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Influence of Electric Power Generation Capacity on Regional Distribution of Bitcoin Mining in China

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ABSTRACT

Bitcoin is a newly emerged digital currency. It was first proposed by Satoshi Nakamoto on 2008 November 1, and officially born on 2009 January 3. The attitudes of different countries towards Bitcoin are largely different. Recently, China has become the major country in Bitcoin mining. However, Bitcoin mining is highly dependent on electric power supply. Then, regional power generation capability and electricity price are important indicators to determine the cost and scale of Bitcoin mining business. Based on the provincial and monthly data from 2019 to 2021 including Bitcoin mining volume and wind, thermal and hydro power generations, the impact of each power generation on the Bitcoin mining is empirically analysed by Panel data analysis. Results show that the provinces whose thermal and hydro power generations are relatively large will attract more Bitcoin mining business. However, the effects of wind power generation on the distribution of the Bitcoin business is negative. This is highly likely caused by the substitution effect.

Keywords: *Bitcoin, Electric power generation, Panel data analysis.*

1. INTRODUCTION

The Bitcoin originated in 2008. A person calling himself Satoshi Nakamoto stated his new idea of e-money in his published paper. Since then, Bitcoin has been launched. According to the original design, everyone can participate in Bitcoin transactions. At the same time, Bitcoin allows individuals to pay directly to others without going through third-party institutions such as banks, clearing centers, securities dealers and electronic payment platforms. Thus, it can avoid high handling fees and government supervision. In some countries, central banks, government agencies and even researchers regard Bitcoin as a virtual commodity rather than a currency. Monetary finance believes that money has three basic functions: transaction medium, bookkeeping unit and value storage, but Bitcoin does not have the latter two basic functions because of its high volatility in price. [1] Unlike most currencies, Bitcoin is not issued by specific currency institutions. It is generated through a large number of calculations according to specific algorithms. Bitcoin uses the distributed database composed of many nodes in the whole P2P network to confirm and record all transaction behaviours. And then the network uses the design of cryptography to ensure the security of all links of currency circulation. The decentralized characteristics and algorithm of P2P can ensure that the currency value cannot be artificially manipulated by manufacturing a large number of Bitcoins. The design based on cryptography can make Bitcoin only be transferred or paid by the real owner. This also ensures the anonymity of money ownership and circulation transactions. The total number of Bitcoin is limited and scarce. The system had no more than 10.5 million in the past four years. In order to avoid inflation, the maximum number of Bitcoin protocols was 21 million. Because of the scarcity of bitcoin and the confidentiality of transactions, the price of Bitcoin reflects an obvious upward trend in the long term as shown in Figure 1.

Bitcoin was originally obtained by “mining”, so people can obtain Bitcoin through “mining” or trading. The process of using computer hardware to calculate the location of bitcoin and obtain it is called mining. In more detail, in every time unit, the Bitcoin system will generate a random code on the system node. All computers in the Internet can look for this code. Whoever finds this code will generate a block and then get a Bitcoin. In other words, for the purpose of getting a bitcoin, people have to find the random code faster than others. Then, under the same other conditions, who has stronger computing power, who can find the random code more quickly or, at least, have a higher probability to get the code. Since the calculation of this random code requires a lot of GPU operations, the "miners" will usually purchase a large number of graphics cards to obtain Bitcoin.

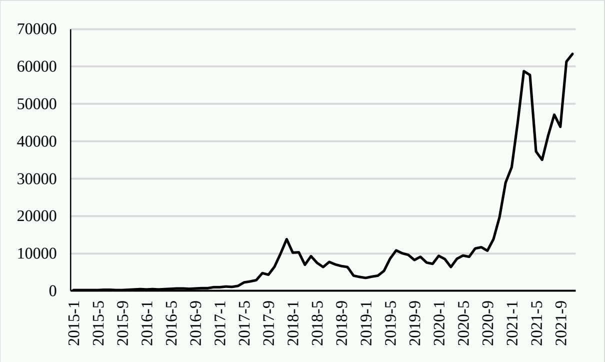

Figure 1 Price of Bitcoin (1BTC = US$)

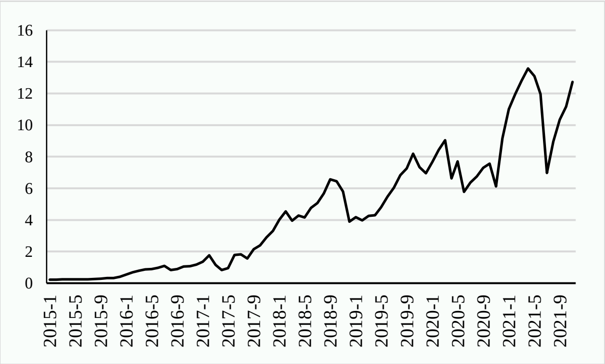

Figure 2 Bitcoin network electric power demand (daily GW, gigawatts)

Beyond the graphics cards, the electric power consumption required to mine Bitcoin is also a very noteworthy aspect. Mining Bitcoin needs to provide huge power to the graphics cards. If the electricity price is 40 cents, the power cost of a Bitcoin is now stable at about $10000. Since December 2020, the price of Bitcoin has not fallen below $20000 and, as shown in Figure 1, the average price of recent periods is $50000. Nearly 500% return on capital has attracted a lot of attention and therefore more and more Bitcoin miners have emerged. As mentioned earlier, Bitcoin mining is actually using machines to “compete to solve problems”. Participants who first give correct answers and are verified by others will receive the corresponding amount of Bitcoin automatically rewarded by the network. Miners with more mining machines and greater computing power are more likely to answer correctly first. The difficulty of answering questions is related to the computing power of the whole network. In light of this, the more mining machines, the more difficult it is to answer questions, and the higher the computing power and power consumption. [1][2][3] Since 2017, as the increased price of the Bitcoin, more and more people have participated in Bitcoin mining. Therefore, the electric power consumption of Bitcoin mining is also increasing since 2017. The Cambridge Centre for Alternative Finance (CCAF) from the Judge Business School of University of Cambridge estimates the electric power demand of the whole Bitcoin network, given in Figure 2. Recently, the whole Bitcoin well use around 10 GW electric powers every day! For illustrate, now the world power consumption of Bitcoin mining has exceeded the power consumption of Argentina.

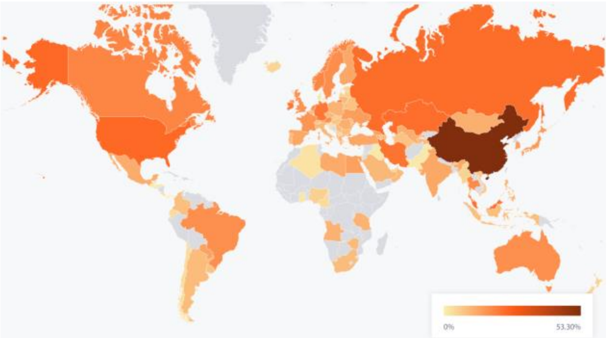

Figure 3 Global map of the Bitcoin power demand (%, January 2021)

The CCAF also estimates the electric power demand of each country. Figure 3 shows the global map of the Bitcoin power demand of each country as a percentage of the world demand at January 2021. Until China completely suppressed and banned Bitcoin in 2021, China has always been the main country of Bitcoin mines and bitcoin miners. In August 2020, China’s Bitcoin miners accounted for more than two-thirds of the world. After the Chinese government took action in 2021, a large number of Chinese Bitcoin miners moved overseas.

2. THEORETICAL DISCUSSION

According to the price trend of Bitcoin, it will consume more and more power in the future. As now the thermal power generation is still the mainstream to generate electric power in the world, the waste gas and sewage discharge generated by thermal power generation are the problems that cannot be ignored. The high power consumption of Bitcoin mine will undoubtedly and directly create environmental pollution. In light of this, environmentalists and organizations around the world are increasingly denouncing Bitcoin mines. However, some Bitcoin miners believe that mining can solve the problem of excess energy. For example, the power generation of some hydropower stations is constant, and power is abandoned when it is not used up. Instead, miners make full use of the energy. In fact, these arguments cannot explain the environmental pollution caused by Bitcoin's use of thermal and even other power generation processes. It is quite clear that, with the rising price of Bitcoin, the power consumption will be higher and higher. No matter what form of power production, such as the thermal power, hydro power, wind power and nuclear power, the production of electricity will always pollute the environment. [4][5]

Power generation refers to the conversion of water energy, fossil fuel energy (coal, oil, natural gas, etc.), nuclear energy, solar energy, wind energy, geothermal energy into electric energy by using power generation power plants. At the end of the 20th century, fossil fuels were mostly used for power generation, but the resources of fossil fuels were drying up day by day. Human beings have gradually used more renewable energy (hydropower, solar energy, wind energy, geothermal energy, marine energy, etc.) to generate electricity. In China, there are four main forms to generates electricity: thermal power generation, hydropower generation, nuclear power generation and wind power generation. As shown in Figure 4, thermal power generation is still the main way of generating electric power. The second is the hydropower generation. It is around 1/3 of the thermal power generation. Wind and nuclear power generations are relative tiny.

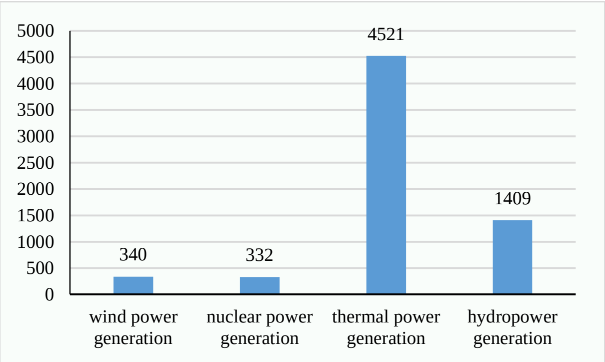

Figure 4 The electric power generations of the four main forms of China (10^8kWh, kilowatts) in March 2021

Due to the loss of power remote transmission, thermal power stations are generally built near the power consumption area. Because the thermal power generation technology is relatively mature, the consumption of fossil fuels can be adjusted according to the amount of power consumption. Therefore, as shown in Figure 5, the overall thermal power generation capacity of various provinces in China shows a decreasing trend from southeast to northwest which is same as the provincial GDP level in China. Different from thermal power generation, hydropower stations have high requirements for water veins and geographical characteristics and so that the places suitable for the construction of hydropower stations are limited. Therefore, even if the power transmission loss is relatively high, the cost of hydropower is much lower than that of thermal power. There are few places with large river drop and high river banks, which are mostly distributed in Southwest China, including Sichuan province. As a big Bitcoin mining province in China, Sichuan's mining power consumption accounts for more than 50% of the country in wet season. Due to the phenomenon of "power abandonment" of many hydropower stations and the relatively low electricity price in areas with abundant hydropower resources, Bitcoin mining often likes to choose these provinces for mining. Therefore, the regional distribution of thermal power generation and hydropower generation is likely to have different effects on the distribution of the Bitcoin business.

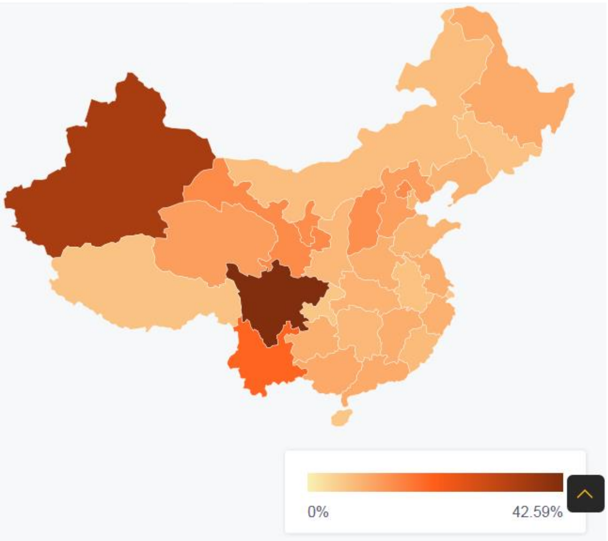

Figure 5 Map of the Bitcoin power demand in China (%, June 2021)

3. EMPIRICAL ANALYSIS

Given on the theoretical interest discussed in last section, now the question becomes that whether or not the local power generation and the way of the power generation will practically affect the site selection of the Bitcoin business as well as the quantity of Bitcoin mining. The empirical equation is given in Equation (1).

$$bitcoin = \beta_0 + \beta_1 ther + \beta_2 hydro + \beta_3 wind + \varepsilon \quad (1)$$

where:

bitcoin = *quantity of Bitcoin mining;*

ther = *thermal power generation;*

hydro = *hydropower generation;*

wind = *wind power generation.*

The CCAF provides the monthly and provincial data of the ratio of the quantity of Bitcoin mining of each province to the total quantity from 2019M09 to 2021M07. But CCAF only shows the data about 8 provinces, they are: Beijing, Shanxi, Nei mongol, Sichuan, Yunnan, Gansu, Qinghai and Xinjiang. This is because the ratio of all other provinces are quite tiny. The China's National Bureau of Statistics (NBS) provides monthly data about the four ways of the electric power generations of all provinces. The four ways are thermal power generation, hydropower generation, wind power generation and nuclear power generation. Since all the 8 biggest Bitcoin mining provinces have no nuclear power generation, the effect of the nuclear power generation is not taken into account in Equation (1). Consistent with the ratios of the Bitcoin mining data, for each kind of the power generations, we also calculate the power generation of each province as a percentage of the national power generation. Finally, given on these panel type dataset, the Equation (1) is estimated by three ways: the pooled OLS, the fixed effect (FE) and the random effect (RE). Estimated results are shown in Table 1.

Table 1. Results of the regressions

VARIABLES	Pooled	FE	RE
thermal	193.599***	84.574	90.087*
	[66.950]	[53.707]	[53.229]
hydro	70.862***	61.439***	60.600***
	[10.783]	[11.783]	[11.491]
wind	-63.384*	-113.335***	-111.714***
	[36.148]	[27.736]	[27.563]
Constant	4.494***	10.768***	10.575**
	[1.563]	[1.165]	[4.489]
Observations	207	207	207
R-squared	0.178	0.178	0.178

Notes: 1. Standard errors in brackets; 2. Significances are: *** p<0.01, ** p<0.05, * p<0.1.

The regression results shown in Table 1 indicates that the fixed and random effect estimators are significantly different compared with the Pooled OLS estimator. So, the individual effect cannot be ignored in this analysis. The statistics of the Hausman test between FE and RE estimators is 2.72 (Prob>Chi2 = 0.44), and thus the random effect estimator is better in describing the relation among variables. All the three explanatory variables are statistically significant at least under 10% significant level. According to the estimated coefficients of the RE, provinces with more thermal and hydro-power generations will attract more Bitcoin mining business. And the positive effect of the thermal power is relatively bigger than the effect of the hydropower generation. However, the negative effect of the wind power generation on the distribution of the Bitcoin business exceeds our expectation. One of the possible answer of this negative value is the substitution effect. As what we have discussed in the theoretical part, Bitcoin business would like to select the province who have more hydropower stations. This is because the hydropower stations may have the abandonment power and therefore the power can be purchased relatively easy and cheap. More specifically, if the power demand cannot be fully satisfied by thermal and hydro- power generation, then the wind power generation will be further developed. This means that the hydropower station in these kind provinces has no too much power abandonment. [6]

4. CONCLUSION

Recently the price of Bitcoin is extremely high and lots of people are interested and going to involve in this business. One of the problem is that the Bitcoin mining needs tremendous electric power which will cause environmental problems. China becomes the majority country to do the Bitcoin mining business. Based on the monthly data of the ratio of the Bitcoin mining volume to the total volume, and the monthly power generation data including thermal power generation, hydropower generation and wind power generation, the effect of these three kinds of the power generations on the distribution of the Bitcoin business is empirically studied through the panel data analysis. Results indicate that thermal and hydro- power generations will attract the Bitcoin business but the wind power generation has a negative effect on the Bitcoin business. This is perhaps caused by the substitution effect between power generations. Highly developed wind power provinces imply less power curtailment of their hydropower stations.

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