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► **To cite this version:**

John W Goodell, Stéphane Goutte. Co-movement of COVID-19 and Bitcoin: Evidence from wavelet coherence analysis. 2020. halshs-02613277

HAL Id: halshs-02613277

<https://shs.hal.science/halshs-02613277>

Preprint submitted on 20 May 2020

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Co-movement of COVID-19 and Bitcoin: Evidence from wavelet coherence analysis

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May 19, 2020

Abstract

We apply wavelet methods to daily data of COVID-19 world deaths and daily Bitcoin prices from 31th December 2019 to 29th April 2020. We find, especially for the period post April 5, that levels of COVID-19 caused a rise in Bitcoin prices. We contribute to the fast-growing body of work on the financial impacts of COVID-19, as well as to ongoing consideration of whether Bitcoin is a safe haven investment. Our results should be of great interest to both scholars and policy makers, as well as investment professionals interested in the financial implications of both COVID-19 and cryptocurrencies.

Keywords: Co-movement; COVID-19; Bitcoin; Wavelet; Safe haven
JEL classification: C58; F37; G14; G15; Q31

1 Introduction and motivations

At the time of writing this article, the COVID-19 pandemic is still ongoing, with the eventual scale of the disaster not yet determined. We are all now tragically familiar with the ongoing enormous costs in lives of this pandemic. However, we are also concerned about the eventual economic impact of this crisis, including the impact on financial markets. In response to this, we investigate the associate of Bitcoin.

We apply the wavelet method of Grinsted et al. (2004) (also used by others, e.g., Kang et al., 2019) to daily data of COVID-19 world deaths and daily Bitcoin prices from 31th December 2019 to 29th April 2020. With this wavelet

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approach we find that levels of COVID-19 caused a rise in Bitcoin prices. This effect is especially strong for the portion of our period post April 5. We consider that our study contributes to the rapidly growing body of work on the financial impacts of COVID-19, as well as to an ongoing focus in the literature regarding whether Bitcoin is a safe haven investment.

Our results are especially meaningful when considering that as COVID-19 unfolds there is greater concern for future economic costs, and likely greater economic uncertainty. As noted by Goodell (2020), the ongoing COVID-19 crisis will have enormous ongoing economic costs. Prior to the current crisis, for instance, Bloom, Cadarette, and Sevilla (2018) point out the economic vulnerability posed by potential pandemics, both in terms of costs to the health system, as well as costs of social distancing: loss to employment productivity, loss to consumer demand, an impact on tourism and other particular industries, and an impact on foreign direct investment¹. This concern is echoed by Fan, Jamison, and Summers (2018). They note very recently “an unmet need for greater investment in preparedness against major epidemics and pandemics.” They estimate the expected annual losses from pandemic risk to be annually approximately 500 billion US dollars, or 0.6% of global income. Considering the costs of COVID-19, this seemingly large sum now seems greatly underestimated. Other works highlighting the need for economic risk management vis-à-vis the potential likelihood of future pandemics include Bloom and Canning (2004); Cavallo et al. (2013); Lewis (2001); Madhav et al. (2017); Tam, Khan, and Legido-Quigley (2016); Yach, Stuckler, and Brownell (2006) and many others. Lagoarde-Segot and Leoni (2013) model the stress to the banking industries of developing countries as a result of large pandemics.

COVID-19 could also lead to a very long-term shifting in costs of equity. As noted by Goodell (2020), Lee and McKibbin (2004) find a 200-basis point increase in the country risk premium for China and Hong Kong following SARS. However, China and Hong Kong were particular risk areas for SARS, while COVID-19 is global. Consequently, a large increase in perceived equity risk is reasonably expected.

We consider our study alongside a number of recent papers that investigate the hedging properties of cryptocurrencies. As early as Dyhrberg (2016a) and Dyhrberg (2016b), it has been considered that Bitcoin might share some of the same hedging properties as gold (Baur and Lucey, 2010; Baur and McDermott, 2010; Bredin, Conlon, and Poti, 2015; O’Connor et al., 2015; Raza, Shah, and Shahbaz, 2018). As with many of the aspects of Bitcoin, our understanding is still developing. It is by no means a settled issue that Bitcoin is a new gold (Klein, Pham Thu, and Walther, 2018)².

As gold is often considered to move with economic policy uncertainty (Raza, Shah, and Shahbaz, 2018), it is natural to extend this inquiry to Bitcoin. Cer-

¹See also Goodell and Huynh (2020) for impact of COVID-19 on US industries

²One hopes perhaps, that the mechanism of any negative correlation between economic conditions and Bitcoin is not simply due to economic downturns causing increased portions of economic output being in illegal or shadow activities that are financed by Bitcoin (Foley, Karlsen, and Putniņš, 2019).

tainly, there are numerous studies investigating the co-movement of Bitcoin and similar currencies with movement in global economic uncertainty. Again, this area is not settled. For instance, Wu et al. (2019) and Wang et al. (2019) find a negligible relationship, while Bouri et al. (2018) and Demir et al. (2018) find a stronger relationship.

It is also reasonable to consider further the movement of Bitcoin with other assets, particularly in the context of changes in economic apprehension. After all, economic conditions manifest to financial markets through changes in asset prices. While Bouri et al. (2017b), Klein et al. (2018) and Smales (2018) do not find consistent evidence that Bitcoin serves as a safe haven for global assets, Selmi et al. (2018) show that Bitcoin, like gold, serves as a hedge, safe haven, and diversifier for oil price movements. However, this property seems to be sensitive to the Bitcoin's and gold's different (bear, normal or bull) market conditions and to whether the oil price is in a downside, normal or upside regime. Kurka (2019) find that the relationship between Bitcoin and other assets depends on whether there are shocks occurring. Further, Matkovskyy and Jalan (2019) find that, during crisis periods, risk-averse investors tend to move away from Bitcoin, with a view that it is riskier than financial markets.

A further question is how the role of Bitcoin in hedging other assets has changed during the period of the COVID-19 crisis. Understandably there are few studies yet on such recent events. An exception is Conlon and McGee (2020), who show that Bitcoin has indeed been a poor hedge against the SP500 during the COVID-19 crisis.

Overall, our study of how Bitcoin prices co-move with the intensity of the COVID 19 crisis will contribute considerably to our understanding both of how COVID-19 is impacting financial systems; as well as how Bitcoin might act as a hedge, diversifier, or safe haven during extreme, global, crises.

2 Data and econometric framework

This study applies the wavelet method of Grinsted et al. (2004) to daily data of COVID-19 world deaths and Bitcoin prices from 31th December 2019 to 29th April 2020.

2.1 Econometric framework

In contrast to standard time series modelling, the wavelet coherence approach allows capturing of the co-movement between two time series in both the time and frequency domains. The wavelet approach uses a bivariate framework established on a continuous wavelet transform (Morlet set to 6). This allows for a variety of scaled localizations (Rua and Nunes, 2009). In order to capture and interpret co-movement between time series both in time and frequency domains, we suggest the use of the wavelet coherence approach by using both the cross-wavelet transform and coherence.

Following the approach of Torrence and Compo (1998), the cross wavelet transform of two time-series $x(t)$ and $y(t)$ is defined using their own cross wavelet transform (CWT) $W_n^x(u, s)$ and $W_n^y(u, s)$ as:

$$W_n^{xy}(u, s) = W_n^x(u, s) * W_n^y(u, s) \quad (1)$$

where u is associated to the location and s to the scale. The $*$ denotes the complex conjugate. The cross wavelet transform highlights areas in the time–frequency domain where time series show a high common power. In other words, it captures the local covariance between the two time series $x(t)$ and $y(t)$ at each scale.

After Torrence and Webster (1999), we define the wavelet coherence capturing the co-movement between two time series as:

$$R^2(u, s) = \frac{|S(s^{-1}W^{xy}(u, s))|^2}{S(s^{-1}|W^x(u, s)|^2) S(s^{-1}|W^y(u, s)|^2)} \quad (2)$$

where S is a smoothing operator over time as well as scale and $0 \leq R^2(u, s) \leq 1$ (Rua and Nunes, 2009). The quantity $R^2(u, s)$ represents the wavelet squared coherence. Its value is between 0 and 1. The higher its value, the higher the co-movement between the two time series. We note that, unlike the classical correlation of two time series, wavelet squared coherence is restricted to positive values. Therefore, that at this step this methodology can not distinguish positive or negative co-movement, or between positive and negative correlation. A way to solve this problem is to use the phase difference of Torrence and Compo (1998) to capture the two possible co-movements: positive and negative. Moreover, in the spirit of Granger causality testing, this graphical presentation of the wavelet squared coherence can give us the causal relationships between the two time series.

Wavelet coherence phase difference is defined as:

$$\Phi_{xy}(u, s) = \tan^{-1} \left(\frac{\text{Im} \{S(s^{-1}W^{xy}(u, s))\}}{\text{Re} \{S(s^{-1}W^{xy}(u, s))\}} \right) \quad (3)$$

where, Im and Re are the imaginary and real parts of the smoothed cross-wavelet transform, respectively.

Phases are indicated by black arrows on the wavelet coherence plots. A phase-difference of zero is consistent with time series moving together. Arrows pointing to the right (left) indicate time series which are in-phase (out of phase), or are positively (negatively) correlated. An arrow pointing upward indicates that the first time series leads the second by $\pi/2$; whereas a downward pointing arrow suggests the second time series is leading the first by $\pi/2$. A combination of positions is usual.

We compute the daily returns by finding the difference between two consecutive prices: $ri, t = P_{i,t} - P_{i,t-1}$ with i is for COVID-19 deaths and Bitcoin.

Figure 2.1 shows the dynamics of the return series and illustrates the stylized factors (e.g., volatility clustering) for the Bitcoin return series.

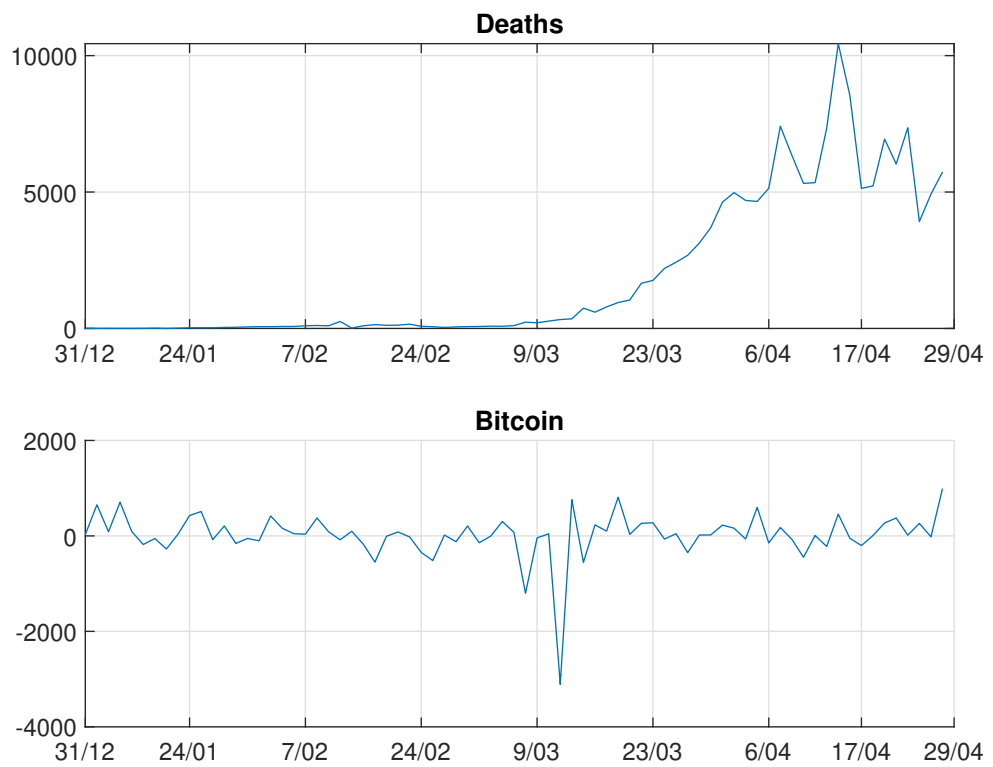


Figure 1: Evolution dynamics of the return series

We see on Figure 2.1, that the dynamic of the COVID-19 pandemic is a two-phase process: an exponential increasing of the death's number until middle of April then a quite linear decreasing.

Table 1 presents descriptive statistics of the return series. booktabs
booktabs

Table 1: Descriptive Statistics

	Covid Deaths	Bitcoin
Mean	1889.519	20.602
Std. Deviation	2678.431	488.075
Skewness	1.272	-3.507
Std. Error of Skewness	0.274	0.274
Kurtosis	0.491	22.184
Std. Error of Kurtosis	0.541	0.541
Shapiro-Wilk	0.730	0.704
P-value of Shapiro-Wilk	< .001	< .001

As shown in Table 1, Bitcoin exhibits skewing, as well as excess kurtosis. These findings and the Shapiro-Wilk statistics demonstrate that the distributions of this series is asymmetric and leptokurtic, rejecting the normality property.

2.2 Wavelet coherence

We apply continuous wavelet power spectrum and coherence methodologies between COVID-19 deaths and Bitcoin return prices. This is illustrated in Figures 2.2 and 2.2. The wavelet power spectrum is defined as the absolute value of the square of the wavelet transform. It gives us a measure of the time series variance for each time and for each scale (frequency). The horizontal axis displays the time component, while the vertical axis shows the frequency component. This ranges from scale 1 (a day) up to scale 16 (more than 16 days). The black contours in the plot indicate regions with significance at the five-percent level. This is estimated by Monte Carlo simulation with phase-randomized surrogate series. The solid curved line shows the cone of influence, or the zone affected by edge effects.

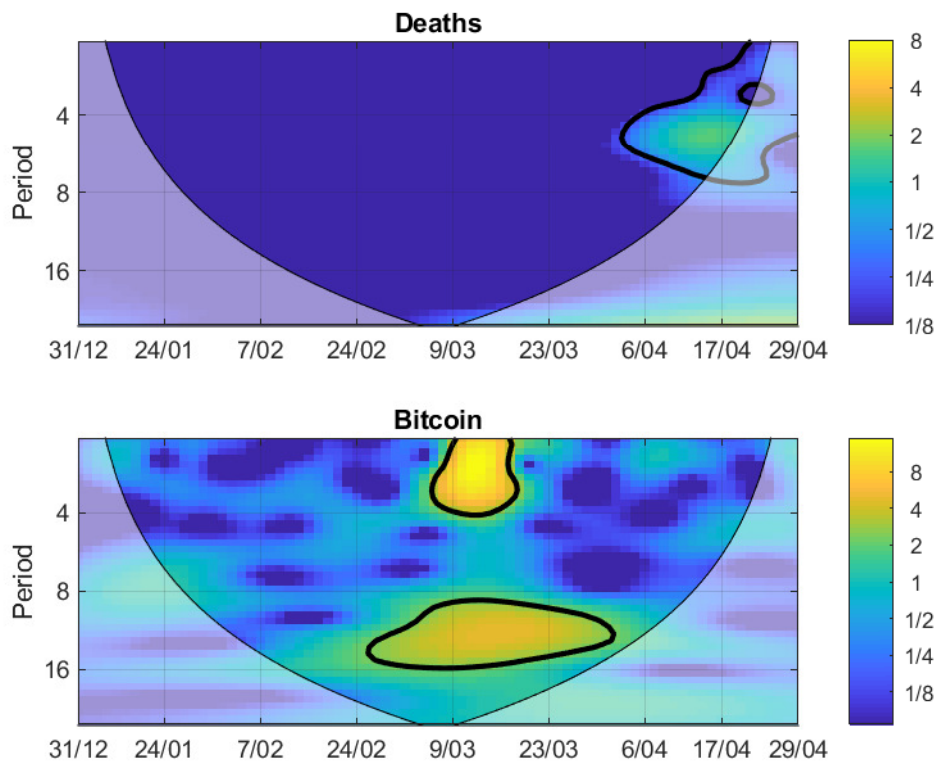


Figure 2: Continuous wavelet transform of COVID-19 deaths and Bitcoin returns. The horizontal axis shows time, while the vertical axis refers to the period in days..

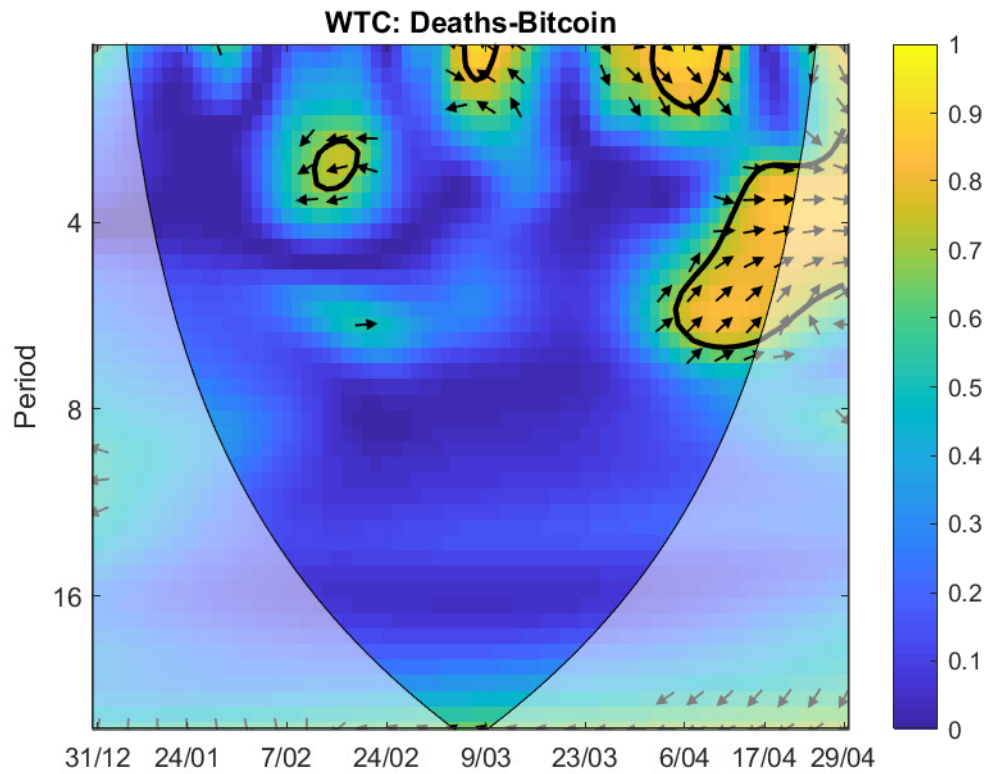


Figure 3: Wavelet coherency (WTC) between COVID-19 deaths and Bitcoin. The level of correlation is indicated by the color on the right side of the charts; the hotter the color (moving from cool (blue) to hot (yellow)) the higher the absolute correlation value with respect to $R^2(u, s)$.

Figure 2.2 illustrates the wavelet coherence and phase difference between COVID-19 deaths and Bitcoin return prices. The coherency ranges from yellow (high coherency) to blue (low coherency) to designate the amount of co-movement. Therefore, a yellow color represents strong co-movement; whereas a blue color indicates weak co-movements. We can identify four significant high-degree co-movements between COVID-19 deaths and Bitcoin.

- For the 10th February to 20th February period across the 2-4 day frequency band.
- A two-day frequency cycle observed during the period 8th March to 10th March and another one during the period 5th April to 10th April.
- A particularly meaningful and significant coherence for 3-7 day frequency cycles observed during the period 5th April to 29th April.

These coherences evidence the contagion effect during the implementation of containment in the majority of the countries of the world (i.e. after middle of March). The increasing of COVID-19 deaths was associated with a reduced value of Bitcoin for short and mid terms during this period. Perhaps these periods roughly match 1) the beginning of the pandemic (i.e., a global threat outside of China; 2) the beginning of large-scale enforced social distancing in many Western countries; and 3) the full global manifestation of COVID-19.

Additionally, we discern causality and phase differences between COVID-19 deaths and Bitcoin returns. Arrows indicate the phase differences between COVID-19 deaths and Bitcoin returns. For example, \rightarrow and \leftarrow indicate that both COVID-19 deaths and Bitcoin returns are in phase and out of phase. Being in phase (out of phase) indicates a positive (negative) correlation between COVID-19 deaths and Bitcoin returns. Moreover, \nearrow and \swarrow indicate that COVID-19 deaths are leading Bitcoin return prices, while \searrow and \nwarrow indicate COVID-19 deaths values are lagging those of Bitcoin return prices.

Thus as shown in Figure 2.2, we can identify causality and phase differences between COVID-19 deaths and Bitcoin return prices. We observe that since 5th April, the main and most significant period of coherence and co-movements in both 1-2 days and 3-7 day bands, that arrows are in majority \nearrow and \rightarrow , signifying an in-phase relationship and a positive correlation between COVID-19 deaths and Bitcoin returns. Moreover, these arrows also indicate that COVID-19 deaths led Bitcoin returns in the short and medium terms, over this period of full world containment.

In summary, we find predominantly a strong negative co-movement of Bitcoin prices and COVID-19. However, levels of the intensity of this co-movement do vary over our overall period of study, with some brief intervals even exhibiting a positive association. It is interesting to compare our results with Demir et al. (2018). Demir et al. (2018) find a negative association of economic policy uncertainty with Bitcoin only for extreme values of this uncertainty. Certainly COVID-19 is an extreme event, with likely an extreme impact on peoples' perception of uncertainty. Our results may result in more questions than answers for future research. For instance, how does the co-movement of Bitcoin

with COVID-19 compare with the co-movements of national financial markets with the pandemic? Why were there strong but brief periods of negative co-movement of Bitcoin with COVID-19 as early as February 10? Could Bitcoin have a signaling value? Many of these questions are outside the bounds of this paper.

3 Conclusions

As the COVID-19 pandemic continues, with the eventual scale of the disaster not yet determined, we are all painfully aware of the continuing cost in lives of this pandemic. However, there is also concern about the eventual economic impact of this crisis, including the effect on financial markets. Additionally, academic finance has also had, in the last few years, considerable interest in the hedging, diversifying and safe-haven qualities of Bitcoin. In response to this, we investigate the co-movement of Bitcoin with levels of COVID-19 related fatalities. We consider that while national equity markets reflect economic concerns at country levels, the evolving COVID-19 crisis affords a measure of a developing global economic threat. We apply wavelet methods to daily data of COVID-19 world deaths and daily Bitcoin prices from 31st December 2019 to 29th April 2020, evidencing that levels of COVID-19 cause a rise in Bitcoin prices. This effect is especially strong for the portion of our period post April 5. We consider that our study contributes both to the fast-growing body of work on the financial impacts of COVID-19; as well as to an ongoing focus in the literature regarding whether Bitcoin is a safe haven investment.

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