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COULD "DIGITAL GOLD" RESIST GLOBAL SUPPLY CHAIN PRESSURE?

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Abstract. Exploring the safe-haven characteristics of bitcoin from novel perspectives is crucial to diversify the investment and reap the benefits. This investigation employs bootstrap full-and sub-sample techniques to probe time-varying interrelation between global supply chain pressure (GSCP) and bitcoin price (BP), and further answer if "digital gold" could resist the strains of global supply chain. The empirical outcomes suggest that GSCP positively and negatively affects BP. The positive influence points out that high GSCP might boost the international bitcoin market, driving BP to rise, which indicates that "digital gold" could resist the pressures of global supply chain. But the negative effect of GSCP on BP could not support the above view, mainly affected by the weak purchasing power and more valuable assets, which is not consistent with the assumption of the inter-temporal capital asset pricing model (ICAPM). In turn, GSCP is adversely affected by BP, highlighting that the international bitcoin market may be viewed as a stress reliever for the global supply chain. Against a backdrop of the deteriorative Russia-Ukraine war and the intensifying global supply chain crisis, the above conclusions could bring significative lessons to the public, enterprises and related economies.

Keywords: global supply chain, bitcoin price, digital gold, Granger causal relation, sub-sample.

JEL Classification: C32, F15, G12.

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Introduction

The exploration purposes to investigate the interrelation between global supply chain pressure (GSCP) and bitcoin price (BP), and further probe whether the strains of global supply chain boost the international bitcoin market and if "digital gold" could resist these stresses. Bitcoin is the first distributed virtual currency put forward by Satoshi Nakamoto on November 1, 2008, which possesses the "decentralization" feature that guarantees its security and freedom (Nakamoto, 2008; Qin et al., 2022a). On January 5, 2009, bitcoin, which is not controlled by any financial institution, was officially born, and it has entered the public view as a new concept of digital currency (Elwell et al., 2013). After that, bitcoin has presented an outstanding performance, not only with high returns, but also as a hedge or safe haven which is similar to gold, thus bitcoin is also known as "digital gold" (Bouri & Gupta, 2019; Su et al.,

2020d; Chkili et al., 2021; Yang et al., 2022; Zhu et al., 2022). As the economic globalisation becomes an irreversible trend (Blanton & Apodaca, 2007), the global supply chain is evolving correspondingly (Ekinci et al., 2022; Feng et al., 2022). The global supply chain refers to the extension of the supply chain system to the whole world, which is characterised by complexity and vulnerability, that is, each node is a "vulnerable point", the collapse of one country's supply could disrupt the global supply system (Golan et al., 2020; Bonadio et al., 2021; Jomthanachai et al., 2022). If there are risks or uncertainties caused by the disruptions of global supply chain, the pessimism about the economic prospect intensifies. Then, the demand for hedging assets or safe heavens (e.g., the international bitcoin market) increases accordingly, driving the price of relevant assets (e.g., BP) to rise (Su et al., 2020c). Additionally, high GSCP tends to cause supply shortages, which inevitably lead to an inflation crisis (Jomthanachai et al., 2022). Since bitcoin could serve as a hedge against inflation risks, causing its demand and price to increase (Su et al., 2020b; Choi & Shin, 2022). Besides, in response to high GSCP and its potential risks or uncertainties, countries or regions may adjust their economic policies, which further disturbs the international bitcoin market (Qin et al., 2021), such as BP surges as the Federal Reserve cuts interest rates (Dyhrberg, 2016; Qin et al., 2022a). Hence, "digital gold" may resist the pressures of global supply chain in some cases, which has not been discussed in the previous studies.

However, some observations are quite different from the above phenomenon. On the one hand, the collapse of bitcoin bubbles makes BP plunge, despite the high GSCP. For instance, the global trade war (particularly the disputes between China and the U.S.) makes GSCP rise obviously (Blessley & Mudambi, 2022; Feng et al., 2022), but BP dramatically declines from 12953.93 dollars in January 2018 to 3713.89 dollars in December 2018, which decreases by 70% due to the bitcoin bubble burst (Li et al., 2019; Qin et al., 2021). On the other hand, during the periods with high GSCP, if the value of other assets is higher than bitcoin, its demand and price might fall. For example, the Russia-Ukraine war in 2022 makes GSCP at a relatively high level (Adekoya et al., 2022; Qin et al., 2022b), while BP plummets due to the significant reduction in the investment value of bitcoin compared to government bonds (e.g., the Federal Reserve has raised interest rates six times in 2022). Conversely, bitcoin has been recognized as a legal currency in several countries (e.g., the U.S., Japan and Germany), thereafter, the fluctuations of its price may reflect the economic (including the supply chains) situation (Su et al., 2020b, 2020c). Thereupon, the international bitcoin market can be viewed as an indicative factor to grasp GSCP more comprehensively. In addition, people might abandon cash and hold bitcoin in times of the economic crisis (accompanied by high GSCP), such as the Venezuelan economic crisis and the Cyprus debt crisis (Luther & Salter, 2017; Qin et al., 2021), which not only helps to avoid risks, but also contributes to resolving the crises. Accordingly, the Infiniti Research has released a report that proclaims bitcoin as an efficient alternative currency in the country or region with unstable economy. Therefore, the international bitcoin market is closely related to the global supply chain, which is important and meaningful but has not been thoroughly dissected in existing efforts. This exploration could not only assist investors in avoiding potential risks or uncertainties caused by the disruptions of global supply chain, but also help relevant economies to stabilize the bitcoin market and the global supply chain.

Moreover, the time-varying interrelation between GSCP and BP is ignored, thereby, this paper tries to fill these gaps.

This exploration could be classified into the literature on bitcoin investment and global supply chain, as well as relates to studies on the hedging ability during the period with high GSCP. There are several innovations in this exploration. To begin with, the existing efforts lay particular emphasis on investigating the hedging property of bitcoin from perspectives of geopolitical risks (Su et al., 2020c), economic policy uncertainties (Wang et al., 2019; Qin et al., 2021), inflation (Choi & Shin, 2022), stock market (Chkili et al., 2021; Baur et al., 2022), international oil market (Su et al., 2020b), currencies (Yang et al., 2022), etc. However, no study has discussed the international bitcoin market from the global supply chain perspective. Thus, this exploration is a groundbreaking effort to probe the interrelation between GSCP and BP, and further investigates if the strains of global supply chain boost the international bitcoin market and whether "digital gold" could resist these stresses. Secondly, the previous studies of the global supply chain primarily concentrate on qualitative research (Golan et al., 2020; Bonadio et al., 2021; Jomthanachai et al., 2022), which can not provide objective empirical evidences. Hence, we choose the global supply chain pressure (GSCP) index, developed by the Applied Macroeconomics and Econometrics Center (AMEC) in the Federal Reserve Bank of New York (Benigno et al., 2022), to analyze quantitatively, which is innovative in previous studies. By identifying the interrelation between GSCP and BP (covering the period of 2010:M07 to 2022:M10), we find that GSCP has positive and adverse influences to BP. The positive influence indicates that high GSCP may stimulate the international bitcoin market, and "digital gold" could resist the stains of global supply chain. However, the negative influence could not support this view, which could be explained by the weak purchasing power and more attractive assets. The negative influence is not consistent with the supposition of the ICAPM, stating that the rise in GSCP could drive BP to increase. Conversely, GSCP is adversely affected by BP, revealing the modest rise in BP may mitigate the risks of global supply chain disruptions. After that, we can offer insightful inspirations from these conclusions: The public and enterprises can view bitcoin as a hedging asset or part of the portfolio to avert possible risks caused by high GSCP. Also, they must take other assets' value and people's purchasing power into account while investing in the bitcoin market, as well as be wary of bitcoin bubbles. Besides, the public should purchase needed merchandise or seek alternatives to avert additional expenses, and the enterprises ought to diversify suppliers to adequately cope with the shutdown or even bankruptcy crisis. Additionally, the relevant economies should take measures to prevent dramatic fluctuations, and stabilize the global supply chain by strengthening cooperation and opposing anti-globalization. Thirdly, the transmission mechanism between GSCP and BP might not be constant, which is ignored by existing efforts. Thereafter, this study performs the parameter stability techniques to evidence that the full-sample approach is inaccurate. Consequently, we apply the sub-sample approach (Su et al., 2020a, 2020b, 2020c, 2020d) to comprehensively capture the variational relation between GSCP and BP.

The structure of this investigation can be organised as follows: Section 1 reviews the relevant literature. Sections 2 and 3 elaborate on the theoretical and empirical models, respectively. The data is introduced in Section 4. Section 5 interprets the empirical outcomes. Finally, the summary and corresponding suggestions are given.

1. Literature review

Bitcoin's ability to hedge risks has drawn considerable attentions for a long time, but the previous studies have yielded entirely different views. Some scholars consider bitcoin as a hedging asset which could withstand risks and stresses. Kliber et al. (2019) believe that bitcoin is treated as a safe haven on stock markets in Venezuela and Bolivars, a diversifier in Japan and China, and a weak hedge in Sweden and Estonia. Urquhart and Zhang (2019) evidence that bitcoin could be viewed as an intraday hedge (e.g., the Swiss franc, the euro and the pound), diversifier (e.g., the Australian dollar, the Canadian dollar and the Japanese yen) and safe haven (e.g., the Canadian dollar, the Swiss franc and the pound) for certain currencies. Wang et al. (2019) suggest that bitcoin could be considered as a safe-haven or diversifier under the U.S. economic policy uncertainty shocks. Matkovskyy et al. (2020) state that bitcoin has the investment attractiveness since it could serve as a tool to avert risks caused by the U.S. economic policy uncertainty, and the shocks of U.S. and Japan economic policy are associated with a decline in bitcoin volatility. Umar et al. (2021) discover that bitcoin actually seems like a safe haven asset while the uncertainty (including partisan conflict and economic policy uncertainty) is on the rise. Wang et al. (2021) prove that bitcoin has a good property of hedging stock markets' risks, but investors ought to take its high volatility into account while investing in the international bitcoin market. Zhu et al. (2022) underline that the hedging ability of bitcoin against Corona Virus Disease 2019 (COVID-19)-related news sentiment risks is primarily reflected in the short-run scenario, but Yang et al. (2022) demonstrate that bitcoin provides better hedging capability in the long term.

However, some scholars do not support the above view. Bouri et al. (2017) suggest that bitcoin is a poor hedging asset, which is suitable for the diversification purpose only. Gozgor et al. (2019) find that the U.S. trade policy uncertainty significantly and negatively influences BP during the regime changes, that is higher uncertainties lead to lower BP. Wu et al. (2019) underline that bitcoin could not act as a strong hedge or safe-haven against economic policy uncertainties. Shaikh (2020) highlights that the U.S. and Japan economic policy uncertainties exert adverse effects to bitcoin returns, and uncertainties in the equity market are also adversely related with BP. Fasanya et al. (2021) argue that the relation between bitcoin and precious metal cannot serve as a hedge or safe haven against the U.S. economic policy uncertainty. Long et al. (2021) state that bitcoin is unable to act as a safe-haven under the shocks of different uncertainties, and investors are also cautious about it. Baur et al. (2022) reveal that bitcoin could not decrease risks when involved into a portfolio, which holds on the average and sub-samples (containing the period with the COVID-19). Hasan et al. (2022) ascertain that bitcoin is adversely affected by cryptocurrency policy uncertainty during the bearish and bullish markets, indicating its failure to serve as a hedge or safe-haven.

Further, others explain these different views that the hedging ability of bitcoin is not immutable. Chan et al. (2019) confirm that bitcoin is a powerful hedge for several stock indices under monthly returns, which is not shown with daily and weekly data. Su et al. (2020c) state that geopolitical risks exert positive influences on BP during several periods, while the negative effects at some points negate bitcoin's safe-haven status (also Su et al., 2020b, 2020d,

2021b). Chkili et al. (2021) indicate that adding bitcoin in a portfolio of Islamic stocks could decrease risks, whereas the hedging strategy involving bitcoin may trigger more costs during the COVID-19. Qin et al. (2021) suggest that there are positive and negative effects from global economic policy uncertainty to BP, indicating that bitcoin could not be considered as a hedge during several times. Choi and Shin (2022) highlight that bitcoin possesses an inflation-hedging property, but it is not a safe haven in financial uncertainty shocks. Qin et al. (2022a) point out that bitcoin could act as a hedge to avert risks caused by strained relations between China and the U.S., while this phenomenon is not held during the period with the bubble burst.

In brief, there are abundant studies explore the bitcoin's ability to avoid risks originated from geopolitical events, economic policy uncertainties, inflation, stock market fluctuations and so on. Still, no scholars probe it from the perspective of global supply chain, and answer if "digital gold" could resist the strains of the global supply chain. In addition, some studies prove that the hedging property of bitcoin is not immutable, but the changing interaction between GSCP and BP might be neglected, and this study attempts to fill these gaps. Thereupon, this exploration performs the more advanced bootstrap sub-sample method, in order to identify the variational influence from GSCP to BP, answering if the strains of global supply chain boost the international bitcoin market and whether "digital gold" could resist these stresses. Additionally, this study could analyze the character of international bitcoin market in the global supply chain by investigating changing effects of BP on GSCP.

2. Inter-Temporal Capital Asset Pricing Model

Through constructing the inter-temporal capital asset pricing model (ICAPM), which is developed by Cifarelli and Paladino (2010), the interrelation between GSCP and BP could be captured. There are two suppositions exist in the ICAPM: First, the international bitcoin market contains two groups, rational and feedback ones. The former determines the bitcoin demand on the basis of systemic risks, but the latter tracks the international bitcoin market through the previous BP. Second, systemic risks concerned by the rational group indicate the risks that could not be decreased or removed through altering the investment strategy, such as global supply chain disruptions. After that, this study applies GSCP to represent the systemic risk, and the rational group's demand for bitcoin is revealed as Eq. (1):

$$R_t = \frac{E_{t-1}(\mathrm{BP}_t) - \mathrm{BP}^f}{\mu(\mathrm{GSCP}_t)}, \tag{1}$$

where R_t is the share of bitcoin that rational investors demand. The value of $\mu(\mathrm{GSCP}_t)$ is positive, which is a monotonically increasing function of the system risk. $E_{t-1}(\mathrm{BP}_t)$ refers to the conditional expectation of BP. BP^f is the risk-free return of bitcoin. Supposing all the investors in the international bitcoin market are rational, then $R_t - 1$ and Eq. (1) could be rewritten as the CAPM introduced by Sharpe (1964). Eq. (2) shows the traditional CAPM, indicating that high GSCP would drive BP to increase:

$$E_{t-1}(\mathrm{BP}_t) = \mathrm{BP}^f + \mu(\mathrm{GSCP}_t). \tag{2}$$

Besides, there are also other investors in the international bitcoin market, which make decisions of current investment based on the previous BP. Thereupon, we ought to take the feedback group into account, the share of bitcoin demand (F_t) can be shown as Eq. (3):

$$F_t = \zeta \mathrm{BP}_{t-1}, \tag{3}$$

where $\zeta > 0$ reveals that the feedback group invests (or withdraws) in the international bitcoin market when BP raises (or declines) during the previous period. If rational and feedback ones are both exist in the international bitcoin market, we have $R_t + F_t = 1$ and Eq. (1) could be further expressed as follows:

$$E_{t-1}(\mathrm{BP}_t) = \mathrm{BP}^f + \mu(\mathrm{GSCP}_t) - \zeta\mu(\mathrm{GSCP}_t)\mathrm{BP}_{t-1}. \tag{4}$$

In Eq. (4), the coefficient of $\mu(\mathrm{GSCP}_t)$ is $1 - \zeta\mathrm{BP}_{t-1}$ and $\zeta\mathrm{BP}_{t-1} = F_t < 1$, that is GSCP still has positive influences on BP. Then, high GSCP leads to an increase in BP, and vice versa. For instance, the "double La Nina" and economic recovery in 2021 make the shortage of supply serious, causing GSCP to increase sharply. And during this time, global investors' panic and risk aversion prompt them to raise the demand for hedging or safe heaven (e.g., the international bitcoin market), driving GSCP to soar. Therefore, we can put forward an assumption from the above ICAPM, that is the strains in global supply chain stimulate the international bitcoin market, and "digital gold" could resist GSCP.

3. Empirical model

3.1. Bootstrap full-sample method

Although the traditional vector auto-regressive (VAR) approach could obtain the relation between variables, these time series and VAR system must obey the standard normal distribution (Su et al., 2021a). If this standard normal distribution is not conformed, the accuracy of estimated results in the VAR model cannot be guaranteed. In order to overcome this difficulty, Shukur and Mantalos (1997) develop the critical values of residual-based bootstrap (*RB*) method, which could be applied to the Granger causality test without the standard normal distributions. Also, this method is suitable for small samples (Qin et al., 2020a). After that, Shukur and Mantalos (2000) produce the likelihood ratio (*LR*) technique, making modifications by characteristics of power and size. Thereupon, this study performs the *RB*-based revised-*LR* approach to explore the Granger causal relation between GSCP and BP. Then, we construct the bivariate VAR (r) process as Eq. (5):

$$Z_t = \alpha_0 + \alpha_1 Z_{t-1} + \ldots\ldots + \alpha_r Z_{t-r} + \mu_t, \tag{5}$$

where r is chosen by Akaike Information Criterion (AIC) and Schwarz Criterion (SC), which are used to acquire the optimising lag order. In addition, we could represent Z as $Z_t = (\mathrm{GSCP}_t, \mathrm{BP}_t)'$, and Eq. (5) can be rewritten as follows:

$$\begin{bmatrix} \mathrm{GSCP}_t \\ \mathrm{BP}_t \end{bmatrix} = \begin{bmatrix} \alpha_{10} \\ \alpha_{20} \end{bmatrix} + \begin{bmatrix} \alpha_{11}(L) & \alpha_{12}(L) \\ \alpha_{21}(L) & \alpha_{22}(L) \end{bmatrix} \begin{bmatrix} \mathrm{GSCP}_t \\ \mathrm{BP}_t \end{bmatrix} + \begin{bmatrix} \mu_{1t} \\ \mu_{2t} \end{bmatrix}. \tag{6}$$

According to the VAR (*r*) process, the original assumption GSCP does not Granger cause of BP ($\alpha_{21,k} = 0$) could be evidenced. This assumption should be rejected while GSCP has certain influences on BP, and vice versa. By analogy, the inverse null hypothesis BP does not Granger cause GSCP ($\alpha_{12,k} = 0$) should be rejected if BP has significant impacts on GSCP.

3.2. Parameter stability tests

The above approach supposes that the parameters are fixed, but this supposition is not usually achieved in reality (Su et al., 2020a). Hence, performing this approach is not suitable if the parameters have structural mutations. In order to prove the robustness of estimations, this study employs the *Sup-F*, *Ave-F* and *Exp-F* approaches, introduced by Andrews (1993) and Andrews and Ploberger (1994). The first technique captures the structural mutations in each time series and the VAR (*r*) process. The latter two techniques recognize whether the parameters change gradually over time. Additionally, this study also employs the L_c statistics approach, developed by Nyblom (1989) and Hansen (1992), to evidence if the parameters obey the random walk. If the parameters possess structural changes, the Granger causal relation between GSCP and BP is not constant. Thereupon, we should apply more advanced sub-sample method to identify the time-varying interrelation between the variables.

3.3. Bootstrap sub-sample approach

This approach is introduced by Balcilar et al. (2010) to catch time-varying characteristics of the relation between variables, which splits the data into small ones on the basis of the rolling window width, and makes these sections scroll from stem to stern continually. But the selection of an appropriate rolling window width is not easy, since a small width might cause to the inaccurate estimations, while a large one may decrease the frequencies. To cope with the above difficulty, Pesaran and Timmermann (2005) state that this width should exceed or equal to 20 if the parameters in the VAR (*r*) process are variational. The specific procedure could be summarized as follows: Firstly, we suppose that the length of the time series is *M* and the rolling window width is *n*. Based on the selected width, the end of each small part is *n*, *n*+1,....., *M*. Secondly, through applying the *RB*-based revised-*LR* approach, each small one could acquire a Granger causal relation. Thirdly, through counting the *p*-values and *LR* statistics chronologically, the estimated outcomes of the sub-sample method could be captured. Moreover, the average values of enormous estimated results ($N_b^{-1}\sum_{k=1}^{r}\hat{\alpha}_{21,k}^{*}$ and $N_b^{-1}\sum_{k=1}^{r}\hat{\alpha}_{12,k}^{*}$) point out the effects of GSCP on BP and the influences of BP on GSCP. Besides, according to Balcilar et al. (2010), this study uses a 90% confidence interval with the corresponding lower (the 5th quantile of $\hat{\alpha}_{21,k}^{*}$ and $\hat{\alpha}_{12,k}^{*}$) and upper (the 95th quantile of $\hat{\alpha}_{21,k}^{*}$ and $\hat{\alpha}_{12,k}^{*}$) bounds.

4. Data

This study chooses the monthly time series of 2010:M07 to 2022:M10 to investigate the interrelation between the international bitcoin market and global supply chain, and further probe whether "digital gold" could resist global supply chain pressure. On July 11, 2010, the famous news website Slashdot has reported that the number of bitcoin users has increased rapidly. And five days later, its price has raised from 0.008 dollars to 0.08 dollars (a 10-fold increase), showing the first dramatic price fluctuation, which indicates the rise of new thing (bitcoin). On the 17th of the same month, the first bitcoin platform Mount Gox (Mt.Gox) has been launched. Since then, bitcoin is more convenient to trade and circulate, as well as attracts considerable investors around the world, its price has also fluctuated significantly. This paper employs bitcoin price in the U.S. dollar (BP), which can be obtained from Yahoo Finance Website, to reflect the international bitcoin market (Qin et al., 2021). Meanwhile, in 2010, the public health events (e.g., influenza A), extreme weathers (e.g., floods in Pakistan) and geopolitical risks (e.g., worsening situation on the Korean Peninsula) have disrupted the global supply chain. After that, there are enormous events that deteriorate the global supply chain, such as the Japan earthquake in March 2011, global trade wars from 2017, COVID-19 in 2020 and Russia-Ukraine war in 2022, and these events might also be closely related to the fluctuations in the international bitcoin market. In order to explore this relevance, we choose the global supply chain pressure (GSCP) index developed by the AMEC in the Federal Reserve Bank of New York, in order to represent the situation of global supply chain (Benigno et al., 2022). This index integrates some generally used metrics (e.g., the Baltic Dry Index, the Harpex Index and the airfreight cost indicator from the U.S. Bureau of Labor Statistics), as well as several supply chain related components (e.g., outputs, output prices and supplier delivery times) from Purchasing Managers Index surveys. The value of GSCP is greater than 0 reveals that the global supply chain is obviously strained, whereas a higher GSCP indicates more pressure, and vice versa. Thereafter, we can identify the interrelation between GSCP and BP, and further answer if "digital gold" could resist the disruptions of global supply chain. The trends of GSCP and BP are depicted in Figure 1.

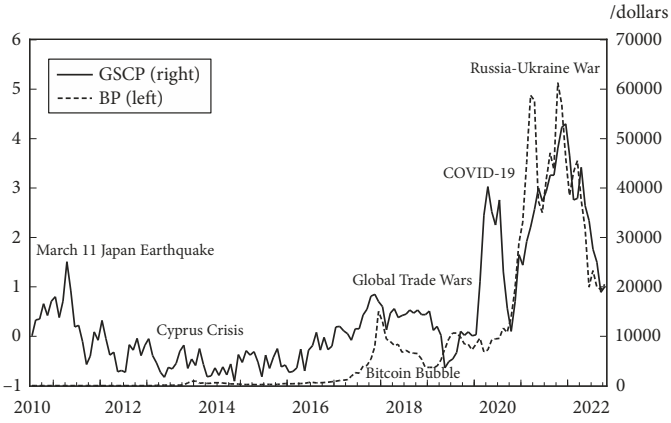

Figure 1. The trends of GSCP and BP
(source: authors' calculations)

From Figure 1, it could be perceived that BP is not always in the same direction as GSCP. In 2010, the public health events, extreme weathers and geopolitical risks have intensified GSCP, and BP has also experienced a dramatic rise during this time. The occurrence of Japan earthquake makes GSCP further increase from 0.71 in March 2011 to 1.51 in April 2011 (a more than 2-fold increase), and BP raises by 55% at the same period. As the negative impacts of this Japan earthquake on the global supply chain fade, both GSCP and BP fall obviously. However, this phenomenon could not be always observed. Although GSCP is relatively low at the end of 2013, BP shows an obvious upward trend (from 169.05 dollars in October 2013 to 935.46 dollars in January 2014, which grows by about 450%) caused by the Cyprus crisis. But after this crisis, BP has declined sharply, which is also accompanied by a low level of GSCP. Affected by the rebound in international oil price and global trade wars, GSCP presents a rising trend from -0.73 in January 2016 to 0.7 in December 2017. During the same period, BP also skyrockets from 410.94 dollars to 15034.53 dollars, showing a 36-fold increase. But the bubble burst in 2018, and BP has declined to 3713.89 dollars in December 2018, while GSCP is in a high range due to the global trade war (particularly the disputes between China and the U.S.). Even though GSCP and BP have increased in 2019, BP shows a downward trend in the first quarter of 2020, while GSCP has soared due to the outbreak of COVID-19. From the second quarter of 2020, BP has surged from 7224.48 dollars in April 2020 to 28949.4 dollars in December 2020 (a 4-fold increase), and GSCP is also in an upward trend. This phenomenon has also continued into 2021, but BP has fluctuated largely. The Russia-Ukraine war in 2022 disrupts the global supply chain severely, while BP shows an extreme downward trend. According to the above discussions, the interrelation between GSCP and BP is not constant but complex. The traditional full-sample method could not capture this complicated relationship between these two variables. Thereby, it is rational to perform the more advanced sub-sample technique, which could identify the time-varying correlation, and then the question of whether "digital gold" resists the pressure of global supply chain could be explored.

Table 1 suggests the descriptive statistics for GSCP and BP. The average of GSCP points out that this variable is concentrated on 0.435 level, indicating that the overall performance of the global supply chain in 2010–2022 is under pressure. Also, it could be found that BP is concentrated on 8478.943 level. The maximum and minimum of GSCP and BP are quite

Table 1. Descriptive statistics for GSCP and BP (source: authors' calculations)

	GSCP	BP
Observations	148	148
Mean	0.435	8478.943
Median	0.085	691.051
Maximum	4.300	61309.600
Minimum	–0.910	0.062
Standard Deviation	1.213	14507.210
Skewness	1.398	2.094
Kurtosis	4.135	6.463
Jarque-Bera	56.173***	182.096***

Note: ***denotes the significance at 1% level.

different, evidencing that these two time series (especially BP) are dramatically volatile. The skewness is positive in GSCP and BP, which reveals that these two variables conform the right-skewed distributions. The kurtosis of GSCP and BP is greater than 3, satisfying the leptokurtic distributions, which possess the features of higher peak and fat tail. In addition, the Jarque-Bera test proves that GSCP and BP could significantly reject the null hypothesis of standard normal distribution at a 1% level. Thereupon, applying the Granger causal relation test on the basis of the traditional VAR system is not reasonable; then, we should perform the *RB*-based revised-*LR* approach to solve this difficulty. Further, this study also employs the bootstrap sub-sample technique to identify the variational Granger causal relation between GSCP and BP. Besides, in order to avert the heteroscedasticity and unit roots, this study transforms BP through making the natural log and first order difference.

5. Empirical results and discussions

On the basis of Eq. (5), we construct the traditional VAR (*r*) system to conduct the bootstrap full-sample test, and then capture the interrelation between GSCP and BP. This study chooses the optimising lag order as 2 according to AIC and SC. The result of the bootstrap full-sample approach is shown in Table 2, the statistics and *p*-values suggest that GSCP is not a Granger cause of BP, and vice versa. This conclusion is inconsonant with the existing literature (Matkovskyy et al., 2020; Su et al., 2020b, 2020c; Qin et al., 2022a; Umar et al., 2021; Zhu et al., 2022; Yang et al., 2022), and the supposition of the ICAPM that states GSCP exerts positive influences on BP.

The above bootstrap full-sample method supposes the parameters are constant, and just a Granger causal relation could be obtained throughout the whole sample period (Balcilar & Ozdemir, 2013). However, when the variables and VAR (*r*) process have structural mutations, the result of full-sample approach is not robust, highlighting that the relation between GSCP and BP is not fixed (Qin et al., 2020a). After that, this study employs the *Sup-F*, *Ave-F* and *Exp-F*, as well as the L_c statistics techniques, in order to provide proofs for parameter stability. Table 3 shows the outcome of these four techniques.

From Table 3, the *Sup*-and *Exp-F* techniques point out that GSCP, BP and VAR (*r*) process could reject the null hypothesis at a 1% level, meaning that all of them have sudden structural mutations. The *Ave-F* technique underlines that GSCP and BP can reject the null hypothesis at 1% and 5% levels respectively, while the VAR (*r*) process could not significantly change over time. Also, the L_c statistics technique refers to that the alternative hypothesis can be accepted at a 1% level, evidencing that the VAR (*r*) process does not conform to the random walk process. Therefore, according to the above four techniques, it could be proved that GSCP has a time-varying relation with BP. Then, this investigation performs the sub-sample approach to capture this variational Granger causality between GSCP and BP. In order to improve the ro-

Table 2. The outcomes of bootstrap full-sample method (source: authors' calculations)

H_0: GSCP is not the Granger cause of BP		H_0: BP is not the Granger cause of GSCP	
Statistic	*p*-value	Statistic	*p*-value
2.745	0.220	0.523	0.790

Table 3. The outcomes of parameter stability methods (source: authors' calculations)

Tests	GSCP		BP		VAR process	
	Statistics	*p*-values	Statistics	*p*-values	Statistics	*p*-values
Sup-F	69.725***	0.000	44.735***	0.000	41.442***	0.000
Ave-F	12.540***	0.005	6.220**	0.046	11.719	0.248
Exp-F	30.230***	0.000	17.724***	0.000	16.083***	0.000
L_c					3.024***	0.010

Notes: This investigation calculates *p*-values through employing 10000 bootstrap repetitions.
** and *** denote the significance at 5% and 1% levels.

bustness of the estimated results, this study chooses the rolling window width as 24-months[1]. Thereupon, we can clarify whether the alternative hypothesis GSCP Granger causes BP (or BP Granger causes GSCP) could be significantly accepted or rejected. Besides, the positive or adverse influences from GSCP to BP (or the impacts from BP to GSCP) could be judged.

Figures 2 and 3 depict the *p*-values and coefficients of GSCP on BP. GSCP is a Granger cause of BP at a 10% level during the periods of 2012:M07-2013:M02, 2014:M10-2015:M04, 2016:M07-2016:M08, 2017:M06-2018:M01, 2020:M02-2020:M03, and 2022:M05-2022:M07. Also, both positive influences (2012:M07-2013:M02, 2014:M10-2015:M04, 2016:M07-2016:M08, and 2017:M06-2018:M01) and adverse effects (2020:M02-2020:M03 and 2022:M05-2022:M07) exist during the above six periods.

The positive influences from GSCP to BP could justify the supposition of the ICAPM, that is the disruptions of global supply chain may stimulate the international bitcoin market. In 2012:M07-2013:M02, the European sovereign debt crisis, the disputes between China and Japan over the Diaoyu islands, as well as the unstable situations in the Korean Peninsula, West Asia and North Africa (Su et al., 2021a) cause GSCP to present an upward trend. The positive effect of GSCP on BP can be interpreted from three ways. Firstly, high GSCP makes investors have pessimistic expectations about the future global economic situation, and they are more inclined to seek hedging assets or safe havens (e.g., the international bitcoin market) to avoid potential losses (Mamun et al., 2020). Then, their strong risk-aversion psychology leads to an increase in the bitcoin demand, driving BP to rise (Su et al., 2020c). Secondly, high GSCP is accompanied by an increase in international oil price (Aggarwal et al., 2012; Brown, 2017), which exceeds 100 dollars per barrel during this period. The rise in international oil price might trigger inflation, and then decrease the real income and profit margins (Wang et al., 2022). As a weapon against inflation (Su et al., 2020b; Choi & Shin, 2022), the bitcoin demand increases accordingly, which causes BP to raise. Thirdly, high GSCP could intensify the uncertainties of global economic policies, which further affects the international bitcoin market (Qin et al., 2021). For instance, in order to restore the economy (including deal with GSCP and its possible risks), the Federal Reserve has announced the fourth round of quantitative easing on December 12, 2012, which inevitably reduces the U.S. dollars' value. Since BP is priced in the U.S. dollars, the depreciation of the latter makes the former rise further

[1] To examine the stability, this investigation also employs the widths of 20-, 28-, 32-months to identify causality, and their results are coincident with this paper.

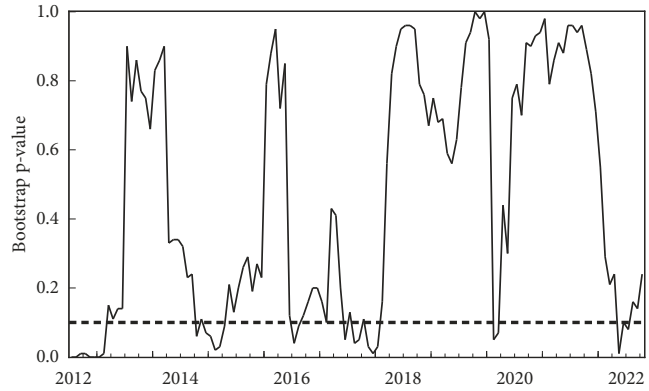

Figure 2. Examining the null hypothesis that GSCP does not Granger cause BP (source: authors' calculations)

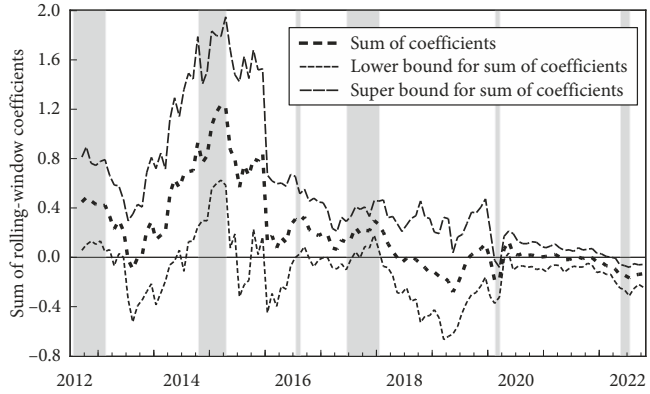

Figure 3. The coefficients of the influence from GSCP to BP (source: authors' calculations)

(Dyhrberg, 2016; Qin et al., 2022a). Thus, the positive effects of GSCP on BP during 2012:M07-2013:M02 could be evidenced.

Although the Russia-Ukraine conflict occurs in 2014 (Caldara & Iacoviello, 2017), it puts little threats to the global supply chain mainly due to the plunge in international oil price. Then, GSCP is at a relatively low level in 2014:M10-2015:M04, its positive effect on BP could be explained from several aspects. First, with GSCP weakening, investors hold optimistic expectations about the future global economic situation, making their risk aversion cool gradually (Mamun et al., 2020). Thereupon, there is a reduction in the need for hedging assets such as bitcoin, resulting in the decline in BP. Second, low GSCP is accompanied by a decline in international oil price, which decreases from 87.43 dollars per barrel in October 2014 to 59.52 dollars per barrel in April 2015, falling by more than 30%. After that, the bitcoin demand for hedging global inflation risks falls accordingly (Su et al., 2020b; Choi & Shin, 2022), also causing BP to decline. Third, the recovery of global economy, including the reduction of GSCP and its corresponding risks, has prompted the withdrawal of quantitative easing in the U.S.

(Beckmann et al., 2015; Qin et al., 2020b). Thereafter, the strength of it leads BP to plummet (Dyhrberg, 2016; Su et al., 2020d; Qin et al., 2022a). In addition, bitcoin policies (e.g., China has issued a "Notice on Preventing Bitcoin Risks") and technical issues (e.g., Mt.Gox has suspended bitcoin withdrawals due to technical reason) make it less attractive to investors, further lowering its demand and price. Thereby, it could be proved that GSCP exerts a positive impact on BP during 2014:M10–2015:M04.

Affected by the extreme climates (e.g., the El Nino event causes to infrastructure damages and labour force shortages in production and transportation fields), geopolitical risks (e.g., the deployment of the Terminal High Altitude Area Defense in South Korea has been boycotted by several countries) and uncertain events (e.g., Brexit has accelerated the reorganization of supply chains), GSCP has risen from –0.19 in July 2016 to 0.08 in August 2016. Then, we could illustrate the transmission mechanism of GSCP on BP from two sides. On the one hand, the rise of GSCP makes the global supply chain experience a restructuring trend, and then relevant enterprises may face difficulties such as the weakening of production and transportation capacity or the lack of raw materials (Nagurney, 2021; Cedillo-Campos et al., 2022). In order to avoid potential costs caused by high GSCP, these enterprises may be more inclined to increase the investment in hedging assets (e.g., bitcoin which gradually gains more acceptances), giving bitcoin demand and BP an upward momentum (Qin et al., 2022a). On the other hand, the rise of GSCP has raised public concerns about the future global economic environment. For instance, high GSCP leads to supply shortage (Jomthanachai et al., 2022), which increases the prices of related products, inevitably bringing the inflation risks. Then, the public tends to hold relatively safe assets (e.g., bitcoin whose price is rising) to avert potential losses or risks, which further boosts the international bitcoin market (Qin et al., 2021; Choi & Shin, 2022). Hence, we could verify that there exists a positive influence of GSCP on BP during 2016:M07–2016:M08.

In 2017:M06-2018:M01, the average of monthly GSCP has risen to 0.53, the primary reason behind this phenomenon is the anti-globalization waves mainly caused by the U.S. (e.g., the Trump administration withdraws from the Trans-Pacific Partnership and the Paris Agreement, and imposes severe economic sanctions on Russia). At the same time, BP shows a surge from 2632.68 dollars in June 2017 to 12953.93 dollars in January 2018, which grows by nearly 400%, and the underlying causes of this positive influence from GSCP to BP could be clarified as follows: Firstly, high GSCP might result in the bankruptcy of related enterprises and even economic recession (Jomthanachai et al., 2022), leading to a decline in investor confidence and sentiment. Then, people are more willing to view the international bitcoin market as a safe haven to reduce potential losses, which increases the bitcoin demand and BP (Su et al., 2020c; Qin et al., 2022a). Secondly, in the context of high GSCP, the "herd effect" makes more people (mainly concentrating in South Korea, China and Japan) invest in bitcoin, and they are not panicking about the future global economic situation, but simply the conformity (Xiong et al., 2019; Qin et al., 2021). After that, there is a dramatic increase in bitcoin demand (especially in Asia), driving BP to skyrocket. Thirdly, high GSCP leads to short supply of some commodities, which inevitably makes their prices increase. For instance, international oil price has increased from 46.37 dollars per barrel in June 2017 to 69.08 dollars per barrel in January 2018, which grows by about 50%. Then, the global inflationary pressures could be exacer-

bated by high GSCP, which spurs the international bitcoin market to fight inflation (Su et al., 2020b; Choi & Shin, 2022). Therefore, we can provide proof that BP is positively affected by GSCP during the period of 2017:M06–2018:M01.

However, the above view that "digital gold" could resist the deterioration of global supply chain can not be sustained by the adverse effects from GSCP to BP. In 2020:M02-2020:M03, the COVID-19 has broken out worldwide, considerably weakening the global production and transportation capacity (Bonadio et al., 2021; Jomthanachai et al., 2022), making GSCP soar to 2.45 in March 2020. The disruption of global supply chain should have provided a boost to the international bitcoin market, but BP has fallen from 9630.72 dollars in February 2020 to 6871.02 dollars in March 2020, which decreases by nearly 30% in just one month. The main causes behind this phenomenon could be elucidated from two perspectives. On the one hand, at the beginning of COVID-19, countries or regions are less able to cope with this epidemic and its corresponding consequences (e.g., high GSCP) effectively, causing to a severe recession in their economies (Pirtea et al., 2021; Cristea et al., 2022; Ekinci et al., 2022; Gamal et al., 2022). Then, people's income and purchasing power have also reduced significantly, which leads to a decline in the investment demand for bitcoin. On the other hand, in response to the COVID-19 and its relevant consequences (e.g., high GSCP), several countries or regions (e.g., the U.S., Germany and the United Kingdom) have adopted a "zero interest rate" policy (Yilmazkuday, 2022). But investors anticipate that the interest rate hike is inevitable (e.g., the Federal Reserve's interest rate hike plan), then they reduce their holdings of bitcoin whose investment value becomes less attractive, further causing BP to decline. Consequently, the adverse influence from GSCP to BP during 2020:M02–2020:M03 can be confirmed.

During the Russia-Ukraine war in 2022, the U.S. and European Union have repeatedly launched sanctions on Russia, the latter has also implemented counter-sanctions (Adekoya et al., 2022; Qin et al., 2022b). Then, this geopolitical event considerably hampers the global supply, especially in energy (Russia is the major producer and exporter of crude oil and natural gas) and agricultural products (Ukraine is the largest producer of sunflower seeds, and Russia is the largest wheat exporter), resulting in a high level of GSCP (the average of monthly GSCP is 2.25). But BP shows a dramatic downward trend (from 31793.4 dollars in May 2022 to 23303.4 dollars in July 2022), the primary reason is that the significant reduction in the investment value of bitcoin leads to a massive sell-off. As some countries or regions gradually raise interest rates to combat inflation (e.g., the Federal Reserve has raised interest rates in May, June and July respectively), the value of government bonds increases accordingly. Thereupon, investors (especially large institutions) are more willing to park their funds in the government bonds rather than bitcoin, which causes BP to decline even if GSCP is in a relatively high range. As a result, we can certificate that BP is adversely affected by GSCP during the period of 2022:M05–2022:M07. These negative outcomes are not coincident with the ICAPM, assuming that high GSCP could boost the international bitcoin market.

The *p*-values and coefficients of BP on GSCP are depicted in Figures 4 and 5. BP significantly Granger causes GSCP at a 10% level during the period of 2013:M11–2013:M12. Also, only an adverse influence exists from BP to GSCP during this period.

In 2013, the Cyprus debt crisis has prompted the public to convert part of their money into the bitcoin market, in order to avoid risks of tax policy changes (Qin et al., 2021). The

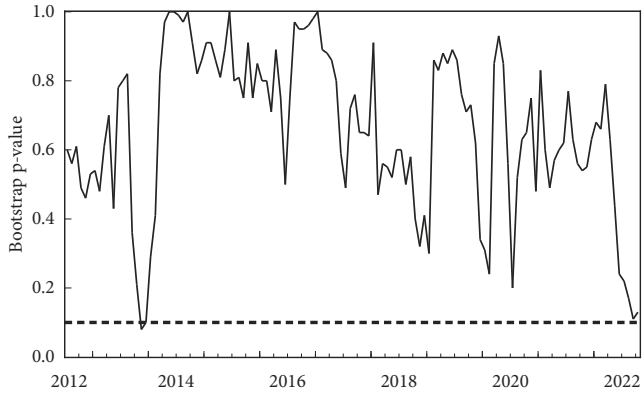

Figure 4. Examining the null hypothesis that BP does not Granger cause GSCP (source: authors' calculations)

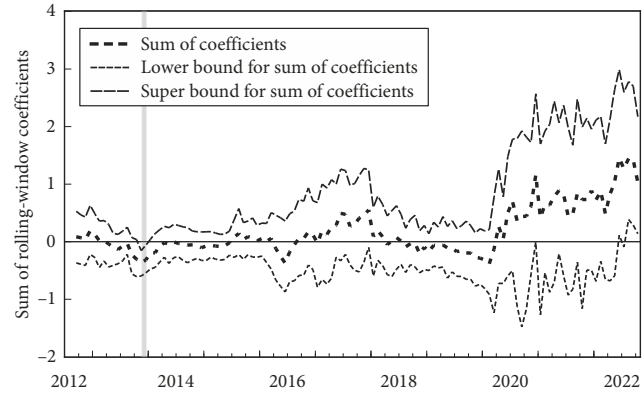

Figure 5. The coefficients of the influence from BP to GSCP (source: authors' calculations)

U.S. has legalized bitcoin the same year, that is bitcoin is legal as long as sellers of goods or services are willing to accept it and use it as a form of payment, which further increases the number of investors in the international bitcoin market. Then, BP has risen from 169.05 dollars in October 2013 to 840.25 dollars in December 2013, which grows by nearly 400% in just two months. BP's negative influence on GSCP can be interpreted as follows: With the growth of BP, the public gains more profits if they hold less cash and more bitcoin during the periods with crisis or uncertainty (Xiong et al., 2019), which helps to revive the economy and thus reduce the risks of supply chain disruption. Moreover, bitcoin's legal status provides a new payment option and facilitates the commodity circulation, further easing GSCP. As a consequence, BP exerts an adverse effect on GSCP during the period of 2013:M11–2013:M12 could be certificated.

All in all, the empirical outcomes of the full-sample method suggest that GSCP has no significant effect on BP, and BP is not a Granger cause of GSCP. But these results are not robust when the parameters are not unchanging. After that, this study performs the pa-

rameter stability techniques, evidencing that there are structural mutations exist in GSCP, BP and the VAR (*r*) process. Thus, this exploration performs the sub-sample approach to capture changing interrelation between the time series. The empirical outcomes of the bootstrap sub-sample approach reveal that positive and adverse effects of GSCP on BP exist. The positive effects point out high GSCP might raise the hedging demand and then boost the international bitcoin market, indicating that "digital gold" could resist the pressures of global supply chain. However, the above view can not be supported by adverse influences. Although GSCP increases significantly, BP is at a low level or even plummets due to the weakening of purchasing power and greater value of other assets (e.g., government bonds), which is not consistent with the supposition of the ICAPM. In turn, GSCP could be adversely affected by BP, underlining that the modest increase in BP may reduce the risks of supply chain disruptions, and the international bitcoin market might be considered as a tool to stabilize the global supply chain.

Conclusions and policy implications

This investigation probes the conduction mechanism between the global supply chain and the international bitcoin market. We perform the bootstrap full-and sub-sample techniques to explore the interactions between GSCP and BP. Firstly, the outcomes point out that GSCP exerts positive and adverse influences on BP. The positive effects suggest that high GSCP could boost the international bitcoin market, and "digital gold" can resist the strains of global supply chain. However, the adverse effects could not support the above view, high GSCP with low BP is mainly due to the weak purchasing power and more attractive assets such as government bonds. Secondly, these negative influences are inconsistent with the ICAPM, supposing that high pressures of global supply chain could boost the international bitcoin market. Thirdly, BP exerts a negative effect on GSCP, which indicates that a modest rise in BP may decrease the risks of supply chain disruptions, and the international bitcoin market may be used to stabilize the global supply chain. Through investigating the time-varying interrelation between GSCP and BP, it could be concluded that "digital gold" could resist global supply chain pressure during several time periods, but this phenomenon does not hold during the COVID-19 and the Russia-Ukraine war.

According to the above conclusions, meaningful insights could be provided for the public, enterprises and relevant economies under the background of an intensifying global supply chain crisis. Firstly, GSCP exerts a positive influence on BP during several periods. The public could predict the changes in the international bitcoin market according to the pressures of global supply chain. If the pressures increase, they can view bitcoin as a hedging asset or part of the portfolio to avert possible losses and risks (e.g., inflation and uncertainties). The enterprises can forecast bitcoin price on the basis of the situation of global supply chain. When the global supply chain experiences a restructuring trend, they may consider the international bitcoin market, in order to avoid potentially high costs or even bankruptcy caused by several difficulties such as the weak production and transportation capacity or the lack of raw materials. Secondly, GSCP also has a negative impact on BP during several times. The public and enterprises should take the value of other assets and the purchasing power of society

into account while investing in the international bitcoin market. Also, they must be wary of bitcoin bubbles to prevent huge losses from the bursting of these bubbles. The relevant economies ought to take measures (e.g., innovate encryption technologies and reinforce supervision) in advance to prevent wild swings in the bitcoin market, in order to ease panic and boost confidence. Thirdly, GSCP could be negatively affected by BP. The public can judge the situation of global supply chain by the international bitcoin market, and then purchase needed merchandise or seek alternatives, in order to avert the inconveniences or additional expenses due to possible inflation or other uncertainties. The enterprises could also analyze the global supply chain from the international bitcoin market, and then diversify suppliers and enhance the steady and flexible supply of important raw materials, to adequately cope with the shutdown or even bankruptcy crisis brought by the supply chain restructuring. The relevant economies should strengthen cooperation and oppose anti-globalization wave, in order to safeguard global supply chain stability and facilitate world economic recovery. In the future researches, we would probe which asset (e.g., bitcoin, gold, currencies) or portfolio is the best safe haven during the intensifying global supply chain crisis. Besides, whether the conclusions have withstood the short-term test of time should be further investigated.

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