

Nvidia and Bitcoin Linkage Study—Based on DCC-GARCH Model

Siyu Yang^{1,a,*}, Kun Liu^{1,b}

¹*School of Mathematics and Physics, Xi'an Jiaotong-liverpool University, Suzhou, China*

^a*Siyu.Yang2202@xjtlu.student.edu.cn*, ^b*Kun.Liu22@xjtlu.student.edu.cn*

^{*}*Corresponding author*

Keywords: Bitcoin, Nvidia, DCC – GARCH, Stock Market

Abstract: This article quantifies the correlation between Bitcoin and NVIDIA using the DCC-GARCH model during the period of 2020-2023. We analyzed data from investing.com for this research. Bitcoin is a cryptocurrency based on blockchain technology, which involves mining by solving complex cryptographic puzzles. Mining refers to the process of verifying and recording Bitcoin transactions through computation, and acquiring newly generated Bitcoins as a contribution to network security and the distributed consensus mechanism. Therefore, it is important to understand the correlation between Bitcoin and graphics cards, especially with the expansion of the virtual currency market. Determining the correlation between Bitcoin mining and graphics cards can help miners optimize their hardware choices, investors better understand market potential, and manufacturers produce and develop graphics cards according to market demand. Due to the high computational requirements of Bitcoin mining, traditional central processing units (CPUs) are not well-suited for this task. On the other hand, graphics cards (graphics processing units, GPUs) have become the preferred hardware for Bitcoin mining due to their highly parallel computing capabilities. Consequently, we hypothesize the existence of a correlation between Bitcoin and graphics cards, which is further validated in subsequent sections.

1. Introduction

Trade cannot do without records. Records can make trade more honest, efficient, and standardized. Centralization is advocated to promote communication, integrate resources, and create more business opportunities. For example, in ancient Mesopotamia, cities such as Babylon and Nineveh became one of the most prosperous trading centers in the world at that time. Similarly, the Nile Valley in ancient Egypt and Athens in ancient Greece were also important trading centers. In ancient China, the Silk Road was a crucial trade route connecting the East and the West. This trade route spanned across China, Central Asia, India, and Europe, promoting the exchange of goods, technology, and culture. Trade centers along the Silk Road included Chang'an (now Xi'an), Samarkand, Baghdad, Damascus, and Rome. Going back to the Industrial Revolution, cities like London, Manchester, and Birmingham in Britain became important industrial and trade centers. Centralized accounting systems like these became mainstream due to their unified standards and rules.

However, centralized accounting systems are not perfect. They rely on centralized institutions or

individuals. If these centralized entities experience failures, attacks, or improper behavior, it may lead to the loss, tampering, or unreliability of accounting data. Additionally, centralized accounting systems require trust in the centralized institution or individual from the participants. If the reputation or sense of responsibility of the centralized entity is damaged, it may raise doubts about the authenticity and reliability of the accounts. Centralized accounting systems store large amounts of account and transaction information involving sensitive data of individuals and businesses. If the centralized institution or individual fails to protect the privacy and security of this data, it may face risks of data leaks, misuse, and infringement.

Since the dissolution of the Bretton Woods system, central banks around the world have adopted loose monetary policies to stimulate economic growth. The excessive issuance of currency is bound to lead to serious inflation and currency credit crises. In the past decade, global currencies have depreciated by 47%. It is under this backdrop that people began to seek "alternative currencies". In 2009, an anonymous netizen named Satoshi Nakamoto proposed the concept of Bitcoin online, and Bitcoin was born.

So, the decentralized accounting system emerged, which transparently records the transactions of several individuals and packages them as a "whole." Each packaged region is called a "block," and when connected, they form a blockchain. This system not only avoids the risk of single point failures but also enhances security due to features like information transparency. In contrast to traditional centralized adjustment methods, such as printing large amounts of currency, which indirectly diminishes the weight of currency owners' "accounts," decentralization can prevent issues like inflation. To incentivize the packaging process as a new requirement, virtual currencies, such as Bitcoin, emerged after traditional currencies could no longer fulfill this role. The production of Bitcoin follows the rules of peer-to-peer networks and relies on an automatically adjusting algorithm that releases 50 Bitcoins every 10 minutes, gradually halving the amount. By the year 2140, it will be capped at 21 million Bitcoins, providing assurance for its value (Xianyu Chen, 2013). Cryptocurrencies like Bitcoin, as represented by digital assets, offer companies a new method of managing cash face values. Globally, 49,000 public companies hold Bitcoin as a form of investment, constituting approximately 2-3% of its total market value, equivalent to around 1.95 billion US dollars (Wu Xinyin, 2022).

As a result, the individuals involved in packaging also undergo selection, which is known as computational power detection or mining. Due to intense competition in mining, specialized hardware designed for this purpose started to emerge. Initially, graphics processing units (GPUs) were widely used in mining due to their good performance in parallel computing. However, over time, application-specific integrated circuit (ASIC) chips specifically optimized for mining became mainstream. ASIC chips are designed specifically for certain hash algorithms, offering higher performance and power efficiency. Meanwhile, with the widespread adoption of Bitcoin and other cryptocurrencies, the energy consumption required for mining has been widely discussed. The devices used to power the mining process require a significant amount of electricity, which in certain regions can lead to energy waste and environmental issues. Therefore, new consensus mechanisms and mining algorithms have been proposed to reduce energy consumption and make mining more sustainable.

Today, NVIDIA is not only the "emperor" of graphics processing in the computing world but also the global leader in parallel computing. It leads the way in the era of artificial intelligence and metaverse. Currently, NVIDIA's core businesses include gaming, data centers, professional visualization, and automotive, with its revenue reaching \$26.9 billion in the fiscal year 2022. More important than revenue is its dominance in each field (Wen Shangtao, 2022). Studying the relationship between NVIDIA and Bitcoin can help us better understand market trends and dynamics. Additionally, the Bitcoin market exhibits high volatility and uncertainty, so researching the relationship between NVIDIA and Bitcoin can provide some references for risk management.

2. Literature Review

Researchers have conducted various studies on Bitcoin as it continues to develop.

XU Youjun (2010) provided a new perspective for our research by establishing the correlation between Bitcoin and Nvidia's stock price using the DCC-GARCH model[1]. Then Yonghui Zhai, Fei Zhao (2019) used the GARCH model to primarily study the risk level of the Bitcoin market[2]. Their findings indicate that Bitcoin's development reflects people's fear of inflation and that countries worldwide need to restore confidence in their currencies. Governments should also address the issues associated with Bitcoin to better promote global economic development.

SHI Yilei (2020) studied the price fluctuations of Bitcoin by comparing events related to Bitcoin in China and the United States[3]. The research indicates that the Bitcoin market will tend to stabilize in the long term and is worth investing in. The profitability of Bitcoin mostly occurs within the same day, without significant lag. It also suggests that short-term investors should observe the market closely.

Thao Phan Thi Dieu LE, Hieu Luong Minh TRAN(2021) applied the Dcc-Garch model to analyze the correlation between the Vietnamese and Philippine markets during the COVID-19 pandemic and the financial crisis[4]. This study provides a good example for our research.

Wu Xinyu, Wang Xiaona (2022) researched the impact of Bitcoin on the Chinese stock market. They found a significant positive correlation between Bitcoin and the Chinese stock market over a long period of time[5]. Then Wu Xinyun (2022) discovered that the Bitcoin market carries risks, and its volatility needs to be taken into consideration when investing. However, the existence of cryptocurrencies is affirmed, leading to the possibility of future legal cryptocurrencies[6].

Zhong Jiahao (2022) found that as the awareness of Bitcoin grows, its price tends to increase. Additionally, the price of futures also rises accordingly[7]. With the development of internet users, the price of Bitcoin is expected to continue to rise. The study also suggests that Bitcoin can be considered as an alternative to gold futures in terms of decentralization.

Zhang Siyu(2022) provides a detailed analysis of the characteristics of virtual currency through the study of Bitcoin and BitTorrent, and conducts an analysis and research on its application potential in conjunction with the application scenarios of blockchain technology[8]. Then Huang Sa(2023) describe the internal logic of virtual currencies such as Bitcoin through an example of a couple engaged in money laundering[9].

Ye Yuning(2023) takes Bitcoin as a representative of digital currencies and explores the differences between them from the perspectives of qualitative analysis and quantitative analysis. It is evident that the existence of Bitcoin cannot be ignored, and it plays a role in today's economy. This study uses the DCC-GARCH model to explore the correlation between the price fluctuations of Nvidia's stock, the production tool for Bitcoin, and the price of Bitcoin itself[10].

3. Method

(1) Sample Data: This study selects stock prices of NVIDIA and the market price of Bitcoin as sample data. The sample data is obtained from Yingying's financial website <http://investing.com/>. Due to the differences in holidays and trading suspensions in different countries' securities markets, there are slight differences in trading days. Therefore, following the approach of Hamao et al. in 1990, we delete trading data that does not overlap with several non-overlapping trading days to obtain a sample size of 666. This study uses EXCEL for data processing and analysis.

Before estimating the parameters of the DCC-GARCH model, it is necessary to test the heteroscedasticity of the data, as well as perform tests for serial correlation and stationarity.

(2) Heteroscedasticity and Serial Correlation Tests:

Upon examination of the price series of both assets, it can be observed that each price series has several abnormal peaks, indicating that the volatility of the returns exhibits suddenness and significance. Moreover, the abnormal volatility in the series exhibits significant clustering phenomena. To some extent, this indicates that the volatility of the return series in each market exhibits conditional heteroscedasticity, and the disturbances in these series are not white noise processes.

(3) Mathematical Principles of GARCH Models:

In 1982, Engle discovered that time series often exhibit periods of high volatility followed by periods of low volatility when studying the issue of inflation in the UK. This characteristic, known as heteroscedasticity in statistics, prompted Engle to propose the ARCH model to model time series with heteroscedastic characteristics. Later, Bollerslev further developed the Generalized Autoregressive Conditional Heteroscedasticity (GARCH) model based on the ARCH model to address the parameter estimation issues in high-order ARCH models. Generally, the GARCH model can be expressed.

Where σ^2_t is the variance at time point t, ε_t is the error term at time point t, α_0 is the constant term, α_i and β_i are the parameters of the model, and p and q represent the orders of the ARCH and GARCH parts, respectively.

The GARCH model models the heteroscedasticity phenomenon in time series by modeling the weighted sum of past squared errors and past variances. The coefficient α_i in the ARCH part represents the impact of past squared errors on the current variance, while the coefficient β_i in the GARCH part represents the impact of past variances on the current variance.

When estimating the parameters of the GARCH model, the maximum likelihood method is generally used to maximize the likelihood function and solve for the optimal model parameters. With the estimated GARCH model, future variances can be predicted, allowing for analysis and forecasting of the volatility of the time series.

(4) Mathematical Principles of DCC-GARCH Models:

But the GARCH model alone would lose the correlation between the two things, so we used the DCC-GARCH model.

4. Experimental analysis

Here are the fitting results obtained from the DCC-GARCH model:

Table 1: DCC GARCH Fit Information Criteria.

	Estimate	Std. Error	t value	Pr(> t)
[sp].mu	-0.001245	0.001543	-0.8069	0.419724
[sp].omega	0.000132	0.000090	1.4698	0.141618
[sp].alpha1	0.081445	0.049813	1.6350	0.102044
[sp].beta1	0.854471	0.077213	11.0665	0.000000
[op].mu	-0.002618	0.001247	-2.1004	0.035696
[op].omega	0.000012	0.000003	3.8620	0.000112
[op].alpha1	0.025494	0.003902	6.5338	0.000000
[op].beta1	0.963768	0.006957	138.5267	0.000000
[Joint]dcca1	0.017141	0.006652	2.5770	0.009967
[Joint]dccb1	0.972877	0.010233	95.0726	0.000000

In the Table1, the estimated values for the parameters in the sp and op series are less than 0.5, indicating that their impact on the model is relatively small. Specifically, for the mean parameters, variance parameters, ARCH parameters, and GARCH parameters in the [sp] series and [op] series, if their estimated values are less than 0.5, it can be considered that their influence is relatively weak.

Table 2: DCC GARCH Fit Optimal Parameters

Distribution	mvnorm
Model	DCC(1,1)
No. Parameters	11
[VAR GARCH DCC UncQ]	[0+8+2+1]
No. Series	2
No. Obs.	665
Log-Likelihood	2512.964
Av.Log-Likelihood	3.78

Furthermore, we observe the Log-Likelihood value in the Table2, which is 2512.964. A higher Log-Likelihood value suggests that the model can explain the observed data well.

In conclusion, based on the provided fitting results, the DCC-GARCH model demonstrates good fitting performance when modeling the given data.

Next, the numerical values of four commonly used information criteria are listed:

Table 3: Information criteria for DCC-GARCH model

Akaike Information Criterion (AIC)	-7.5247
Bayesian Information Criterion (BIC)	-7.4503
Shibata Information Criterion	-7.5252
Hannan-Quinn Information Criterion	-7.4959

According to Table 3, we find that:

Akaike Information Criterion (AIC): -7.5247

Bayesian Information Criterion (BIC): -7.4503

Shibata Information Criterion: -7.5252

Hannan-Quinn Information Criterion: -7.4959

In Table 3, these information criteria are used to evaluate the goodness of fit of the model to the data and select the optimal model. Generally, smaller values of the information criteria indicate better fit of the model to the data. In this report, the values of AIC, BIC, Shibata information criterion, and Hannan-Quinn information criterion are all relatively close and negative, indicating a relatively good fit of the model to the data.

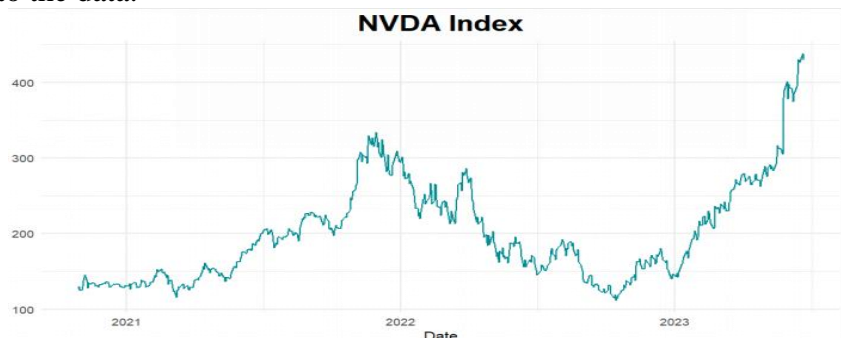


Figure 1: The correlation coefficient graph between NVDA and bitcoin

Based on the Figure 1, we obtained the following results: During the first half of 2021, the coefficient remained stable at around 140, indicating a relatively stable correlation. In the second half of the year, the coefficient showed fluctuating upward trends and reached a local peak of 300, followed by a downward trend in the second half of 2022. As we entered 2023, the coefficient continued to rise and reached 400.

5. Conclusions

According to the provided data, we will analyze the changes in correlation between Nvidia and Bitcoin for the years 2021, 2022, and 2023.

First Half of 2021: The correlation coefficient between Nvidia and Bitcoin remained stable at around 140. This may indicate that during this period, the price fluctuations of Nvidia and Bitcoin were relatively stable, and there were no significant changes in their relationship.

Second Half of 2021: During this period, the correlation coefficient between Nvidia and Bitcoin started to rise, reaching a local peak of 300. This suggests that the relationship between Nvidia and Bitcoin began to strengthen, possibly due to the following reasons:

Bitcoin price increase: If Bitcoin experienced a significant price increase in the second half of 2021, it could have attracted more investors and miners to participate in the Bitcoin market, thereby increasing the correlation with Nvidia.

Increased mining demand: A rise in the price of Bitcoin usually leads to increased mining activity as mining becomes more profitable. Nvidia, as a major supplier of mining equipment, may have benefited from the increased demand for mining, thus raising its correlation with Bitcoin.

In fact, in 2021, more and more traditional financial institutions and large corporations began to recognize and accept Bitcoin. Notable institutions such as Tesla and MicroStrategy announced their purchases of Bitcoin as part of their investment portfolios, which drew widespread attention and interest from the market. The participation of these institutions increased market liquidity and acceptance. As Bitcoin's price rose, the demand for mining technology also increased. At that time, Nvidia released the state-of-the-art NVIDIA A100 GPU chip, which was well-suited for this purpose, aligning with the changes in correlation.

2022: The correlation coefficient between Nvidia and Bitcoin experienced a decline and returned to a level of approximately 140. This could be due to the following reasons:

Bitcoin market volatility: The Bitcoin market is known for its high volatility, and price increases or decreases can impact mining industry activity. If Bitcoin's price declined in the second half of 2022, mining activity may have decreased, leading to a decrease in correlation with Nvidia.

Market conditions and other factors: Besides Bitcoin price, there are many other factors that can influence the correlation between Nvidia and Bitcoin. Factors such as market competition, technological innovations, policy regulations, etc., can all affect the demand for Nvidia products, thereby impacting the correlation with Bitcoin.

Specifically, in 2022, Bitcoin and other cryptocurrencies faced some adjustments in mining difficulty. As mining power continued to grow, the difficulty of the Bitcoin network typically adjusts to maintain a stable block generation time. This means that mining becomes more challenging, requiring more computational power to solve complex mathematical problems. Other cryptocurrencies may also undergo corresponding difficulty adjustments based on their own algorithms and network conditions. Additionally, competition increased, with ASIC (Application-Specific Integrated Circuit) miners becoming more efficient and optimized for specific cryptocurrencies. GPU mining machines also introduced updated models to meet the demands of different cryptocurrency mining. Furthermore, innovative mining devices emerged, aiming to provide higher processing power and lower energy consumption.

2023: The correlation coefficient between Nvidia and Bitcoin continues to rise, reaching 400. This indicates a further strengthening of their relationship. Possible reasons include:

Bitcoin market growth and maturation: In 2023, the market value of Bitcoin may continue to increase, attracting more investors and participants. This leads to growth opportunities for industries and markets related to Bitcoin, including mining hardware suppliers like Nvidia.

Increased mining activity: If, in 2023, Bitcoin's price remains stable or increases further, it may

further stimulate mining activity. Nvidia, as a mining equipment provider, may benefit from the increased demand for mining, thus raising its correlation with Bitcoin.

References

- [1] Xu Youjun, Wang Xiaoxia, Jia Jinjin. (2010) An Analysis of the linkage between Chinese and International Stock Market. *Economic Survey*, 5, 124-128.
- [2] Zhai Yonghui, Zhao Fei. (2019) A comparative study of Bitcoin market risk measurement of the Bitcoin Based on the GARCH-T model and the GEV model. *Hans*, 9, 19-27.
- [3] Shi Yilei (2020) Bitcoin price fluctuation characteristics and investment value research. *Finance and Accounting Newsletter*, 14, 143-147
- [4] Le, T. P. T. D., & Tran, H. L. M. (2021). The Contagion Effect from US Stock Market to the Vietnamese and the Philippine Stock Markets: The Evidence of DCC? GARCH Model. *The Journal of Asian Finance, Economics and Business*, 8(2), 759-770.
- [5] Wu Xinyu, Wang Xiaona. (2022), The impact of bitcoin on the volatility of China's stock market: Empirical evidence from double asymmetric GARCH-HMIDAS modal [J]. *Journal of Chongqing University of Technology*, 2022(8), 65-75
- [6] Wu Xinyun. (2022) The risks of Bitcoin investment for businesses: the case of Tesla. *observation scope view*, 7, 72-74
- [7] Zhong Jiahao. (2022) Internet search index with Bitcoin price. *Financial View*, 11, 134-137
- [8] Zhang Siyu. (2022) Exploring Virtual Currency Investment Using Bitcoin as an Example. *Financial View*, 3, 101-103
- [9] Huang Sa (2023), 36 billion dollars worth of Bitcoin stolen, *Financial*, 5, 62-64
- [10] Ye Yuning. (2023) Comparative Study of Digital Currency and Fiat Currency - A Case Study of Bitcoin, *Finanal*, 2, 392-409