markets are quite similar to those concerning the US stock markets, with the FTSE returns leading the COVID-19 casualties from April to July (i.e., a period of under ~64 days). These co-movements are also visible during the first quarter of 2020 and then again in July and August, albeit with low magnitudes. The likely reason for the UK stock markets’ leading behavior is the high integration with other G7 equity markets. Since the effects of the COVID-19 pandemic were quite apparent in many other countries, the UK stock markets received returns spillover from those other international stock markets. The co-movements between the UK stock returns and the COVID-19 deaths are prominent during May and August, which indicates the strong magnitude by which stock markets are leading the relationship. Similar results have been reported by Tahat and Ahmed (2020), who noted the negative impact of COVID-19 deaths on the FTSE 100 daily returns.

The wavelet coherence results concerning the Canadian stock markets differ from those concerning the UK and US markets, as the magnitude of the co-movement of the numbers of COVID-19 cases and casualties with the stock returns is comparatively weak. For the Canadian stock markets, the COVID-19 deaths lead the stock returns from May to August (i.e., a period of under ~64 days). However, in terms of the affected cases, the stock markets lead the way, albeit with low magnitude, from April to June (i.e., ~32 to ~64 days). It is also possible to witness the relationship between the number of confirmed COVID-19 cases and the Canadian stock returns in April as well as from August to September (i.e., under ~4 to ~8 days), which is visible in the form of small scattered patches.

The case of Germany is quite similar to the UK stock markets in terms of the COVID-19 deaths, with the maximum coherence being seen from April to August (i.e., a period of under ~64 days), although the stock markets lead the causality rates. These results are consistent with the earlier findings of Zeren and Hizarci (2020), who documented a cointegrating relationship between the number of COVID-19 deaths and the DAX 30 returns. This could be attributed to the small reaction time and the high connectedness of the German equity markets with regard to the other European stock markets both before and during the COVID-19 pandemic. It is also possible to observe small patches from July to September, which highlights the significant relationship between the German stock markets and the number of COVID-19 deaths; however, the stock returns lead the relationship for a period under ~4 to ~8 days. A similar situation can also be witnessed in relation to the confirmed COVID-19 cases from July to September, although the relationship remains cyclical from May to April (i.e., a period of 32–64 days), thereby exhibiting a high magnitude.

With regard to the French stock markets, there is a strong relationship between the CAC 40 returns and the number of COVID-19 deaths, with the stock returns leading the relationship at the ~64-day frequency band. In the short run, it can be seen that the numbers of COVID-19 deaths and confirmed cases lead the relationship during April and June, respectively, with a strong magnitude. However, in the long run, the number of confirmed cases in France and the stock returns do not exhibit a significant relationship.

The results of the wavelet coherence concerning Italy are quite similar to those concerning the other G7 economies, as the relationship between the COVID-19 deaths and the stock returns remains in phase and follows a cyclical path. The magnitude of the relationship remains quite high in the long run (i.e., beyond a ~32-day period); however, in the short run, the Italian stock markets lead the COVID-19 deaths in April for a ~4- to ~16-day period. The relationship between the number of COVID-19 cases and the stock returns follows a different pattern, as it remains significant across different time periods and frequencies. For instance, small patches of coherence are evident in April and August for periods of ~8 to ~16 days and ~4 to ~8 days, respectively. According to Gherghina,
Armeanu, and Joldeș (2020), the Italian stock market returns and the number of COVID-19 cases exhibit a significant relationship at varying frequencies.

Finally, the case of the Japanese stock markets appears quite different to the stock markets of the other G7 economies. No significant traces of a relationship between the Nikkei 225 stock returns and the numbers of confirmed COVID-19 cases and deaths can be seen. It is possible to observe small traces of a significant relationship between the stock returns and the COVID-19 deaths in June, August, and October (i.e., under ~4 to ~8 days), with the stock returns leading the deaths in Japan. During October and November, the number of confirmed cases leads the stock returns in Japan (i.e., a period of under ~16 to ~32 days); however, aside from these two

Fig. 2. (continued).
months, there are no traces of a significant relationship. In the recent work by Khan et al. (2020), the number of confirmed COVID-19 cases was found to have a very pronounced negative effect on the stock returns of the CAC 40, FTSE 100, and Nikkei 225 indices, which supports the present results.

We now summarize and further elaborate heterogeneous results between the sensitivity of different G7 countries to the number of COVID-19 confirmed cases and death. From April 2020 to June 2020, US stock returns exhibit high comovements with COVID-19 confirmed cases and deaths under ~64 days' period with leading behavior of the stock returns. These results are quite similar to the UK stock market however, Canadian stock market differs from both US and UK equity markets as COVID-19 deaths lead stock returns over ~64 days' period. The behavior of German stock market resembles the UK stock market however, German stock returns
lead COVID-19 deaths over short-run period of ~4 to ~8 days. French stock market’s behavior remains similar to the UK and US markets in the short-run however, we do not witness any significant comovements between confirmed cases and stock returns. Stock market of Italy remains sensitive to COVID-19 confirmed cases during the months of April and August 2020. Though we witness differences among the behavior of all the above G7 stock returns, Nikkei 225 remains completely insensitive to the number of confirmed COVID-19 cases as well as COVID-19 deaths across all periods. These results are also displayed in Table 2.

5. Conclusions

In this paper, we examine the impact of the number of confirmed COVID-19 cases and the associated deaths on the G7 equity market returns from December 31, 2019 to November 13, 2020. More specifically, we employ the WTC approach to measure the impact of the numbers of confirmed cases and deaths on the G7 stock markets. Our findings reveal that both the number of confirmed COVID-19 cases and the number of deaths exhibit strong coherence with the G7 equity markets, although we find heterogeneous results for a couple of stock markets. The observed effects are more pronounced in the majority of the G7 countries than in the Canadian and Japanese stock markets, where low coherence is seen between the stock returns and the numbers of COVID-19 cases and deaths.

Our study has important implications for investors, as the adverse effects of COVID-19 are observed globally, while the responses of the stock markets vary significantly. The effects of COVID-19 are felt quite strongly in the US and UK, as developed economies, as well as in Brazil and India among emerging countries, however, stocks markets in different countries responded heterogeneously to the COVID-19, which implies that a careful analysis can help investors in terms of switching or adjusting their portfolio holdings. The relationship between the numbers of COVID-19 cases and deaths and the stock returns entails a mix of lead-lag relations across different countries. For example, in the US, UK, France, and Germany, the stock markets lead the numbers of COVID-19 cases and deaths, whereas in other countries, the numbers of cases and deaths lead the stock market returns. This difference in phases could be attributed to the sensitivity of each individual stock market to its international counterparts. For example, the effects of COVID-19 became more intense in the US during the second and third quarters of 2020, which was quite a bit later than in other countries such as China, Brazil, Spain, and Italy. Thus, the integration levels of the different markets could result in more downside returns spillover than the actual adversities associated with the COVID-19 pandemic. On that basis, investors and policymakers need to think ahead, rather than waiting for the pandemic to have a negative impact on the stock market returns. The increasing coherence level among the international stock markets raises additional concerns regarding the risk spillover and, therefore, the probable contagion. Another important implication of the findings of this study concerns the differences in the relationships across different periods. For example, all the G7 counties’ stock markets in general, and the stock markets of the US, Canada, and Germany in particular, only exhibit a significant relationship with the numbers of COVID-19 cases and deaths in the long run. In terms of short-run relationship, we report few traces of significant relationship between stock returns and the numbers of COVID-19 cases and deaths. In terms of the sensitivity of the G7 stock markets to COVID-19, the Japanese stock markets are the least affected in both the short run and the long run. These results are also supported by our preliminary analysis, which reveals the Japanese stock markets to exhibit positive daily returns during the COVID-19 pandemic. Therefore, the Japanese markets appear appropriate in terms of the diversification for investors in both tranquil and turbulent periods.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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