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Economic activity and financial markets: the case of air travel in COVID-19 pandemic

Xiaoyang Wang
University of New Mexico - Albuquerque

Peimin Chen
Shanghai Business School

Jianhe Liu
Zhejiang University of Finance & Economics (ZUFE)

Abstract

We investigate the co-movements of real economic activity with COVID-19 cases, crude oil and financial markets using the case of US airline industry. The pairwise relationships are examined through wavelet coherence method. Results show that air travel activity positively leads COVID-19 infections in the 4-8 days scales. But it has no consistent relationship with crude oil or financial markets. The findings connect the literature in the nexus of real economic activity, COVID-19 infections and financial markets. A policy implication is that, despite dampening real economic activities, restrictive policies to curb the pandemic may pose limited impact on financial markets if coupled with stimulus policies.

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Contact: Xiaoyang Wang - xiaoyangwang@unm.edu, Peimin Chen - pmchen@sbs.edu.cn, Jianhe Liu - bruceliu@zufe.edu.cn.
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Economic Activity and Financial Markets: The Case of Air Travel in COVID-19 Pandemic

1. Introduction

The COVID-19 pandemic has disrupted both real economic activities and their related financial markets. Out of cautions to avoid contracting virus, economic activities slow down. In addition, governments in most countries implemented social distancing and lockdown policies to control the pandemic. These policies further deteriorate economic operation environment. One major concern on the restrictive policies and the decline of real economic activities is that they can translate into financial market turbulence (Baker et al. 2020), which may further aggravate the economy during the pandemic (Goodell 2020). As a result, policies that restrict economic activities face the dilemma between financial market turbulence or worsening pandemic. Under this background, an important question to ask is whether there is an opportunity to impose restrictions on economic activities without causing financial instability or mitigate the impact? Answering this question has vital implications for both market and policy makers.

Here we answer this question from the case of US airline industry. Passenger airlines are among the most suffered industries during the pandemic. Air travel activity declined sharply since the beginning of COVID-19 outbreak due to the fear of contracting virus and travel bans that curbed flights. To alleviate market anxiety, government issued stimulus packages for airline companies, like the CARES Act.[1] As an important economic indicator, the airline industry provides an ideal case to study the interactions of economic activity with COVID-19 development and related commodity and financial markets.

Specifically, we examine how the US daily air passenger volume comoves with new COVID-19 cases, crude oil price, airline stock index, S&P 500 index and Bitcoin price. Crude oil market is linked to travel activity through fuel demand. Airline and S&P 500 stock indices represent the airline sector and overall equity markets. Bitcoin has recently been viewed as a safe haven asset for equities (Goodell and Goutte 2020; Wang and Wang 2021). We investigate their lead-lag causality relationship which can be nonlinear and dependent on the time scale. New COVID-19 cases are caused by a combination of different drivers acting on different time scales. For example, new COVID-19 cases may respond to air travel activity at shorter time scales like one or two weeks. Beyond that, other factors like seasonal temperature change can create longer term trend. Traditional time series causality methods, e.g. Granger tests, do not differentiate the relationships across the time frequency scales (Percival and Walden 2000; Vacha and Barunik 2012). For this reason, we employ the wavelet coherence method, which can identify the interactive lead-lag relationship between time series in the frequency domain and robust to non-stationarity in the data. This method has been used to study causal relationships across a variety of markets including energy, equity and cryptocurrencies (Roboredo et al. 2017; Choi 2020; Goodell and Goutte 2020).

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[1] Passenger airlines in the US reported a loss of $28 billion in the first three quarters of 2020 (US Bureau of Transportation Statistics, https://www.bts.gov/newsroom/us-airlines-report-third-quarter-2020-losses). (BTS 2020). The US government intervened with the Coronavirus Aid, Relief, and Economic Security (CARES) Act on March 27, 2020 which provided $50 billion financial assistance to passenger airlines through a combination of loans, loan guarantees, and payroll support (US Congress 2020).

We find that in the case of US airline industry, real economic activity positively leads COVID-19 infections, but exhibits little co-movements with the related commodity and financial markets. The recovery of these markets is more likely benefitted from the stimulus policies. This result offers a policy implication. There is an opportunity to curb COVID-19 with stringent social distancing restrictions, meanwhile still maintaining financial market stability through stimulus policies. Because the lack of relationship between economic activity and financial market returns, there is limited risk of transmitting the shock from real economy to financial sector in the presence of fiscal/monetary policy interventions.

The empirical findings also contribute to three areas of literature. The first contribution is to the literature studying the relationship of economic activity and financial market. As stated by Fama (1981), real economic activities are the fundamental determinants of stock price returns. This rationale has been further enhanced by Fama (1990), Schwert (1990), Cheung and Ng (1998). However, Binswanger (2000a; 2000b) presents evidence that the relationship between real economy and stock market began to break down in the US as early as 1980s. Binswanger attributes the reasons to liquidity bubbles and monetary policies, which make the stock price movement more independent of changes in real economic activity. During the subprime financial crisis, Ait-Sahalia et al. (2012) find stimulus policies can boost market confidence and performance by providing liquidity support. More recently in the COVID-19, Humpe and McMillan (2020) attribute about half of the stock market recovery to the increase of money supply. Their finding is further corroborated by Fiordelisi et al. (2014) and Ricci (2015). In this study, our analysis identifies no significant relationships between air passenger volume and airline stock performance, despite the more than 50% drop in passenger volume and continued financial losses in the airline industry. The driving force is unrelated to the air travel activity, but more likely to the stimulus package that helped the overall financial markets. This result contributes to the findings of Ait-Sahalia et al. (2012), Fiordelisi et al. (2014), Ricci (2015) and Humpe and McMillan (2020) that stimulus can stabilize financial market not only in economic shocks like the financial crisis, but also in more complicated shock events like the COVID-19 pandemic.

The second contribution is to the literature examining the relationship of COVID-19 and financial markets. Previous research has focused on how COVID-19 cases relate to the performance of various markets. Examples include Al-Awadhi et al. (2020) and Ashraf (2020) on the response of stock market to COVID-19 cases, Goodell and Goutte (2020) on the co-movement of COVID-19 deaths with Bitcoin price, and Sharif et al. (2020) on the co-movement of COVID-19 cases with crude oil price and stock market. However, less attention has been paid to understand how the driving factors of COVID-19, like the real economic activity is related to these markets. We find that air travel activity positively leads to COVID-19 cases, but not comoves with the markets in any consistent manner. The comparison corroborates the first contribution that financial markets respond less to shocks in real economic activity than COVID-19 infections.

The third contribution is to the literature of how real economic activity affects COVID-19 infections. Studies have identified that economic activities can spread coronavirus through gathering and interactions (Lemieux et al. 2020). For example, Taylor et al. (2020) find the operation of livestock packing plants increases infection in surrounding areas. The risk is particularly high in travel activities. It has been well recognized that human mobility can spread infection (Chinazzi et al. 2020; Kraemer et al. 2020; Yilmazkuday 2020). However, there is little research on the time dependent properties of the causal relationship between human activity and COVID-19 infections. We reveal that air travelling significantly leads to COVID-19 infections in the following 4-8 days scales.

2. Methods

The wavelet coherence method consists three steps. First, for two time series $x(t)$ and $y(t)$ that have the same frequency and length, we convert them into the frequency domain using continuous wavelet transformation (CWT). CWT separates the changes of a time series into different time-frequency regions through the formula

$$W_u(\tau, s) = \int_{-\infty}^{\infty} u(t) \frac{1}{\sqrt{s}} \psi^* \left(\frac{t}{s}\right) \tag{2.1}$$

where $u = x, y$ standing for the individual time series; τ and s are the location and scale parameter that respectively determine the location and length of wavelet transformation. $\psi^* \left(\frac{t}{s}\right)$ is the complex conjugate function of the mother wavelet $\psi(t)$, which controls the signal admissibility conditions. The mother wavelet satisfies the zero-mean condition of $\int_{-\infty}^{\infty} \psi(t) dt = 0$ and uniform-scale condition of $\int_{-\infty}^{\infty} \psi^2(t) dt = 1$. Following Roboredo et al. (2020) and Goodell and Goutte (2020), we use the Morlet wavelet function with central frequency $w_0 = 6$ defined as

$$\psi(t) = \pi^{-0.25} e^{i w_0 t} e^{-t^2/2}. \tag{2.2}$$

Next, the cross wavelet of $x(t)$ and $y(t)$ is calculated as

$$W_{xy}(\tau, s) = W_x(\tau, s) W_y^*(\tau, s) \tag{2.3}$$

where * denotes the complex conjugate. The cross wavelet measures the covariance of $x(t)$ and $y(t)$ across different time scale s.

Finally, based on the cross wavelets, the co-movement of $x(t)$ and $y(t)$ is measured by the wavelet coherence coefficient as proposed by Torrence and Webster (1999):

$$R^2(\tau, s) = \frac{\left|S\left(\frac{1}{s} W_{xy}(\tau, s)\right)\right|^2}{S\left(\frac{1}{s}|W_x(\tau, s)|^2\right) S\left(\frac{1}{s}|W_y(\tau, s)|^2\right)}. \tag{2.4}$$

$R^2(\tau, s)$ is similar to the correlation coefficient with a value range between 0 to 1, with values close to 0 indicating weak correlation and values close to 1 indicating strong correlation. S is smoothing parameter on the time scale. The statistical significance of $R^2(\tau, s)$ is obtained through Monte Carlo simulation (Torrence and Compo 1998; Grinsted et al. 2004).

The direction of correlation and lead-lag relationship in the frequency space is given by the phase difference, which is defined as

$$\phi_{xy}(\tau, s) = \tan^{-1}\left(\frac{\Im\{S(s^{-1} W_{xy}(\tau, s))\}}{\Re\{S(s^{-1} W_{xy}(\tau, s))\}}\right), \phi_{xy} \in [-\pi, \pi]. \tag{2.5}$$

$\Im(\cdot)$ and $\Re(\cdot)$ are respectively the imaginary and real parts of the cross wavelet, which is a complex number. The phase value ϕ_{xy} can be illustrated by black arrows in the wavelet coherence plot. Table 1 summarizes the interpretations of ϕ_{xy} values and corresponding arrow directions. The flat → (←) arrow indicates positive (negative) correlations of x and y but no lead-lag relationship. The straight ↑ (↓) arrow indicate x leads (lags) y but mixed correlation directions. The ↙ (↗) arrows indicate x negatively (positively) leads y, while the ↘ (↖) arrows indicate y positively (negatively) leads x.

Table 1. Interpretations of ϕ_{xy} Value and Arrow Directions

ϕ_{xy} Value	Correlation	Lead-Lag	Arrow Direction
$-\pi$ or π	$-$	NA	←
$(-\pi, -\pi/2)$	$-$	$x \rightarrow y$	↙
$-\pi/2$	mixed	$y \rightarrow x$	↓
$(-\pi/2, 0)$	$+$	$y \rightarrow x$	↘
0	$+$	NA	→
$(0, \pi/2)$	$+$	$x \rightarrow y$	↗
$\pi/2$	mixed	$x \rightarrow y$	↑
$(\pi/2, \pi)$	$-$	$y \rightarrow x$	↖

3. Data

We obtain the following data for pairwise analysis. The daily US air passenger volume is from the US Transportation Security Administration. The daily new infected COVID-19 cases are from John Hopkins University Coronavirus Resource Center. Crude oil price is represented by the nearby price of NYMEX WTI futures. Airline stock and overall stock market performance are represented by the Dow Jones US Airline Index and the S&P 500 Index. Bitcoin price is obtained from Coindesk. The data starts from March 1st 2020 when COVID-19 cases started to rapidly increase in the US and through December 31st 2020. For data frequency calibration we only keep the business days with a total of 213 observations.

Figure 1 shows the data series. In March, daily air passenger volume sharply dropped by 95% from around 2 million to less than 100 thousand. The volume slowly recovered during April – June but remained below 50% of the pre-pandemic level. COVID-19 cases show three major increasing waves in March, June and November. WTI crude oil price declined during March – May and then started the recovery path. Notably WTI price even dipped into negative territory on April 20th due to surging supply and dampened demand (Corbet et al. 2020). Both US airline stock index and S&P 500 crashed in March, but airline stock restored to pre-pandemic level despite the dampened passenger volume and S&P 500 even reached a new record despite an ongoing pandemic. Bitcoin market suffered a decline in March but rapidly surged in the last two months of 2020.

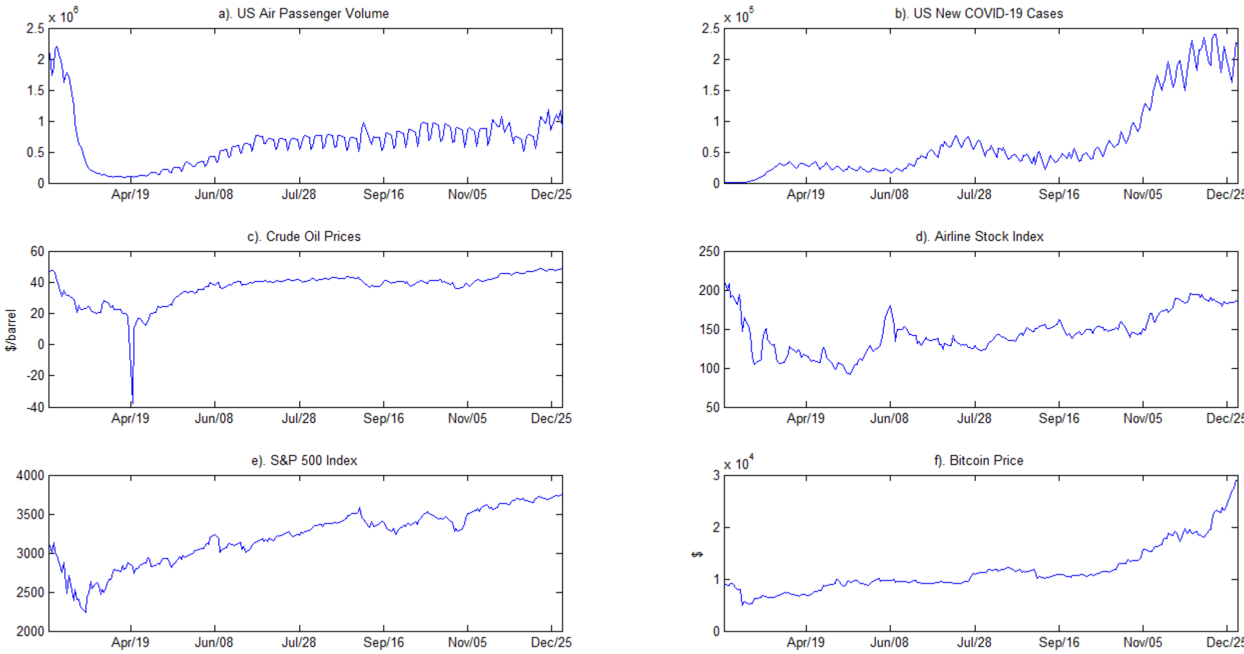

Figure 1. Time series trend of US air passenger volume, COVID-19 cases, crude oil price, airline stock index, S&P 500 index and Bitcoin price

4. Results

The pairwise wavelet coherence estimates of air passenger volume with COVID-19 cases, crude oil price, stock indices and Bitcoin price are presented in Figure 2. In the charts, warmer color (red) areas represent stronger co-movements between two series at corresponding time scales, while colder colors (blue) represent weaker co-movements. The black contour lines delineate the area where the correlation is significant at 5% level. The black arrows represent the lead-lag directions corresponding to their ϕ_{xy} values. The time scales range from 1 to 64 days based on the available observations. The area contained in the cone is unaffected by edge effects.

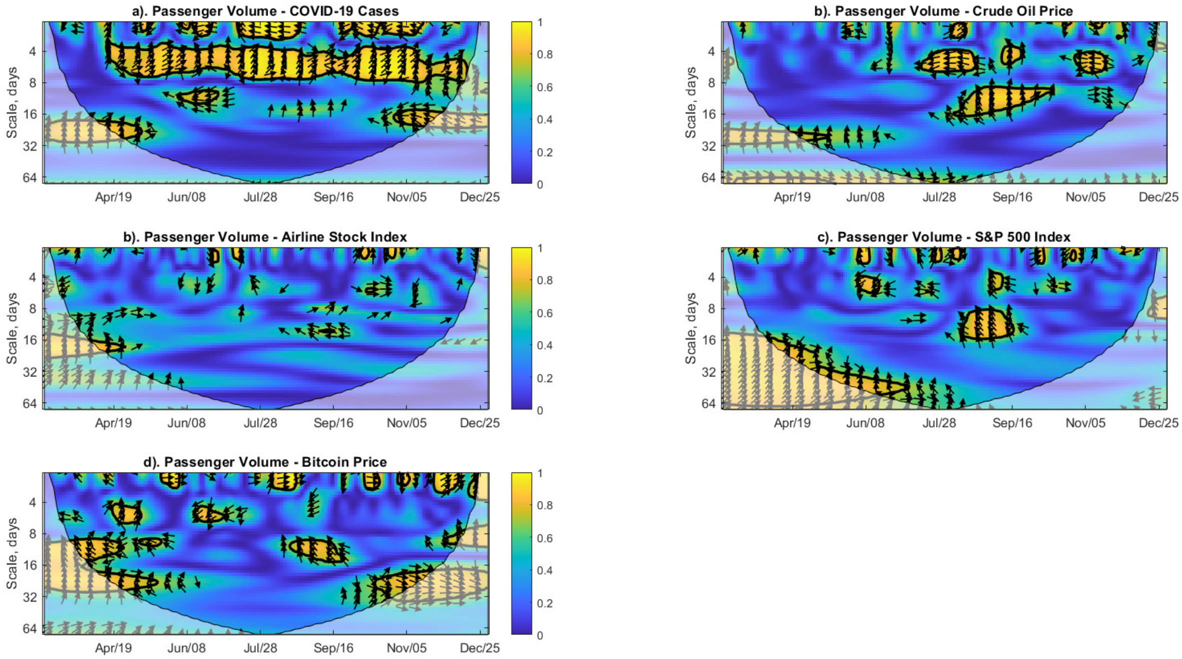

Figure 2. Wavelet coherence estimates for pairwise analysis of US air passenger volume with COVID-19 cases, crude oil price, airline stock index, S&P 500 index and Bitcoin price

The first finding is that air passenger volume significantly leads COVID-19 cases in the 4-8 days scale, as shown in Figure 2 (a). The ↗ arrows indicate the relationship is positive. This positive causal relationship starts from April through the rest of sample period. This finding corroborates the medical literature that human mobility can cause COVID-19 spread (Kraemer et al. 2020; Chinazzi et al. 2020; Yilmazkuday 2020). The effect mainly appears on 4-8 days scale. It is consistent with medical evidence that COVID-19 has a median incubation period of 5.1 days and then develops symptoms after exposure (Lauer et al. 2020). Moreover, on the 1-2 days scale, there are isolated areas of negative contemporaneous correlations between these series as indicated by the ← arrow. These areas correspond to periods of surging COVID-19 cases in June and November, suggesting that rapidly developing infections maybe a concern for travel decisions. The positive causality relationship at 4-8 days scale suggests that less air travel activity can significantly reduce COVID-19 cases in 4-8 days.

A noticeable phenomenon is that since November 2020, there is a rapid surge of COVID-19 cases despite the stabilization of air travel activities since July 2020, as shown in Figure 1 (a) and (b). Meanwhile, the wavelet coherence results in Figure 2 (a) detect a consistent positive causality from air travel activity to COVID-19 cases at 4-8 days scale. It is because there are multiple contributing factors to the COVID-19 cases aside from air travel activity. For example, the cooling temperature since November can lead to an increasing trend of cases (Notari 2021). On the other hand, wavelet method successfully identifies the significant relationship between air travel activity and new cases only at the time scales of 4-8 days, where these two variables are actually connected to each other.

The second finding is a lack of consistent causality and correlations between air passenger volume and related markets, as shown in Figure 2 (b) – (e). Particularly for the passenger volume with airline stock index as in Figure 2 (c), almost no co-movement can be detected at any scale. Despite dampened travel activity and continued financial losses, airline stock index has completely recovered to the pre-pandemic level by the end of 2020 as shown in Figure 1 (d). This is similar to the findings of Binswanger (2000a) that stock market movement has become more independent of real economic activities. An important contributor to the stock price recovery is the CARES Act passed on March 27th that provided direct financial aid to airline companies. Similar to the findings of Ait-Sahalia et al. (2012), Fiordelisi et al. (2014), Ricci (2015) and Humpe and McMillan (2020) that policy intervention can improve stock returns during financial crisis, we find stimulus policies work in pandemic situations as well.

Noticeably, a common area of strong co-movement is detected with crude oil, S&P 500 index and Bitcoin price on the 8-16 days scale during August-September. However, despite the concurrence in both the timing and scales, the nature of co-movements is inconsistent. For that period, air passenger volume leads crude oil prices with mixed directions as indicated by the ↑ arrow. In another word, air passenger volume affects the volatility of crude oil market instead of price directions. On the other hand, S&P 500 index and Bitcoin price negatively lead the air travel activity. Thus, even though there are occasional strong linkages, we fail to identify a consistent pattern for air travel activity with the directly related crude oil market, neither with the benchmark equity index or cryptocurrency.

The results suggest that the air travel activity does not have significant impact on the collapse or recovery of financial and commodity prices as shown in Figure 1. Because the air travel activity is the primary real economic activity in the airline industry and is also an important indicator of the overall economic activeness, the lack of causal relationship suggests there are other more influential factors driving the changes of financial markets. This is consistent with the recent findings of Humpe and McMillan (2020) that stimulus policies are the dominant driving forces of stock market recovery during the pandemic. The implication is that the reductions in air travel activity can impose limited impact on the financial markets as the stimulus policies can lend support to market.

5. Conclusion

This study assesses how real economic activity co-move with pandemic infections, as well as related commodity and financial markets. Using the wavelet coherence method, we explore this question from the case of US airline industry. We find significantly positive causality of air travel activity to COVID-19 cases in the 4-8 days scale. However, there is a lack of consistent co-movement for air travel activity with financial and crude oil markets, particularly for the airline stocks. The implication is that less air travel activity can significantly reduce the COVID-19 cases in the following 4-8 day, but does not impact the related financial markets. Thus, the recovery of airline stocks and other markets during COVID-19 is not directly related to air travel activity, but more likely benefited from stimulus policies.

The finding contributes to previous literature studying the relationship of real economic activities and stock markets. The finding generates an important policy implication. Despite concerns that dampened economic activities can lead to financial market turbulence, stimulus policies can intervene to maintain financial stability. As a result, this finding suggests that there is an opportunity to restrict economic activities to curb COVID-19 infection, while still limiting the risk of financial market turbulence through the interventions of stimulus policies.

Reference:

Ait-Sahalia, Y., J. Andritzky, A. Jobst, S. Nowak, and N. Tamirisa (2012) "Market response to policy initiatives during the global financial crisis." *Journal of International Economics* 87(1):162–177.

Al-Awadhi, A.M., K. Alsaifi, A. Al-Awadhi, and S. Alhammadi (2020) "Death and contagious infectious diseases: Impact of the COVID-19 virus on stock market returns." *Journal of Behavioral and Experimental Finance* 27:100326.

Ashraf, B.N. (2020) "Stock markets' reaction to COVID-19: Cases or fatalities?" *Research in International Business and Finance* 54:101249.

Baker, S.R., N. Bloom, S.J. Davis, K. Kost, M. Sammon, and T. Viratyosin (2020) "The unprecedented stock market reaction to COVID-19." *The Review of Asset Pricing Studies* 10(4):742–758.

Binswanger, M. (2000a) "Stock market booms and real economic activity: Is this time different?" *International Review of Economics & Finance* 9(4):387–415.

Binswanger, M. (2000b) "Stock returns and real activity: is there still a connection?" *Applied Financial Economics* 10(4):379–387.

BTS (2020) "U.S. Airlines Report Third Quarter 2020 Losses." Bureau of Transportation Statistics, https://www.bts.gov/newsroom/us-airlines-report-third-quarter-2020-losses

Cheung, Y.-W., and L.K. Ng (1998) "International evidence on the stock market and aggregate economic activity." *Journal of Empirical Finance* 5(3):281–296.

Choi, S.-Y. (2020) "Industry volatility and economic uncertainty due to the COVID-19 pandemic: Evidence from wavelet coherence analysis." *Finance Research Letters* 37:101783.

Corbet, S., J.W. Goodell, and S. Günay (2020) "Co-movements and spillovers of oil and renewable firms under extreme conditions: New evidence from negative WTI prices during COVID-19." *Energy Economics* 92:104978.

Fama, E.F. (1981) "Stock returns, real activity, inflation, and money." *The American Economic Review* 71(4):545–565.

Fama, E.F. (1990) "Stock returns, expected returns, and real activity." *The Journal of Finance* 45(4):1089–1108.

Fiordelisi, F., G. Galloppo, and O. Ricci (2014) "The effect of monetary policy interventions on interbank markets, equity indices and G-SIFIs during financial crisis." *Journal of Financial Stability* 11:49–61.

Goodell, J.W. (2020) "COVID-19 and finance: Agendas for future research." *Finance Research Letters*:101512.

Goodell, J.W., and S. Goutte (2020) "Co-movement of COVID-19 and Bitcoin: Evidence from wavelet coherence analysis." *Finance Research Letters*:101625.

Grinsted, A., J.C. Moore, and S. Jevrejeva (2004) “Application of the cross wavelet transform and wavelet coherence to geophysical time series.” *Nonlinear Processes in Geophysics* 11:561–566.

Humpe, A., and D. McMillan (2020) “The Covid-19 stock market puzzle and money supply in the US.” *Economics Bulletin*, *40*(4): 3104-3110.

Kraemer, M.U., C.-H. Yang, B. Gutierrez, C.-H. Wu, B. Klein, D.M. Pigott, L. Du Plessis, N.R. Faria, R. Li, and W.P. Hanage (2020) “The effect of human mobility and control measures on the COVID-19 epidemic in China.” *Science* 368(6490):493–497.

Lauer, S.A., K.H. Grantz, Q. Bi, F.K. Jones, Q. Zheng, H.R. Meredith, A.S. Azman, N.G. Reich, and J. Lessler (2020) “The incubation period of coronavirus disease 2019 (COVID-19) from publicly reported confirmed cases: estimation and application.” *Annals of Internal Medicine* 172(9):577–582.

Lemieux, J.E., K.J. Siddle, B.M. Shaw, C. Loreth, S.F. Schaffner, A. Gladden-Young, G. Adams, T. Fink, C.H. Tomkins-Tinch, and L.A. Krasilnikova (2020) “Phylogenetic analysis of SARS-CoV-2 in Boston highlights the impact of superspreading events.” *Science*.

Notari, A. (2021) Temperature dependence of COVID-19 transmission. *Science of the Total Environment*, *763*, 144390.

Percival, D.B., and A.T. Walden (2000) Wavelet methods for time series analysis (Vol. 4). Cambridge university press.

Reboredo, J.C., M.A. Rivera-Castro, and A. Ugolini (2017) “Wavelet-based test of co-movement and causality between oil and renewable energy stock prices.” *Energy Economics* 61:241–252.

Ricci, O. (2015) “The impact of monetary policy announcements on the stock price of large European banks during the financial crisis.” *Journal of Banking & Finance* 52:245–255.

Schwert, G.W. (1990) “Stock returns and real activity: A century of evidence.” *The Journal of Finance* 45(4):1237–1257.

Sharif, A., C. Aloui, and L. Yarovaya. (2020) “COVID-19 pandemic, oil prices, stock market, geopolitical risk and policy uncertainty nexus in the US economy: Fresh evidence from the wavelet-based approach.” *International Review of Financial Analysis* 70:101496.

Taylor, C.A., C. Boulos, and D. Almond (2020) “Livestock plants and COVID-19 transmission.” *Proceedings of the National Academy of Sciences* 117(50):31706–31715.

Torrence, C., and G.P. Compo (1998) “A practical guide to wavelet analysis.” *Bulletin of the American Meteorological Society* 79(1):61–78.

Torrence, C., and P.J. Webster (1999) “Interdecadal changes in the ENSO–monsoon system.” *Journal of Climate* 12(8):2679–2690.

US Congress (2020) “H.R.748 – CARES Act.” US Congress, https://www.congress.gov/bill/116th-congress/house-bill/748

Vacha, L. and J. Barunik (2012) “Co-movement of energy commodities revisited: Evidence from wavelet coherence analysis.” *Energy Economics 34*(1): 241-247.

Wang, J., and X. Wang (2021) “COVID-19 and financial market efficiency: Evidence from an entropy-based analysis.” *Finance Research Letters*:101888.

Yilmazkuday, H. (2020) “COVID-19 spread and inter-county travel: Daily evidence from the US.” *Transportation Research Interdisciplinary Perspectives* 8:100244.