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Review

Current analysis of cryptocurrency mining industry

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Abstract: In this regard the key factor determining the success of the mining industry is the cost of electricity. By understanding the risks associated with crypto mining industry. The method is based on systemic literature review and bibliometric analysis exploring keyword "bitcoin mining". This review paper studies 50 papers for the period of 2019–2023. The results propose recommendations for crypto miners. Currently, the results confirm that bitcoin mainly depends on the consumption of inexpensive electricity. Consequently, the bitcoin network predominantly uses energy in regions where it is abundant and cannot be stored or exported. Most miners rely on electricity generated from hydroelectric power plants, geysers and geothermal sources, which are not easy to transport or store. Bitcoin will continue to look for such cost-effective and underutilized energy sources, as mining in urban areas or industrial centers will remain financially unviable. If the price of bitcoin stabilizes and a sufficient number of miners enter the market, it is quite possible that in the near future we may witness a fivefold increase in their energy consumption.

Keywords: cryptocurrency; mining; bitcoin; inflation

1. Introduction

The cost of operations, particularly the energy consumption, is a major consideration for the entire cryptocurrency mining industry.

The purpose of paper is current analysis of cryptocurrency mining industry. Originality is novel recommendations for cryptocurrency mining industry.

Nowadays, oh how things have changed. The unprecedented and exponential growth of the cryptocurrencies in the recent past has led to its oh so glorious proliferation around the world. The continuous block mining cycle, oh how it just can't help but incentivize people all over the world to mine Bitcoin and other cryptocurrencies. As mining, oh how it can provide a solid stream of revenue, people are just oh so willing to take part in these oh so glamorous crypto mining activities (Bouri, Cepni, et al., 2021; Bouri, Saeed, et al., 2021).

The methodology is based on systemic literature review of novel 50 papers for the period of 2019–2023. The paper proposes recommendations for crypto miners.

In the vast majority of countries, including those with excess energy capacity, mining activities are permitted, and energy intensive data centers are subject to general electricity and environmental regulations. And only countries with a shortage of energy capacity (for example, China, Kazakhstan, Kyrgyzstan and Uzbekistan) go down the path of banning or significantly restricting mining activities.

The main finding is that the current analysis of cryptocurrency mining industry has annual growth about 30%–40%.

Countries that take advantage of crypto mining in practice encourage the development of related business activities. In April 2023, the US states of Arkansas and Montana passed laws against discrimination of crypto mining data centers. In particular, they prohibit an increase in electricity rates for crypto mining companies in each of these states, prevent other forms of discrimination, i.e., prohibit the restriction of locating industrial crypto mining facilities in certain areas of the states, if other commercial consumers work there. The latest development of the mining industry is the high share of the use of renewable energy sources. According to expert estimates in the first half of 2023, this indicator is 59.9% and continues to grow steadily. To encourage the use of these energy sources, the Australian Committee on Technology and Finance recommended the government to change the law to allow miners to receive a 10% tax rebate on income tax, if they use their own renewable energy sources. In Brazil, the local legislature is considering a proposal to exempt import duties on cryptocurrency mining equipment, as well as taxes on mining activities, if renewable electricity is used in the mining process (Gao et al., 2023; Gao et al., 2022).

Crypto mining data centers are costly and require a large investment to set up the operation and many professionals with expert knowledge to provide on-site servicing of the mining equipment. In this regard the key factor determining the success of the project is the cost of electricity (**Figure 1**, **Table 1**). For example, according to US Midcontinent System Operator data, which operates in the central part of the United States, the average price for electricity is 2.5–3 cents per 1 kWh. Such price allows US companies to attract customers and charge them with the electricity price of 7 cents per 1 kWh (Chen et al., 2022; Chirtoaca et al., 2020).

Table 1. Top miner companies in world in 2023 (CoinMarketCap, 2024).

Rank	Name	Marketcapitalisation	Price (USD)	Country
1	Marathon Digital Holdings	5.170804736	19.32	United States
2	Clean Spark	3.452272896	17.43	United States
3	Phoenix Group	3.344075755	0.55	United Arab Emirates
4	Riot Blockchain	2.941040896	11.6	United States
5	Cipher Mining	1.046620224	3.53	United States
6	Bitdeer Technologies Group	0.895736000	8	Singapore
7	Bitfarms	0.755185728	2.26	Canada
8	Hut 8 Mining	0.670780992	7.54	Canada
9	Core Scientific	0.632696640	3.42	United States
10	Tera Wulf	0.531490208	1.78	United States

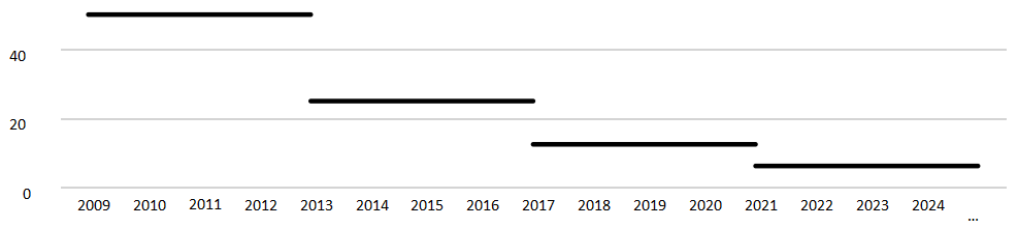

Figure 1. Bitcoin rewards per block (CoinMarketCap, 2024).

Despite the fact that the introduction of cryptocurrency emission technologies (mining) can potentially lead to significant transformations in the financial sector, which will lead to new opportunities for raising capital and significant savings due to transaction optimization, it would be premature to say that digital currencies based on these technologies will be able to compete effectively with traditional currencies in the foreseeable future. In light of the ongoing industrial revolution, there has been a marked shift in the qualitative aspects of demand with a growing emphasis on the environmental sustainability of electricity production. It is worth noting that experts who rely on data from the International Energy Agency stressed that electricity accounts for a staggering 42% of anthropogenic greenhouse gas emissions, which not only contributes to global warming, but also places a significant financial burden on governments and businesses.

In addition, the expansion of industrial mining can support the implementation of environmental and social programs in the health sector. Experts stressed that digital transformation in the electric power industry not only increases the efficiency of traditional energy systems, but also facilitates the integration of distributed generation into energy exchange. This integration includes the use of renewable energy sources, energy storage systems, as well as devices and complexes with regulated consumption, which makes it possible to provide a variety of energy services. In accordance with coinmarketcap.com Thus, by the end of 2023, the number of cryptocurrencies has approached a staggering 10,000. These cryptocurrencies, which bear a striking resemblance to fiat money issued by central banks, unfortunately are not able to fully implement or perform the prescribed set of functions usually associated with traditional currencies. It should be recognized that cryptocurrencies only partially embody the characteristics of money as a universal equivalent or measure of value. Currently, digital currencies primarily serve to determine prices for a limited range of goods and services. Delving into the sphere of the most famous cryptocurrency, bitcoin, you can, to your surprise, find that by the end of April 2018, it was accepted in about 12,300 retail outlets scattered around the world. The most common areas of approval were concentrated in Western Europe, the United States, Southeast Asia and Latin America. It is extremely important to emphasize the fact that most of these establishments are companies specializing exclusively in online trading, although there are a significant number of ordinary retailers who have agreed to accept payments in bitcoins.

2. Review of literature

Cryptocurrency mining is a cost—effective activity based on the use of computer equipment to create cryptocurrency coins. It requires considerable

theoretical and practical knowledge and can be economically feasible both in the short and long term. The profitability of mining has prompted private players in the electrical industry to use their renewable energy sources for mining, which can make a positive contribution to electricity production. However, the price of electricity and the environmental impact of mining are important factors to consider (Mikhaylov, 2023; Metaxas et al., 2023; Srbová et al., 2023).

The use of renewable energy sources can help mitigate the problems of sustainable development associated with mining. In addition, the energy-intensive nature of cryptocurrency mining can lead to negative social benefits, especially if electricity needs continue to grow without constant price increases. In general, the economy of cryptocurrency mining depends on factors such as the cost of electricity, the use of renewable energy sources, as well as the environmental and social consequences of mining (Häusler and Xia, 2021; Hoang and Baur, 2021; Horky et al., 2022) (**Table 2**).

Table 2. Top mining pools in world in 2023 (CoinMarketCap, 2024).

Number	Name	Hash rate	Blocks
1	Foundry USA	29.96%	16,069
2	Ant Pool	21.06%	11,299
3	F2 Pool	14.37%	7709
4	Binance Pool	10.09%	5411
5	Via BTC	8.77%	4702
6	Unknown	4.08%	2187
7	Braiins Pool	2.51%	1349
8	Luxor	2.29%	1229
9	BTC.com	2.00%	1074
10	Poolin	1.54%	824

Cryptocurrency mining is a legitimate and economically profitable activity that requires both theoretical and practical knowledge in the field of economics and technology. This is considered economically feasible both in the short and long term (Corbet et al., 2020; Dowling, 2021a; Dowling, 2021b).

As summary it is noted that the combination of efficient use of energy resources based on renewable energy sources, as well as the development of incentive measures to significantly increase their share in the total balance of electric energy, continues to be the focus of attention of scientists and specialists in the field of economics and energy (Rahman et al., 2024; An and Mikhaylov, 2020; An and Mikhaylov, 2024; Mutalimov et al., 2021; Mikhaylov et al., 2024).

3. Methodology

There are various methods of mining cryptocurrencies, including the use of application-specific integrated circuit (ASIC) for industrial mining, cloud mining for investment purposes and mining on personal devices such as computers, laptops or smartphones. However, mining on video cards is considered the most effective and common method (Goodell and Goutte, 2021; Grobys and Huynh, 2021; Hamill et al.,

2021; Hasan et al., 2021).

The article highlights the relationship between the earnings of miners in the Ether mine mining pool and the daily profit from mining, which indicates the potential profitability of mining cryptocurrencies.

Russia is recognized as one of the world leaders in the introduction of cryptocurrencies, and cryptocurrency mining is considered a significant and cost-effective activity in the country. Attempts are being made to legislatively regulate cryptocurrency mining, but they do not have a significant impact on the creation, distribution and use of cryptocurrency coins (Goodell and Goutte, 2021; Grobys and Huynh, 2021).

The method is based on systemic literature review and bibliometric analysis exploring keyword "bitcoin mining". These methods are chosen on the back of several research (Hamill et al., 2021; Hasan et al., 2021) (**Figure 2**).

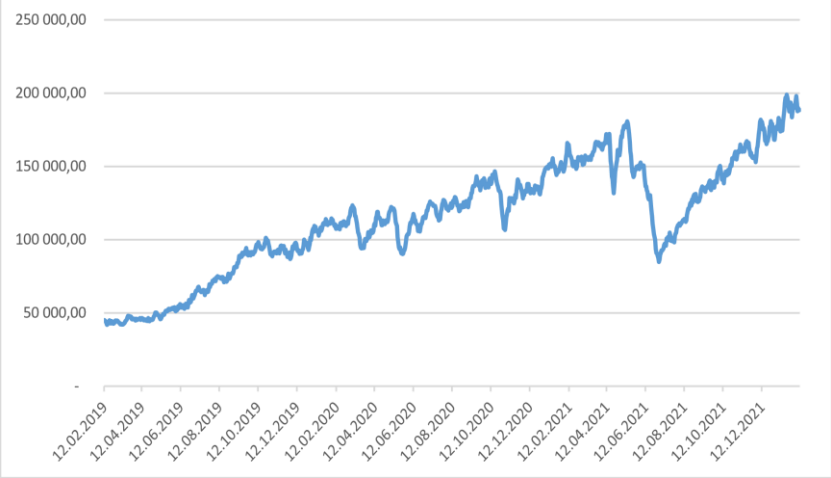

Figure 2. The estimated number of hash rate of Bitcoin network is performing.
Source: CoinMarketCap, 2024.

Miners secure the Bitcoin network and process transactions. Every time a miner successfully solves Bitcoin's proof of work algorithm, it means this miner has mined a "block". In return for miner's security and processing services, they are rewarded with new Bitcoins, which are create delivery 10 min at a decreasing and predictable rate (Candila et al., 2021; Saqib et al., 2021; Yumashev and Mikhaylov, 2020) (**Figure 2**).

4. Findings

The novel finding is that cryptocurrency mining industry has annual growth about 30%–40%.

This is the only way that new Bitcoins are created. Since May 2020 and until the middle (May or June) of 2024, the block reward is 6.25 Bitcoins per block (**Figure 3**) (Náñez Alonso et al., 2021; Fadeyi et al., 2019; Guidi et al., 2020).

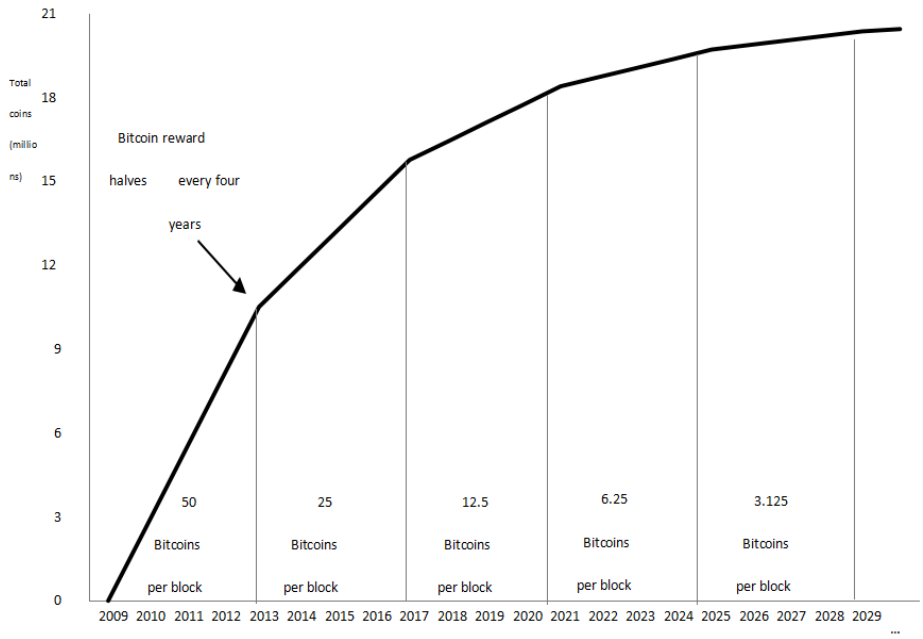

Figure 3. Total Bitcoins per block (CoinMarketCap, 2024).

The block reward halves many times, and in future it will become so small that new Bitcoins cannot be created. Looking forward, the block reward will decrease to zero in 2140, and the issuance of new Bitcoins will halt with the total number of Bitcoins reaching 21 million (**Figure 4**).

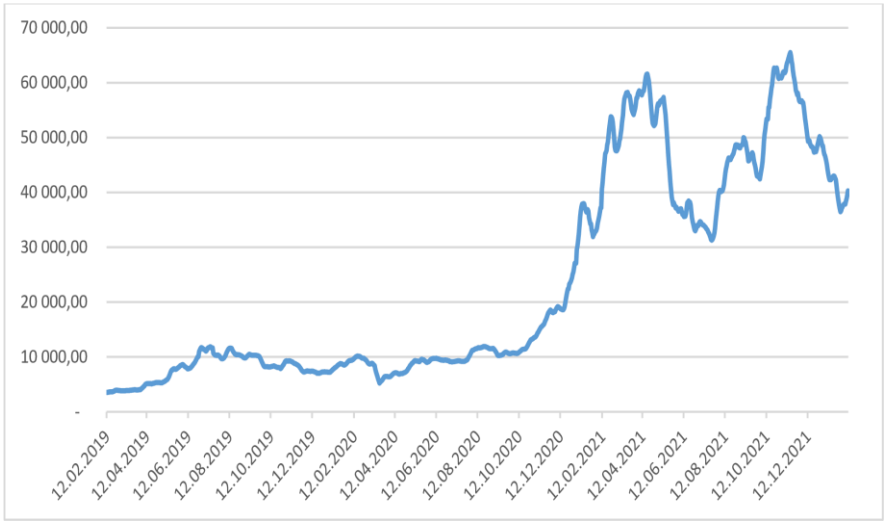

Figure 4. Bitcoin market price (USD/BTC) (CoinMarketCap, 2024).

The number of Bitcoins has been growing since the creation of this virtual currency in 2009 and reached 18.9 million in December 2021. In the past 10 years, 90% of the total Bitcoins that will ever be available have been mined (Siddique et al., 2023; Jia and Li, 2023; Benhamed et al., 2023).

There are only 2.1 million Bitcoins left to mine before the 21 million Bitcoin cap is reached. Assuming that there are no changes to the protocol, the Bitcoin cap will be reached by 2140, 120 years from now (Jabłczyńska et al., 2023; Nerem and Gaur, 2023; Podhorsky, 2023; Sarkodie et al., 2023).

The Bitcoin protocol makes the creation of new blocks very difficult for miners by regularly adjusting the difficulty to ensure that all miners in the network are able to produce only one valid block every 10 min on average. This is why the calculations needed to verify a block are getting more difficult, and the Bitcoin award is shrinking (Han et al., 2019; Li et al., 2019; Thuy and Khai, 2020; Wang et al., 2021).

Bitcoin prices demonstrate upward trends for the last three year. It creates additional opportunity for mining industry (**Figure 4**).

The main finding is that the current analysis of cryptocurrency mining industry has annual growth about 30%–40%.

Around the world, the main focus is on the use of renewable energy sources as the main source of electricity for cryptocurrency mining and blockchain technology, with particular attention being paid to the energy consumption of cryptocurrencies using renewable energy sources.

Despite the fact that much attention is paid to the issues of sustainable development of the financial sector through the use of renewable energy sources, there are very few studies devoted to the use of cryptocurrencies in this context (An et al., 2024; Mikhaylov et al., 2023a, 2023b; Moiseev et al., 2023).

The authors also propose two important methods—optimization of GPUs and the use of renewable energy sources—as potential solutions to reduce the amount of electronic waste and increase electricity consumption when mining cryptocurrencies, as well as maximize the benefits of mining on GPUs without harming the environment.

Dogecoin mining using solar energy as renewable energy consumes 2000 watts of energy when overclocking and 1700 watts when using the undervoltage method.

The use of renewable energy sources for mining cryptocurrencies can reduce the amount of electronic waste and improve sustainable development (**Figure 5**).

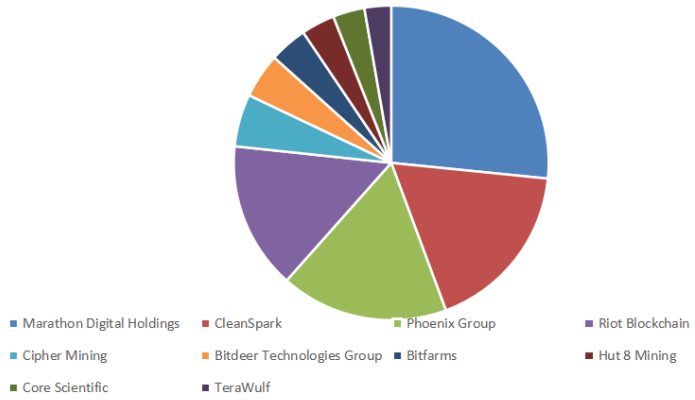

Figure 5. Top 10 Miners capitalization (CoinMarketCap, 2024).

The implementation of environmental and social health programs can also be supported by the spread of industrial mining.

5. Discussion

In early 2009, the crypto-mining industry was a small and widely distributed

network of a few thousand private miners. Their activities were limited and their power requirements were low. However, at present, this situation has changed. The unprecedented and exponential growth of the cryptocurrencies in the recent past has led to a very sharp increase in energy consumption (Chicarino et al., 2020; Jung et al., 2019; Qin et al., 2020; Tang et al., 2019; Yang et al., 2020).

Mining is done by powerful and specialized computers that consume a lot of electricity. As the costs of energy or electricity have risen and continue to rise, only the mining operators who have very low energy costs overall can earn adequate returns on the capital invested. The energy costs are bound to rise further as the complexity and time consumption of the Bitcoin mining increases (An et al., 2020; Mikhaylov, 2021; Mikhaylov, 2022; Zhang, 2020).

One of the most accessible ways to get involved in the world of cryptography and to acquire cryptographic assets is mining. Currently, there are three types of crypto-mining solutions that are available on the market: personal mining, cloud mining, construction of an owner mining facility.

The first two options are for private mining facilities, while the latter is for business. However, all options are associated with corresponding risks and have their disadvantages, including:

A home-based mining system is expensive and demanding: High electricity costs, constant noise and heat, a large room is needed for miners, need for constant attention. It is to ensure that minors operate at maximum efficiency. A cloud mining installation is opaque and may contain many hidden costs. No knowledge of the brand name, model number, serial number of the equipment, lack of information on energy efficiency and energy consumption, lack of sufficient equipment capacity, no cost distribution, most often, no information on the mining pool, or even the location of the installation.

6. Conclusion

Due to the fact that bitcoin cannot fully fulfill the function of money as a measure of value, using it as a means of payment becomes, to put it mildly, a difficult task. The limitations of bitcoin's operational risks, combined with its relatively limited geographical area of active use, further exacerbate the problem under consideration. Firstly, it is extremely important to recognize that in a number of countries transactions using bitcoin are either completely prohibited or exist within the confounding “gray” zone, where the legal status of these transactions remains ambiguous. In most national jurisdictions, the determination of the status of bitcoin is still under consideration, which exacerbates the uncertainty associated with its use. Consequently, international payments using bitcoin are often made “at your own risk”, thereby emphasizing the uncertainty associated with its use. Secondly, as is the case with the introduction of any innovative concept, cases of outright fraud, unfortunately, are not uncommon, especially in the field of electronic wallets, which temporarily store funds in cryptocurrency. These wallets are deliberately brought to bankruptcy by their owners, and are also subject to malicious hacker attacks. In addition, the lack of transparency in numerous bitcoin-mediated transactions exacerbates the detrimental impact. The legal loopholes associated with this

particular cryptocurrency do not allow us to completely exclude the possibility of conducting transactions for the purpose of money laundering or supporting terrorist organizations. Given these aforementioned factors, it would be reasonable to assume that leading financial powers, such as the United States and the European Union, may consider the idea of banning transactions using bitcoins and other cryptocurrencies if they discover cases of financing terrorist attacks, both in the past and in the future.

It is worth emphasizing that the Financial Action Task Force has expressed caution about the emergence of cryptocurrencies. Having experienced an almost "vertical takeoff", bitcoin has undergone a significant correction, with intraday fluctuations in its exchange rate reaching several tens of percent.

Currently, the results confirm that bitcoin mainly depends on the consumption of inexpensive electricity. Consequently, the bitcoin network predominantly uses energy in regions where it is abundant and cannot be stored or exported. Most miners rely on electricity generated from hydroelectric power plants, geysers and geothermal sources, which are not easy to transport or store. Bitcoin will continue to look for such cost-effective and underutilized energy sources, as mining in urban areas or industrial centers will remain financially unviable. If the price of bitcoin stabilizes and a sufficient number of miners enter the market, it is quite possible that in the near future we may witness a fivefold increase in their energy consumption.

Conflict of interest: The authors declare no conflict of interest.

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