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Financial implications of fourth industrial revolution: Can bitcoin improve prospects of energy investment?



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ABSTRACT

Bitcoin and the blockchain technology on which it is based are the key drivers behind the accelerated pace of Fourth Industrial Revolution in the domain of Finance. The offshoots of this technology however are not limited and are rapidly spreading in other domains such as oil market. This paper investigates the causality or influences that both markets, Bitcoin price (BP) and oil price (OP) have on each other by applying the bootstrap Granger causal relationship tests considering full as well as sub-samples. Our analysis reveals that shocks originated in OP and transmitted towards BP can be both positive or negative. The positive impact indicates that Bitcoin can be viewed as an asset helpful in avoiding the risks of the high OP, which also indicates that Bitcoin and oil are in the same boat, however, the negative effects cannot support this view. The negative influence of OP on BP can be explained by the burst of the Bitcoin bubble which has weakened its hedging ability. In turn, there is also a negative influence or reverse causality running from BP to OP, highlighting that the demand for oil by investors can be threatened by the increasing BP. Keeping in view the more integrated and complexed financial dynamics which are the results of Fourth Industrial Revolution, investors can benefit from this interrelationship to diversify the risks and optimize their investment by building a more balanced portfolio. Also, governments could promote and protect the healthy development of the Bitcoin and energy market by preventing the Bitcoin bubbles and understanding the reasons of oil price volatility.

1. Introduction

The Fourth Industrial Revolution unarguably presents tremendous changes in all aspects of human society, especially in the financial system (Min et al., 2019; Valencia et al., 2019). The cryptocurrencies and related technologies can bring enormous value to the economic and financial spheres (Lee, 2019; Perera et al., 2020), which can significantly promote the outbreak of the Fourth Industrial Revolution. As the first decentralized cryptocurrency, Bitcoin is a virtual encrypted digital currency in peer-to-peer (P2P) form which has been invented by Satoshi Nakamoto (Nakamoto, 2008). Subsequently, Bitcoin and the blockchain technology proved to be an essential component of the Fourth Industrial Revolution. Thus, exploring the relationship between Bitcoin market and its determinants is beneficial in forecasting Bitcoin price (BP). This could not only reduce the uncertainty of the Bitcoin market but can also increase the trading enthusiasm. Moreover, this exploration can help to grasp the evolutionary trends in Bitcoin and

associated blockchain technology, reflecting the progress of the Fourth Industrial Revolution, which can be extremely helpful in developing future technological strategies. It is important to note that in the early days of the Bitcoin market, buyers were extremely confused about the use of it, and BP was volatile, a situation which is quite similar to the oil market in 1860 (Carlos, 1990). One can, therefore, should not ignore the possibility of observing certain interrelationship between Bitcoin and oil market (Okorie and Lin, 2020).

Doesn't matter how different the Bitcoin and oil do look as products, there are strong reasons to believe that the two have lots of similarities and they may have influences on each other's prices based on their relationship with each other. However whether this relationship is positive or negative, it would be difficult to say anything without carefully understanding the dynamics of the two markets.

Let us hypothesize that the two products have positive influences on each other's prices, in other words both Bitcoin and oil are in the same boat. This view is not an arbitrary view and has been under discussion

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since the birth of the digital currency market owing to the potential diversification benefits Bitcoin offered to hedge the risks not only in the oil market but in other markets as well. Since the increase in OP may trigger inflation, reduce the real income and profit, as well as diminish the public confidence (Salisu et al., 2017; Elfayoumi, 2018; Bildirici et al., 2019; Shahzad et al., 2019), more hedging assets (e.g., Bitcoin), are needed to be held to obtain diversification benefits. It is highly likely that the BP, which moves in the same direction as OP increases due to its diversification potential (Karalevičius et al., 2017; Bouoiyour et al., 2019; Fang et al., 2019). Moreover, economic and geopolitical situations also make it logical and strengthen the positive relationship between BP and OP. For instance, the policy of quantitative easing by the U.S. authorities causes dollar to depreciate, which drives BP and OP to increase since these two variables are denominated in U.S. dollars (Dyhrberg, 2016; Sun et al., 2017; Wen et al., 2017; Mcleod and Haughton, 2018; Anjum, 2019). Similarly, the departure from the quantitative easing policy has the opposite effects, which both markets observed in late 2014. The geopolitical events and conflicts that occur in the oil-producing countries, may reduce the supply of oil and increase OP and subsequent risk aversion coupled with wealth reallocation could increase the demand for Bitcoin and forces BP to move in the same direction as OP (Al-Yahyaee et al., 2019; Mamun et al., 2020). This is the phenomenon that has already been observed by market participants during the high geopolitical risk environment in 2016 (Caldara and Iacoviello, 2017).

There is an abundant literature supporting this conjecture. Dyhrberg (2016) suggests that Bitcoin is beneficial for risk-averse investors to maintain their returns if they face the expected negative shocks to the market. Gajardo et al. (2018) identify that Bitcoin has an interrelationship with commodities, such as oil, which should be taken into account when investing. Bouoiyour et al. (2019) point out that oil can be viewed as an effective safe haven against political risks, and Bitcoin also acts as a hedge to reduce the U.S. stock losses but only in the short-term, which shows that BP and OP move in the same direction. Bouri and Gupta (2019) evidence that Bitcoin is a hedge against uncertainty which partly caused by the fluctuations in OP, and based on this BP can be predicted more accurately. As high OP makes the public panic and the economy unstable, López-Cabarcos et al. (2019) indicate that investor sentiment has certain influences on BP and Bitcoin volatility. Symitsi and Chalvatzis (2019) reveal that there are significant diversification benefits from Bitcoin within traditional asset portfolios, especially in the portfolios of commodities which include oil (also Guesmi et al., 2019).

Nonetheless, the view that Bitcoin possesses the ability to avoid risks and provide good hedge and therefore it is in the same boat with oil, cannot be supported all the times. The concerns were raised by (Baek and Elbeck, 2015; Cheng and Yen, 2019) on the quality of hedge provided by Bitcoin to oil investors, if the two are not in the same boat and their prices move in opposite direction. This is exactly what happened when the Bitcoin bubble burst in 2017 and caused BP to plummet (Li et al., 2018; Xiong et al., 2019), at the time when OP was observing an upward trajectory, indicating complete inability of Bitcoin to avoid the risks of high OP. Later when economic uncertainty, such as the global trade wars, made the expected global economic outlook even worse, and the demand for oil and OP collapsed. At the same time the Bitcoin demand and BP increased in response to the actions of investors who wanted to hedge the risks and uncertainty in oil market, (Demir et al., 2018; Wu et al., 2019; Fang et al., 2019), yielding completely different directions in the prices of two assets. Bouri et al. (2017a) reveal that Bitcoin is a poor hedge or safe haven for other assets, such as oil, gold and stock. Panagiotidis et al. (2018) indicate that the impact of OP on BP is inferior to search for behaviour and gold returns. Das et al. (2019) ascertain that Bitcoin is not the superior asset over others (e.g., gold, dollar) to avoid the risks of oil volatility, also its hedging ability depends on the essence of oil risks and market environment (also Shahzad et al., 2020).

Charfeddine et al. (2020) suggest that cryptocurrencies, such as Bitcoin, are poor hedging tools by analysing an investment portfolio that includes oil. Das and Dutta (2020) also suggest that the higher prices of energy (e.g., high OP) may impede the miners to break-even, which is harmful to the development of Bitcoin market, thereby affecting BP.

Additionally, the geopolitical events occurring in the non-oil producing countries, may increase the demand for Bitcoin and BP to hedge the risks (Al-Yahyaee et al., 2019; Mamun et al., 2020), while the same events may not have significant effects on oil supply and OP (Su et al., 2019a) and therefore, offer a possibility of divergence in the prices of two assets.

Further support to this idea has been provided by the large-scale outbreak of the Corona Virus Disease 2019 (COVID-19) in January 2020 which has caused BP and OP to move in different directions. Bitcoin has performed well as a hedging asset which has driven BP to exceed \$10,000, but the oil market has proven not so fortunate. Since China is the largest oil importer around the world, this infectious disease has affected many industries and society, the demand for oil has plummeted which causes OP to fall. Also, the collapse of the organization of the petroleum exporting countries (OPEC) and the failure to conclude production reduction agreement with Russia has also exacerbated the plunge in OP. Another reason of negative association between the BP and OP may be the substitution effect, when high BP may increase the willingness of investors to hold Bitcoin, instead of other assets, such as oil. As a result, the reduced investment in the oil and its related markets leads to a decline in OP, and forces the two variables to move in opposite direction.

In the light of two conflicting opinions presented above we are of the view that the issue whether the Bitcoin and oil are in the same boat has not been clearly understood, examined and interpreted. We, therefore, in this paper investigate the time-varying Granger causality between BP and OP to further explain this issue and to understand the true nature between the observed prices in the two markets.

There are several contributions of this paper. To begin with, the existing studies mainly investigate the impact of OP on BP, or vice versa (Gajardo et al., 2018; Panagiotidis et al., 2018; Bouri and Gupta, 2019b; Das et al., 2019; Das and Dutta, 2020). It is obvious that there could be a bidirectional relationship between BP and OP, hence, a one-way influence cannot reflect the interaction between the two variables comprehensively. Given the limited scope of the existing studies, this study is a groundbreaking attempt to solve the issue of whether Bitcoin and oil are in the same boat or not by employing the time-varying Granger causality test. There could be however issues with the Granger causality which may not be constant between BP and OP, a dimension primarily ignored by the existing studies. To cope with this issue, we first examine the non-stable parameters in the empirical models. The results support our suspicion and provide evidence that employing the traditional Granger causal relationship test is not suitable and therefore, this paper uses the bootstrap sub-sample rolling-window Granger causality test (Balcilar et al., 2010; Su et al., 2019b, 2020a) to improve the accuracy of the outcomes. We use monthly data, covering the period of 2010:M7 to 2020:M1, to investigate the correlation between OP and BP by applying the full- and sub-sample tests. The empirical results reveal that OP has both positive and negative influences on BP, while OP is negatively affected by BP, indicating that Bitcoin and oil are not always in the same boat. Furthermore, the mutual influence between BP and OP provides insights to the investors, they can predict BP by considering the oil market and beware of the Bitcoin bubbles to diversify the risks and optimize their investment. Also, they can decide the amount to invest in the oil market, in order to obtain a more profitable portfolio. The government can benefit from this interaction to grasp the trends of BP and OP, then they can prevent the large fluctuations in Bitcoin and oil markets, in order to prompt the stable development of these two markets. By the predictions of OP, oil-importing and -exporting countries can prevent inflation and avoid the overcapacity, respectively.

The rest of the paper is arranged as follows: Section 2 explains the

empirical methods. Section 3 introduces the data. Section 4 reveals the empirical results. Section 5 summarizes the study of this paper.

2. Methodology

2.1. Bootstrap full-sample Granger causality test

According to the traditional vector autoregression (VAR) model, the Granger causality test statistics must obey the standard asymptotic distributions. In order to avoid the incorrect results and enhance the correctness of the Granger causal relationship test, the critical values of the residual-based bootstrap (RB) method are proposed by Shukur and Mantalos (1997). Additionally, they point out that RB method is appropriate for the tests with standard asymptotic distributions, even in the small samples. Shukur and Mantalos (2000) develop the likelihood ratio (LR) tests, which can be revised by the features of power and size. In this paper, we examine the mutual influences between BP and OP by employing the RB-based modified-LR test. To conduct these tests the VAR (p) system with two variables is constructed as Eq. (1):

$$Z_t = \beta_0 + \beta_1 Z_{t-1} + \dots + \beta_p Z_{t-p} + \mu_t \quad t = 1, 2, \dots, T \quad (1)$$

where p is selected based on the Schwarz Information Criterion (SIC), which indicates an optimal lag order. The bivariate VAR (p) system can split Z into BP and OP, that is $Z_t = (BP_t, OP_t)$. Since, BP and OP are denominated in U.S. dollar, which may affect the interaction between these two variables (Dyhrberg, 2016; Sun et al., 2017; Wen et al., 2017; Mcleod and Haughton, 2018; Anjum, 2019; Su et al., 2020b). Therefore, we choose the U.S. dollar index (USDX) as a control variable, and rewrite Eq. (2) as follow:

$$\begin{bmatrix} BP_t \\ OP_t \end{bmatrix} = \begin{bmatrix} \beta_{10} \\ \beta_{20} \end{bmatrix} + \begin{bmatrix} \beta_{11}(L) & \beta_{12}(L) & \beta_{13}(L) \\ \beta_{21}(L) & \beta_{22}(L) & \beta_{23}(L) \end{bmatrix} \begin{bmatrix} BP_t \\ OP_t \\ USDX_t \end{bmatrix} + \begin{bmatrix} \mu_{1t} \\ \mu_{2t} \end{bmatrix} \quad (2)$$

where $\mu_t = (\mu_{1t}, \mu_{2t})'$ is a white-noise process. $\beta_{ij}(L) = \sum_{k=1}^p \beta_{ij,k} L^k$, where $i = 1, 2, j = 1, 2, 3$ and L is a lag operator, and there is $L^k Z_t = Z_{t-k}$.

The null hypothesis that OP has no influences on BP, that is $\beta_{12,k} = 0$ for $k = 1, 2, \dots, p$, can be tested based on the Eq. (2), and it can be accepted if OP is not a Granger cause for BP, and vice versa. Also, the null hypothesis that $\beta_{21,k} = 0$ for $k = 1, 2, \dots, p$, which suggests the changes of BP have no influences on OP can be accepted in the same way.

2.2. Parameter stability test

The supposition of the above estimation is that VAR system only has constant parameters, which is inconsistent with reality. Thus, if the parameters are non-stable, performing the full-sample test is not suitable. To deal with this issue, we employ the parameter stability tests, including *Sup-F*, *Ave-F* and *Exp-F* tests, developed by Andrews (1993) and Andrews and Ploberger (1994). *Sup-F* test can examine the sudden structural changes in parameters, *Ave-F* and *Exp-F* tests can evidence whether the parameters have a gradual change over time. Furthermore, we also use the L_c statistics test (Nyblom, 1989; Hansen, 1992), in order to evidence whether the parameters follow a random walk process. By performing the above stability tests, there must be a non-stable interaction between BP and OP if the parameters are time-varying. Hence, we should apply the sub-sample test to investigate the mutual influences between these two-time series.

2.3. Bootstrap sub-sample rolling-window Granger causality test

Balcilar et al. (2010) develop this sub-sample method, in order to discrete the whole time series into small sections based on the rolling-window width. The selection of the width is complex matter. A small width may not ensure the robustness of the results, and although the

large width can enhance the correctness of the results, but it may decrease the times of scrolls. We follow Pesaran and Timmermann (2005) in this regard who ascertain that this width cannot be less than 20 if the parameters in the VAR system are non-stable and the separated small parts are scrolled from the start to the end of the entire time series. We assume that the extent of the entire sample is L and the rolling-window width is w . The final of every separated small part is $w, w + 1, \dots, L$ and we can get $L-w + 1$ sub-samples. Each sub-sample can obtain a Granger causality result through applying the RB-based modified-LR statistic. Next, we can obtain the outcomes of the sub-sample test. $N_b^{-1} \sum_{k=1}^p \hat{\beta}_{12,k}^*$ and $N_b^{-1} \sum_{k=1}^p \hat{\beta}_{21,k}^*$ are the mean values of a huge number of estimations, which suggest the impact of OP on BP and the influence from BP to OP, respectively. N_b is the frequency of bootstrap repetitions. $\hat{\beta}_{12,k}^*$ and $\hat{\beta}_{21,k}^*$ are parameters from Eq. (2). For the rejection of null hypothesis, 90% confidence interval is applied in this paper, also with the relevant lower (5th quantile) and upper (95th quantile) limits (Balcilar et al., 2010).

3. Data

In this paper, we consider the monthly data from 2010:M7 to 2020:M1 to explore the Granger causal relationship between Bitcoin and oil prices, then evidence whether Bitcoin and oil are in the same boat. We use Bitcoin price (BP) which is denominated in U.S. dollars,¹ to reflect the international Bitcoin market. We further choose West Texas Intermediate (WTI) crude oil price (OP) which is also denominated in U.S. dollars,² to represent the international oil market (Wang et al., 2011; Chiroma et al., 2015). As we have explained earlier, BP and OP may have certain relationships, which means that there may be interactions between the digital currency and international oil markets. Fig. 1 reveals the trends of BP and OP while relating these trends with important events that have occurred in both markets.

We can observe that Bitcoin and oil are not always in the same boat. When Bitcoin first appeared, BP increased slightly due to the fact that there were few traders and no formal Bitcoin exchange existed at that time. The Arab Spring drove oil supply and OP to soar until U.S. President Barack H. Obama announced that Al-Qaida³ leader Bin Laden was killed by the U.S. military on May 1, 2011. The Syrian war and Cyprus crisis in 2013 led investors to be more willing to hold digital currencies, immediately after which, the rise in demand drove BP to soar. Since the unstable situation in the Middle East during this period, there are certain restrictions on oil production, which has kept OP at a high level. In the second half of 2014, the U.S. withdrew from quantitative easing policy, and the value of the U.S. dollar increased, leading to a rise in its need which caused the demand for Bitcoin and oil to decrease. In addition, the U.S. shale oil and gas revolution increased the supply of oil, and thus OP further plummeted at that time. The U.S. Federal Reserve Board announced that its Federal Funds Rate would be unchanged, causing the dollar to depreciate, while BP and OP increased in 2016. Moreover, the large-scale investment of Bitcoin (especially by China, Japan and South Korea) drove BP to skyrocket, then, BP soared by about 2000% in 2017, and OP was also on an upward trend. Thus, Bitcoin and oil are in the same boat during these periods. This dramatic growth trend does not continue and there is a sharp decrease in BP in 2018, while OP has experienced a rise and then a decline. Although the situation in the Middle East has deteriorated in 2019, its impacts on OP are short-lived. However, the global trade wars, especially the Sino-U.S.

¹ BP in U.S. dollars is taken from the Yahoo Finance (<https://finance.yahoo.com/quote/BTC-USD?p=BTC-USD&.tsrc=fin-srch>).

² OP in U.S. dollars is taken from the Energy Information Administration (<https://www.eia.gov/petroleum/>).

³ Al Qaeda is an Islamic military organization founded in the late Soviet Union's invasion of Afghanistan in 1988. It is considered as a global terrorist organization.

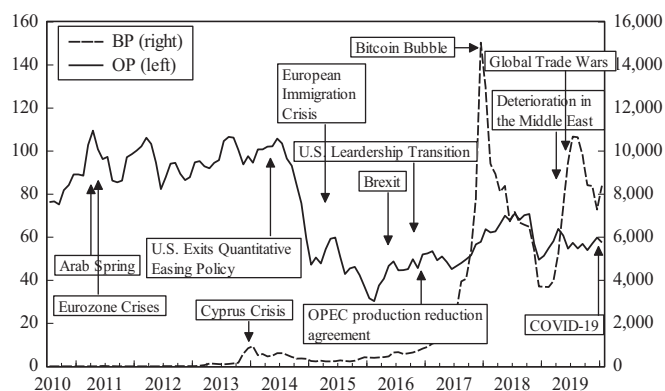


Fig. 1. The trends of BP and OP.

trade disputes, have slowed the global economy and led to a decline in oil demand and OP. Additionally, the increasing demand for Bitcoin as a hedging asset drives BP to soar. The COVID-19 breaks out in January 2020, which also makes BP and OP move in different directions. Hence, Bitcoin and oil are not always in the same boat. Furthermore, both BP and OP are denominated in U.S. dollars which may influence the fluctuations in Bitcoin and oil markets. An interest rate cut may decrease the value of the U.S. dollar (e.g., quantitative easing policy), which may lead to the rise in BP and OP, and vice versa (e.g., Federal Reserve Board plans to raise interest rates). Thus, the U.S. dollar index (USD_X)⁴ may have effects on the interaction between BP and OP, then we choose it as a control variable in Eq. (2). Generally, the mutual influence between BP and OP is complicated, as well as affected by USD_X.

Table 1 reports descriptive statistics. The averages of BP, OP and USD_X suggest that they are centred at the 2209.370, 71.986 and 88.725, respectively. The positive skewness can reflect that BP and OP have right-skewed distribution, while USD_X has left-skewed distribution due to its negative value. The kurtosis of BP is greater than 3, thereby this series is satisfying the conditions of leptokurtic distributions. Meanwhile, OP and USD_X satisfy the identification criteria of platykurtic distributions, since the kurtosis is less than 3.⁵ Furthermore, the Jarque-Bera index points out that BP, OP and USD_X are significantly non-normally distributed at 1% level. Therefore, it is not appropriate to employ the traditional Granger test., This paper therefore employs the *RB* method to analyse these three variables with potentially non-normal distributions and also apply the bootstrap sub-sample rolling-window test to explore the mutual influences between BP and OP. Also, these three variables (BP, OP and USD_X) are taken in their natural logarithms form to avoid the potential heteroscedasticity.

4. Empirical results

In order to examine the unit roots, this paper applies the Augmented Dickey-Fuller (Dickey and Fuller, 1981), Phillips-Perron (PP, 1988) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS, 1992) tests. The outcomes of the above tests are reported in Table 2, and we can conclude that BP, OP and USD_X are I(1). Then, we use the first differences of these three variables to construct the Granger causality test models, which can ensure the stationary of the time series.

The VAR system, based on Eq. (2), is performed to test the full-sample Granger causality between BP and OP. We choose the optimal lag order of 2 based on the SIC. Table 3 reports the results of the full-

⁴ USD_X is taken from the Federal Reserve Board (https://www.federalreserve.gov/econres/notes/ifdp-notes/IFDP_Note_Data_Appendix.xlsx).

⁵ The leptokurtic distribution shows a much higher peak around the mean value, and fat tails, or higher densities of values at the extreme ends of the probability curve. The platykurtic distribution is exactly the opposite.

Table 1 Descriptive statistics for BP, OP and USD_X.

	BP	OP	USD _X
Observations	115	115	115
Mean	2209.370	71.986	88.725
Median	423.549	68.060	91.796
Maximum	15,034.530	109.530	102.350
Minimum	0.062	30.320	73.030
Standard Deviation	3456.542	22.365	8.563
Skewness	1.622	0.081	-0.162
Kurtosis	4.622	1.549	1.455
Jarque-Bera	63.048***	10.216***	11.943***

*** denotes significance at the 1% level.

Table 2 The results of the unit root test.

	ADF	PP	KPSS
Levels	BP - 2.495(3)	-2.624 [1]	1.150 [9]***
	OP - 1.682 (1)	-1.420 [5]	0.727 [9]**
	USD _X - 0.833 (1)	-1.030 [5]	1.026 [9]***
First differences	BP - 6.795 (1)***	-6.822[2]***	0.336 [2]
	OP - 6.796 (1)***	-7.997 [1]***	0.095 [6]
	USD _X - 7.373 (1)***	-11.903 [5]***	0.081 [5]

Notes: The number in parenthesis indicates the lag order which is selected based on the SIC. The number in the brackets indicates the bandwidth which uses Bartlett Kernel as suggested by the Newey-West test (1987).

** and *** denote significance at the 5% and 1% level, respectively.

Table 3 Full-sample Granger causality tests.

Tests	H ₀ : OP does not Granger cause BP		H ₀ : BP does not Granger cause OP	
	Statistics	p-values	Statistics	p-values
Bootstrap LR test	6.789***	0.010	0.467	0.780

Notes: To calculate p-values using 10,000 bootstrap repetitions.

*** denotes significance at the 1% level.

sample test, the p-values point out that there is an influence from OP to BP at a 1% level, while BP cannot significantly affect OP. These findings are not consistent with the previous studies (Panagiotidis et al., 2018; Das et al., 2019).

The full-sample estimation in the bivariate VAR system assumes that the parameters are constant and there is only one Granger causality in the whole period. However, if there are structural changes, the Granger causality between BP and OP is non-constant (Balcilar and Ozdemir, 2013). We employ *Sup-F*, *Ave-F* and *Exp-F* tests (Andrews, 1993; Andrews and Ploberger, 1994) to examine the parameter stability, and also use the *L_c* statistics test (Nyblom, 1989; Hansen, 1992) to examine whether the parameters follow a random walk process. The results of parameter stability test are highlighted in Table 4.

Sup-F test indicates that BP and the VAR system have sudden structural changes at the 1% level, while OP has it at 5% level. *Ave-F* test highlights the parameters can change over time in BP at the 5% level. OP can accept the alternative hypothesis of evolution along the time trajectory through *Exp-F* test at the 5% level, while BP and the VAR system are at the 1% level. Additionally, the null hypothesis of *L_c* statistics test can be rejected at 5% level, revealing that the parameters in the VAR system do not follow a random walk process. Therefore, through the parameter stability test, we can conclude that there is a non-stable interrelationship between BP and OP, and the full-sample test is not suitable for this paper. Subsequently, we apply the bootstrap sub-sample rolling-window Granger causality test to investigate the

Table 4
The results of parameter stability test.

Tests	BP		OP		VAR system	
	Statistics	p-value	Statistics	p-value	Statistics	p-value
Sup-F	94.423***	0.003	24.706**	0.019	57.156***	0.000
Ave-F	13.428**	0.018	9.451	0.153	16.965	0.185
Exp-F	43.334***	0.000	9.148**	0.017	24.820***	0.000
L_c					3.693**	0.022

Notes: To calculate p-values using 10,000 bootstrap repetitions.

** and *** denote significance at the 5% and 1% level, respectively.

time-varying interaction between these two variables. Also, we choose the rolling-window width of 24-months,⁶ in order to ensure the accuracy of the Granger causal relationship analysis. We can evidence whether the null hypothesis that OP does not Granger cause BP (or BP does not Granger cause OP) can be accepted or rejected. Moreover, the orientation of the influence from OP to BP (or the effects of BP on OP) can also be acquired.

Figs. 2 and 3 reveal the p-values and the orientation of the influences from OP to BP. OP Granger causes BP during the periods of 2013:M1–2013:M10, 2016:M8–2017:M6 and 2018:M12–2019:M1 at the 10% significance level. And during these periods, both positive effects (2013:M1–2013:M10 and 2016:M8–2017:M6) and negative effects (2018:M12–2019:M1) exist from OP to BP.

The positive effects of OP on BP can confirm that Bitcoin and oil are in the same boat. The slow recovery of the global economy has increased the demand for oil (Hammou et al., 2010). The instability in the Middle East (e.g., the Syrian war and the Libyan civil war) has cut oil supplies (Su et al., 2020a). In addition, the U.S. dollar, which is the denominated currency of OP, has depreciated due to the quantitative easing policy (Sun et al., 2017; Wen et al., 2017; Mcleod and Haughton, 2018; Anjum, 2019). All of these cause OP to be at a high level during the period of 2013:M1–2013:M10. There are three reasons that can explain the transmission mechanism from OP to BP. Firstly, the rise in OP may trigger inflation, reduce the real income of residents and the profit margins of companies, especially in oil-importing countries (Salisu et al., 2017; Elfayoumi, 2018). Then, the public confidence declines, which in turn stimulates them to hold hedging assets (e.g., Bitcoin) to avoid the risks of the high OP. Thereby, the increasing demand for Bitcoin drives BP to rise. Secondly, the instability in the Middle East and the Cyprus crisis not only cause OP to increase, but also make the investor sentiment low. They are more willing to purchase Bitcoin to avoid the risks of geopolitical events, which drives BP to soar (Ciaian et al., 2014; Bouri et al., 2017b; Wang et al., 2019; Mamun et al., 2020). Thirdly, BP is also denominated in U.S. dollars, which indicates a negative relationship between BP and USDX (Dyhrberg, 2016). Although the U.S. economy has recovered, the quantitative easing policy has kept USDX at a relatively low level, which leads BP and OP to move in the same direction. Also, the value of the U.S. dollar's investment is low, which increases the demand for other assets (e.g., Bitcoin), thereby causing BP to further rise. On the basis of above explanations, the positive influence from OP to BP during the period of 2013:M1–2013:M10 can be proved and rationalized.

From 2016, oil has experienced a rise in its price. The U.S. Federal Reserve Board has announced that it would keep its Federal Funds Rate unchanged, causing the dollar to depreciate. The OPEC has agreed to cut the production in its member states, also the geopolitical events (e.g., the counterattacks to the “Islamic State”, the civil war in Syria) make oil supply decline. Although other events, such as the Brexit and the U.S. presidential election (Donald J. Trump v.s. Hillary D. R.

⁶To test the robustness of the empirical analysis, the study also applies the widths of 20-, 28- and 32- months to investigate the causal relationship, and the outcomes are unanimous with 24-months rolling-window.

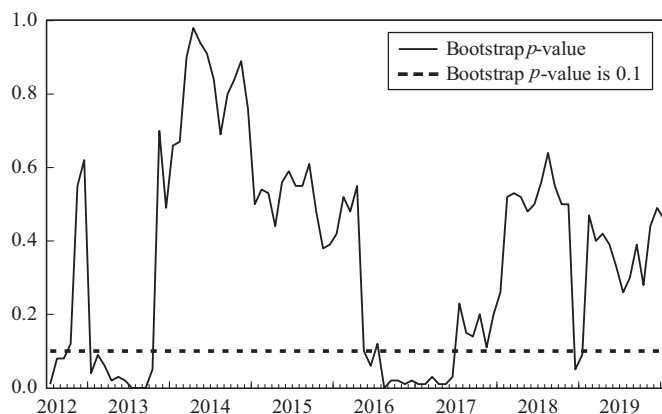


Fig. 2. Bootstrap p-values of rolling test statistic testing the null hypothesis that OP does not Granger cause BP.

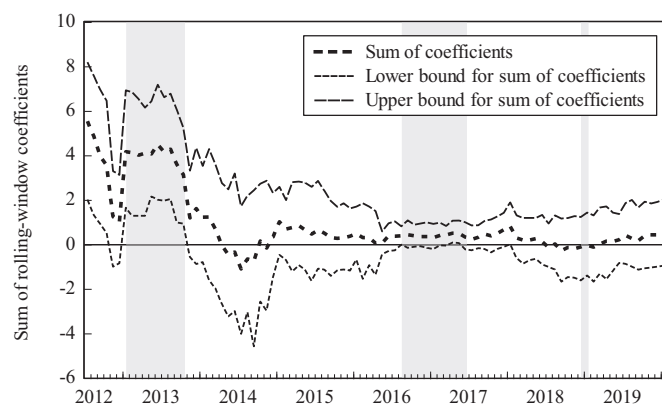


Fig. 3. Bootstrap estimates of the sum of the rolling-window coefficients for the impact of OP on BP.

Clinton), lead OP to fluctuate slightly, the overall upward trend is unchanged. We can explain the rise in BP caused by OP in four ways. Firstly, the high OP may trigger inflation, reduce the real income of residents and the profit margins of companies, as well as the public confidence, especially in oil-importing countries (Salisu et al., 2017; Elfayoumi, 2018; Shahzad et al., 2019; Bildirici et al., 2019). Then, they are more willing to hold Bitcoin to avoid the risks of the high OP, which drives BP to increase. Secondly, the falling USDX not only causes OP to rise but also leads BP to increase due to its denomination in U.S. dollars. Thirdly, the geopolitical events in the Middle East increase OP, and also reduce the consumer confidence and investor sentiment. Then, they tend to store assets with hedging ability to reduce losses, increasing the demand for Bitcoin the price of which is already on an upward trend, and then BP increases (Ciaian et al., 2014; Bouri et al., 2017b; Wang et al., 2019; Mamun et al., 2020). Also, the Brexit and the U.S. presidential election bring uncertainty to the world (Davis, 2016), which further increases the demand for Bitcoin and BP. Fourthly, the rising trend of BP has attracted more investors to invest, especially in China, Japan and South Korea, further prompting BP to soar in 2017 (Li et al., 2018; Xiong et al., 2019). Thus, we can evidence that OP can positively affect BP during the period of 2016:M8–2017:M6.

However, the view that Bitcoin and oil are in the same boat cannot be supported by the negative influence of both variables on each other. There are three reasons to explain the rise in OP. Firstly, the Federal Reserve Board has signalled interest rate cuts, and the yen has experienced huge fluctuations against most G10⁷ and some emerging markets

⁷The G10 includes Belgium, Netherlands, Canada, Sweden, France, Switzerland, Germany, the U.K., Italy, the U.S. and Japan

(e.g., China) currencies. All of them lead investors to be more inclined to invest in another asset, such as the oil and its related products, which in turn drives OP to rise. Secondly, on December 1, 2018, China and the U.S. have negotiated that no additional tariffs would be imposed from January 1, 2019. As a result, the economy is expected to be improved, which leads to the demand for oil and OP to further increase (Hammou et al., 2010). Thirdly, due to the resolute implementation of production reduction agreements by major oil-producing countries, such as Saudi Arabia and Russia, oil supply has continued to decline, which causes OP to rise especially during the period of 2018:M12–2019:M1. Nevertheless, BP does not move in the same direction as OP to be helpful in avoiding the risks, and it can be explained from three aspects. To begin with, the Bitcoin bubble bursts in 2017, and since then BP decreases sharply (Li et al., 2018; Xiong et al., 2019). This burst is mainly caused by the massive sell-off of Bitcoin asset in Mt. Gox, a bitcoin exchange based in Japan, and the subsequent herd behaviour⁸ of investors, as well as government policy constraints (e.g., the U.S. Securities and Exchange Commission has hinted at strengthening supervision and crackdown on unregistered online digital asset trading platforms). Additionally, the economy was expected to be improved, as a result there was a positive reinforcement for public and countries to purchase more oil but which decreases the demand for Bitcoin to avoid the risks of trade policy uncertainty (Ciaian et al., 2014; Bouri et al., 2017b; Wang et al., 2019; Mamun et al., 2020). Furthermore, the rise in OP and the sharp decline in BP make the public less willing to hold Bitcoin, since it is not as valuable as oil and its related products. Hence, we can argue that these reasons provide sufficient justification for the negative influence from OP to BP during the period of 2018:M12–2019:M1.

Figs. 4 and 5 underline the bootstrap p -values and the orientation of the impacts from BP to OP. BP Granger causes OP during the periods of 2013:M12–2014:M1 at the 10% significance level. There is a negative effect from BP to OP, indicating that Bitcoin and oil are not in the same boat. After the outbreak of the Cyprus crisis, the public was in danger and they rushed to exchange their currencies for Bitcoin to avoid policy risks. Also, Bitcoin was increasingly recognized by investors around the world, especially after Germany officially admitted the legal and tax status of Bitcoin on August 19, 2013. Therefore we can say, the rising BP attracts more investors to invest in the Bitcoin market, which leads it to further increase during the periods of 2013:M12–2014:M1. The public also considers that Bitcoin has more investment prospects than oil, and they seem more willing to hold Bitcoin, which causes the oil demand and OP to decrease during this period. In addition, the U.S. government has appeared 16-days shutdown, due to the disputes of a short-term increase in the debt ceiling. Then, the whole of society has been brought to a high degree of uncertainty, which has continued to put downward pressure on OP. Therefore, the negative influence of BP on OP during the period of 2013:M12–2014:M1 can be evidenced.

To sum up, the results of the bootstrap full-sample Granger causality test suggest that OP Granger causes BP, but the opposite is not significantly established. However, this result may not be comprehensive as the parameters in the VAR system are supposed to be stable. The parameter stability tests prove that these two variables and the VAR system have sudden structural changes. Hence, in this paper, we apply the sub-sample test to explore the time-varying interrelationship between BP and OP. The empirical results evidence that there are both positive and negative influences from OP to BP. The positive effect indicates that Bitcoin can be viewed as an asset to avoid the risks of the high OP, also we can conclude that Bitcoin and oil are in the same boat since the value of Bitcoin will enhance if OP is high. However, this view cannot be supported by the negative effects. The burst of the bubble makes Bitcoin incapacitated to hedge the risks of the high OP, which

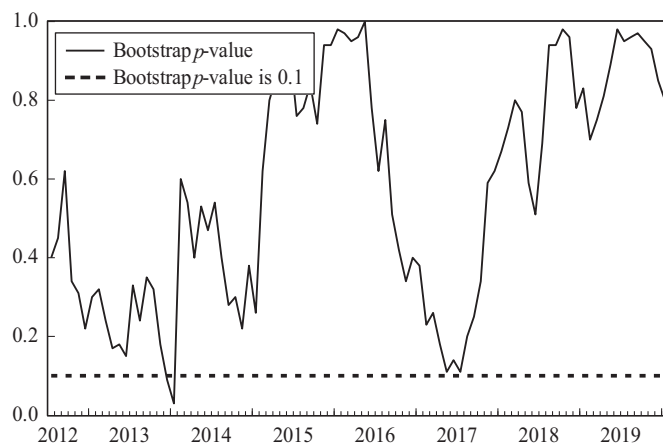


Fig. 4. Bootstrap p -values of rolling test statistic testing the null hypothesis that BP does not Granger cause OP.

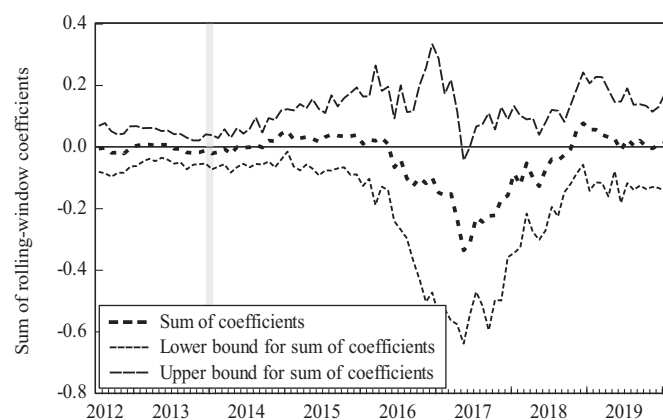


Fig. 5. Bootstrap estimates of the sum of the rolling-window coefficients for the impact of BP on OP.

also highlights that there is a negative effect from OP to BP. In turn, BP has a negative influence on OP, revealing that oil has fewer investment prospects than Bitcoin during the few periods, which also indicates that high BP may threaten the demand for oil to invest and also OP.

5. Conclusion

As one of the core factors of the Fourth Industrial Revolution, Bitcoin has certain interactions with the global economy (e.g., international energy market), which provides insights that could be useful for the development of the cryptocurrency market. With the continuous progress of blockchain, Internet of Things, cloud computing, big data, artificial intelligence and other technologies, the transformation of society has increased dramatically. Amongst all above mentioned technologies, cryptocurrencies have enormous potential to promote the reduction of international transaction fees and liquidity costs, and efficiently complete the movement of international wealth. Secondly, the improvement of the encryption technology and the reinforcement of the market supervision reduce the large fluctuations in the prices of cryptocurrencies, which makes them more acceptable to the public. Thereby, the view that Bitcoin can be considered as a hedging asset is becoming more reliable over time. Thirdly, Bitcoin is the first Internet-scale open platform for value exchange. With blockchain technology supporting a wide range of value exchanges, it will inevitably bring about an explosion of tradable assets and spawn a greater industry wave which in conjunction with many innovative forces could promote the progress of human society.

⁸ Herd behavior describes the herd mentality of economic individuals, that is, if Mt. Gox sells Bitcoin, other investors do the same.

This paper explores the Granger causality between the Bitcoin and oil markets, in order to evidence whether or not Bitcoin and oil are in the same boat. We perform the sub-sample test to investigate the mutual influence between BP and OP. The empirical results establish that there are both positive and negative influences from OP to BP. On the one hand, the positive effect indicates that Bitcoin can be considered as an asset to hedge the risks of the high OP, and we can also evidence that Bitcoin and oil are in the same boat. On the other hand, the negative influences are not consistent with this view particularly when we see the negative effect from OP to BP, which can be explained by the burst of the Bitcoin bubble that has weakened its hedging ability. In addition, OP can be negatively affected by BP, pointing out that Bitcoin has more investment prospects than oil during several periods, which also reveals that the demand for oil to invest can be threatened by the high OP. By analysing the time-varying interrelationship between BP and OP, we can conclude that Bitcoin and oil are in the same boat during certain periods, but this is not always the case.

Clarifying the demand for Bitcoin to avoid the risks of the fluctuations in the oil market and the transmission mechanism between BP and OP can give lessons to investors and governments. On the one hand, OP can affect BP during certain periods. Thus, investors can predict BP more accurately according to the fluctuations in OP and determine the amount to invest in the Bitcoin market. Also, they can consider Bitcoin as an asset in the portfolio, in order to diversify the risks and optimize their investment. More importantly, they should beware of the Bitcoin bubbles to avoid herd behaviour, reduce the losses and maintain their returns. The government can also grasp the trend of BP based on OP, in order to implement related policies to prevent the Bitcoin bubbles or the plunge in BP which may reduce the public confidence and hinder the economic stability. By this way, relevant authorities can promote the healthy growth of the Bitcoin market. On the other hand, the increase in BP may lead OP to fall during a few periods. Hence, investors should decide the amount to invest in the oil market by considering the changes in BP, then they can obtain the optimal proportion of the portfolio and make it more profitable, in order to maximize their revenues. In addition, oil-importing countries can grasp the trend of OP to increase or reduce the amount to import, then they can prevent inflation and minimize the costs. Others can avoid the overcapacity and maintain national wealth-income by adjusting production, especially for countries or regions where oil is the pillar industry (e.g., Russia, the Middle East). Also, the government is able to capture the fluctuations in the oil market, then, taking measures in advance to ensure the stable development of its energy system and national economy. In the future study, we will consider whether the Fourth Industrial Revolution can strengthen the hedging ability of Bitcoin. Also, the relationships between Bitcoin market and other energy or energy assets (e.g., natural gas and energy futures) should be taken into consideration.

Author statement

Chi Wei Su: Conceptualization, Methodology, Software Meng Qin.: Data curation, Writing- Original draft preparation. Ran Tao: Visualization, Investigation. Muhammad Umar: Writing, Reviewing and Editing

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