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A DISCUSSION ON THE KAZAKH ENERGY CRISIS OF 2021: THE ROLE OF CRYPTOCURRENCY MINING FACTORIES AND THE ENVIRONMENTAL IMPLICATIONS

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Abstract. This work investigates the factors determining the Kazakh energy crisis which occurred in the second half of 2021. From the correlation observed among some data gathered to the purpose of the analysis, the relevant role played in this by cryptocurrency mining factories is identified. Beginning from June 2021, a massive number of them were relocated to Kazakhstan from the Popular Republic of China (PRC) because of normative restrictions introduced by the latter. The work also develops a reflection aimed at understanding the economic and environmental impact which has been produced by this relocation. The descriptive analysis will proceed as follows: the first section of the article will focus on the regulation of cryptocurrencies; the second section will focus on final electricity consumption and supporting empirical evidence and is closely related to the third and last section; the latter will focus on primary macroeconomic indicators in relation to the increase in CO2 emissions in the Kazakh republic. To this end, it is useful to demonstrate a correlation between the energy crisis, the transfer of cryptocurrency mining to Kazakhstan, and to fuel the discussion regarding the need for a supranational institution with the aim of codifying a common international legislation, thus reinforcing the efforts made so far in this direction. Present and future implications and scenarios derived by the analysis are also introduced.

Keywords: cryptocurrency, mining factories, energy crisis, Kazakhstan, economic impact, environmental impact.

JEL Classification: E02, F6, P18.

Introduction

The main purpose of the article is to fuel a critical discussion about the role of cryptocurrencies in the international arena; to this end it was considered appropriate to take into consideration the Kazakhstan energy crisis as the main parameter to highlight the current specific weight of cryptocurrencies mining activity.

Therefore, the main objective of this work is to discuss the relocation of mining farms in Kazakhstan and the relevance of the change of the Chinese regulation about the cyptomining activities.

As pointed out by Wang et al. (2022), there is a lack of shared regulations and policies to limit the environmental impact caused by cryptomining activities (Bondarev, 2020; De Vries et al., 2022).

Such situation is fundamental for a rethinking of the role of international institutions that should guarantee the sustainability of the cryptocurrency mining (Lansky, 2019; Syzdykova & Zhetibaev, 2020). The energy crisis took place during the relocation of the mining farms – a transfer favored by the Kazakh legislation – which were present on the territory of the PRC following the protectionist measures adopted by the Chinese government.

The specific weight of mining farms in the context of the Kazakhstan energy crisis is highlighted by the fact that the relocation took place in perfect timing with respect to the protectionist measures promoted by the Chinese government starting in June 2021 – as can be seen from observing the time series elaborated by the Cambridge Bitcoin Electric Consumption Index (CBECI). The data provided by the CBECI highlight a relationship between the increase in mining in Kazakhstan after the measures taken by the Chinese government in June 2021; in this case, precisely, reference will be made to the cryptocurrency with the highest value, namely: Bitcoin. The data provided by the CBECI are corroborated, among others, by the analyzes of Bondarev (2020), and the methodology for elaborating a mapping of Bitcoin mining has proved to be reliable despite its

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limitations; numerous studies confirm that final electricity consumption is very high (An et al., 2020).

The descriptive analysis will proceed as follows: the first section of the article will focus on the regulation of cryptocurrencies; the second section will focus on final electricity consumption and supporting empirical evidence and is closely related to the third and last section; the latter will focus on primary macro-economic indicators in relation to the increase in CO_2 emissions in the Kazakh republic.

Hence, the expected results foresee to highlight that, although it does not represent the only cause, the relocation of mining farms to Kazakhstan is a contributing cause of the Kazakhstan energy crisis of 2021; at the same time, the analysis of this phenomenon foresees the establishment of a supranational body capable of producing and applying shared international legislation, in order to favor a regulation of cryptocurrencies to limit their energy and environmental impact on a global level, and to identify future international developments.

1. Legislative factors that have favoured the relocation of mining farms

1.1. The absence of a common international legislation and the vetoes of the PRC

The PRC government has opted for a protectionist strategy towards bitcoin-yuan trading operations. Another especially important fact: according to the Finance Magnates, since the 2018, the People's Bank of China had planned to ban Bitcoin transactions in banks, retailers and payment operators, including Alipay and Tencent (Mashraky, 2018).

What has given the Chinese governance input to such initiatives? The need to prevent volatility in the digital currency market is one of the biggest problems related to the world of cryptocurrencies (Ashimbayev & Tashenova, 2018; Iwamura et al., 2019; Šimonová, 2019). To better enlighten the importance of the political-economic phenomenon to which reference is made, it is advisable to first consider the value acquired by the best known and most profitable cryptocurrency in the world.

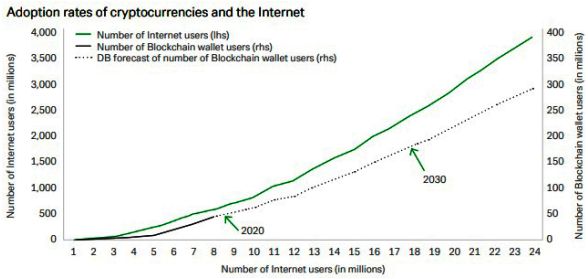

Figure 1. Graph extracted from the Deutsche Bank research: *The future of payments*

As shown in Figure 1, Deutsche Bank analysts noted that between 2012 and 2020, the price of Bitcoin has increased by over 540%. Bitcoin reached an annual growth rate of 274% in 2020, and the cryptocurrency market is predicted to grow with a compound annual growth rate of 56.4% from 2019 to 2025.

The Chinese government has progressively increased the pressure on the mining companies, which, in turn, have applied countermeasures to circumvent the restrictions (Mashraky, 2018); many companies felt that the low costs of electricity in Kazakhstan played in favor of a relocation to that territory.

The wealth of raw materials for energy production and the low cost of electricity are the basis of profitability for cryptocurrency mining; in fact, the extraction and release that characterize the mining activity requires a very high number of terminals with high energy consumption – as described in paragraph 1.1, Tables 1 and 2 of this paper, in which the values of the annualized total Bitcoin footprints and the single Bitcoin transactions footprints are determined (Pakenaite & Taujanskaite, 2019). Kazakhstan government admitted that, in the 2021 energy crisis, mining companies played a leading role; in this regard, a regularization of mining activities has been envisaged, but this regularization has not been fully implemented (Vorobey, 2017; Cvetkova, 2018; Baek & Elbeck, 2014; Lansky, 2019).

Recently, the Europe Central Bank proposed to introduce measures to regulate cryptocurrency trading and mining (European Central Bank, 2015); the future attempt is to issue a duly regulated virtual currency. In parallel, the Central Bank of Russia is preparing to launch the digital ruble in 2022, in the same way that the Chinese government has spent its energy promoting the e-yuan (Litova & Malyarenko, 2017).

China was the hub of mining; thanks to the low costs of energy sources, developed infrastructure, as well as producers of hardware needed for mining, the country has managed to achieve a dominant position in the cryptocurrency business. As reported by Chudinovskikh and Sevryugin (2019), transactions with cryptocurrencies were carried out commission-free on Chinese exchanges until 2018, which facilitated the attraction of investors; such a high interest in cryptocurrencies has thereby caused a huge outflow of capital; in 2016, 2 billion dollars were withdrawn from China.

The following figure, on the other hand, offers a previous case of what affected Kazakhstan between 2021 and 2022, as, in January 2018, China stopped mining bitcoin; one of the most relevant causes is related to the high final consumption of electricity. In anticipation of the launch of the e-yuan, the PRC has not abandoned the idea of adopting blockchain technology. To highlight this passage there is an event of March 2018; since then, authorities have seen fit to establish national standards for developing distributed ledger and blocking technology (DLT), a decision that would have made no sense except in anticipation of the creation of a properly controlled national digital currency (Financial Action Task Force, 2014; Chudinovskikh & Sevryugin, 2019; Lansky, 2019).

What is important to point out is that these restrictive measures, rather than from a green environmental

policy, or from energy factors, or even from the need to safeguard the safety of citizens, could indicate the need to control and regulate every activity related to mining for encourage the launch of a state digital currency (Syzdykova & Zhetibaev, 2020).

Neither international law, nor Kazakh law, provides for a legal equation between cash and cryptocurrency, much less between digital currency and cryptocurrency (Chudinovskikh & Sevryugin, 2019); which means equating it to a form of ownership by a specific legal entity (Zakon, 1995; 2016; 2018). This legal rule plays a very important role because it not only defines the concept of currency in Kazakhstan, but prevents any cryptocurrency from acting as a substitute means of payment, which is why it is appropriate to adopt an independent regulatory legal act both at the national and the international levels (Siddiqi, 2015; Lansky, 2019), which would incorporate all legal mechanisms for regulating cryptocurrency (Temirzhanova et al., 2020).

2. Final electricity consumption and empirical evidence that underlines the relocation of mining farms

2.1. The energy required for the operation of a single mining farm unit and for a single transaction

The enormous energy demand that mining farms need has led the Kazakh government to import energy into its own country; a country with a territory which, paradoxically, is in turn rich in energy sources (this data can be deduced, among other sources, from the WB report *Kazakhstan Economic Update Winter 2021/2022* (The World Bank, 2022).

Despite the repercussions of the last year, in 2021 reached an exchange value equal to 540% compared to that of 2012 (Deutsche Bank, 2020); this growth in value is linked to an increase in the demand for electricity by miners, regardless of whether the project is eco-sustainable or not (Stoll et al., 2019); this means increasing the amount of carbon emissions and electronic waste (Mikhaylov et al., 2018). Each mining company includes numerous structures and infrastructures, and many of them are concentrated in a single location, which means that the energy needs in the territory in which they are built increase exponentially.

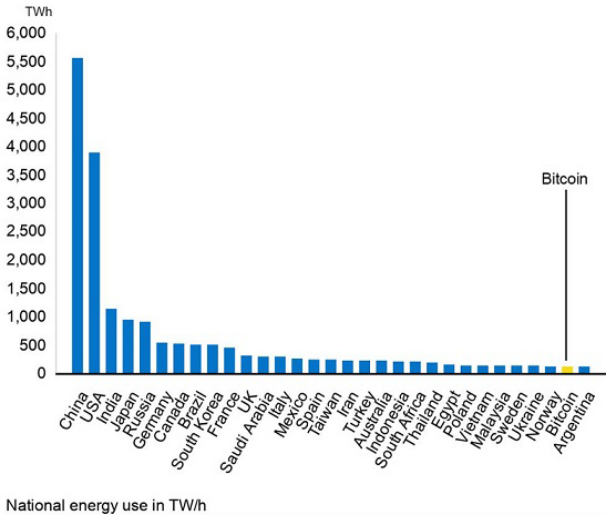

Figure 2. Graph extracted from the CEBCI DB

As can be observed in Figure 2, Bitcoin mining used more energy than Argentina, according to an analysis by the University of Cambridge in February 2021. With 121.36 terawatt hours, cryptocurrency mining, if it were a country, would be in the top 30 by the energy consumption. The CBECI "ranked Bitcoin's electricity consumption above Argentina (121 TWh), the Netherlands (108.8 TWh) and the United Arab Emirates (113.20 TWh) – and is gradually moving closer to Norway (122.20 TWh)" (Criddle, 2021).

To describe what has just been outlined by way of example, it is worth considering the case of the mining farm built in Ekibastuz, in the Pavlodar region, in northeastern Kazakhstan. If, in the Sichuan region, the mining farms could take advantage of renewable energy sources (e.g., hydroelectricity), after the relocation to Kazakhstan they used the electricity produced in the coal plants.

In the course of 2021, one of the largest mining farms globally came into operation in Kazakhstan – which requires a power supply that has contributed to the stress of the Kazakhstan electricity grid. The plant is in Ekibastuz, and is close to the Russian and Chinese borders, in the north-east of the country.

The facility can house up to 50,000 mining facilities, according to sales director Dmitriy Ivanov. Assuming full capacity with Bitmain's AntMiner S19 series or MicroBT's WhatsMiner M30 series, this would represent a mining power of around 5–6 EH/s, around 4% of bitcoin's current hashrate. Enegix already operates two mining facilities, but the Ekibastuz site is the largest: it will employ over 160 people, including engineers, electricians and security personnel. The facility would handle all the electricity needed to power 180,000 US homes. Construction of the facility began in August 2019 and, according to a series of slides shared with CoinDesk, cost $ 23 million (Baker, 2020).

This step offers a clearer overview than assumed in the previous lines. As announced, the plant uses the electricity supplied by the Kazakhstan grid, using a nearby coal-fired power plant, thus far beyond any rational eco-sustainability as observed by Nyangarika et al. (2018). One of the advantages that the mining company has certainly benefited from is the possibility of using low-cost energy sources (De Vries et al., 2022). To understand the impact of such an undertaking, it is appropriate to refer to the following data; primarily, the CBECI provides the latest estimate of the total energy consumption of the Bitcoin network. The data relating to final energy consumption are one of the parameters that make it possible to subsequently identify the carbon footprints linked to the extraction of Bitcoins.

Figure 3. Graph extracted from the CBECI database

Furthermore, the CBECI determines the total Bitcoin footprints and the individual Bitcoin transaction footprints, supporting the previously enunciated observations (Figure 3).

Table 1. The following data is extracted from the research: *Revisiting Bitcoin's carbon footprints* (source: De Vries et al., 2022)

Annualized Total Bitcoin Footprints		
Carbon Footprint	Electrical Energy	Electric Waste
114.06 Mt CO_2	204.50 TWh	32.22 kt

According to the data provided in Table 1, it is possible to observe that the carbon footprint, the consumption of electricity and waste from electronic equipment are comparable, respectively, to those of the Czech Republic, Thailand, and the Netherlands. The following table, on the other hand, provides the data relating to consumption per single transaction.

Table 2. The following data is extracted from the research: *Revisiting Bitcoin's carbon footprints* (source: De Vries et al., 2022)

Single Bitcoin Transaction Footprints		
Carbon Footprint	Electrical Energy	Electric Waste
1211.28 kg CO_2	2161.68 kWh	352.20 grams

Again, according to the data provided by the CBECI in Table 2, it can be observed that the carbon footprint, the consumption of electricity and waste from electronic equipment are equivalent, respectively, to the carbon footprint of 2,791,925 VISA transactions or 209,950 hours of viewing on YouTube; the energy consumption of an average American family in 77.41 days; to the weight of 2.17 iPhone 12 or 0.73 iPad[1] (Digiconomist, n.d.).

2.2. Evolution of the hashrates level

On June 21, 2021, the People's Bank of China (PBOC) enforced repressive legislation against cryptocurrency mining, under pressure from the Beijing government. The objective, officially, was to reduce the risks of illegal cross-border transfers of illegal assets and activities such as money laundering (Chudinovskikh & Sevryugin, 2019; Temirzhanova et al., 2020). Whatever the PRC government's goals, this event triggered the great migration of mining to countries where energy prices are among the lowest in the world, particularly in the southern United States. Let us now consider the data processed by the CBECI on hashrate levels by country[2] (Cambridge Centre for Alternative Finance, n.d.):

- IP addresses of mining facility operators are an accurate indicator of hashrate location;
- Data provided by participating mining pools constitutes a representative sample of Bitcoin's total geographic hashrate distribution;
- The available sample of Chinese province data is representative of the total hashrate distribution within China.

Below three tables depict the evolution of mining in Kazakhstan, the PRC, and the USA before and after the vetoes promoted by the PRC, starting from September 2019 until August 2021 (two months after the suppression of mining promoted by the PRC).

Table 3. The following data, relating to hashrate levels on an annual basis, is extracted from the CBECI database

	Evolution of Network hashrate (Eh/s)		
	PRC	USA	Kazakhstan
September 2019	66.8	3.6	1.3
September 2020	91.1	9.6	5.5
August 2021	0.0	42.7	21.9

Table 4. The following data, relating to the evolution of country share on an annual basis, is extracted from the CBECI database

	Evolution of country share (%)		
	PRC	USA	Kazakhstan
September 2019	75.5	4.1	1.4
September 2020	67.1	7.1	4.1
August 2021	0.0	35.4	18.1

Table 5. The following data, relating to the evolution of Chinese province share on an annual basis, is extracted from the CBECI database

	Evolution of Chinese province shares (%)		
	September 2019	September 2020	August 2021
Sichuan	49.5	61.1	0.0
Xinjiang	19.1	9.6	0.0
Yunnan	13.5	14.9	0.0

The absolute hash level estimated in Table 3, i.e., the detection of the miner's hardware power and the calculation frequency of the hash function per second

[1] General data can be consulted on the following web page: https://digiconomist.net/bitcoin-energy-consumption

[2] General data can be consulted on the following web page: https://ccaf.io/cbeci/mining_map/methodology

in absolute terms, highlights a notable increase in Kazakhstan starting in June 2021, second only to that of the USA.

Table 4 highlights a very significant data in terms of the average monthly share of hash rates by country; according to the CBECI, in August 2021, Kazakhstan is the second country in the world, after the USA, in Bitcoin mining, hence in percentage: USA = 35.40%; Kazakhstan = 18.10%.

Beyond just bitcoin, 2021 data for the global distribution of mining energy is only partially available, but past estimates (Table 5) have shown that 65% to 75% of the world's bitcoin mining has taken place in China, mainly in four Chinese provinces: Xinjiang, Inner Mongolia, Sichuan, and Yunnan. Hydropower in Sichuan and Yunnan make them renewable energy pivot, while Xinjiang and Inner Mongolia are home to many of China's coal-fired power plants – data is unstable, as miners move from one Chinese region to another to benefit from abundant electricity at advantageous market prices. After the vetoes imposed by the Beijing government these levels have been canceled, at least de jure. The evolution of the share by country, and the evolution of the network hashrate at a global level have seen the PRC as the absolute protagonist; in particular, the provinces of Sichuan and Xinjiang were the leaders in the sharing of hashrate. In Xinjiang, located on the border with Kazakhstan, there has been an increase in mining operations, just before the relocation.

3. Primary macro-economic indicators and CO2 emissions level

3.1. GDP increase

As noted in the report on the Kazakhstan economy of winter 2022, compiled by analysts of the World Bank Group and entitled *The Economic Recovery in Challenging Times*, during 2021, Kazakhstan's GDP has been recovering since the beginning of 2021 – as can be seen from the graph, it is approaching pre-pandemic levels (Figure 4).

In the first quarter there was a growth of 1.3%, and then stopped and resumed in the third quarter. Real GDP grew by around 0.4 and 1.4 percent quarterly in the second and third quarters, respectively, bringing the economy to pre-crisis size.

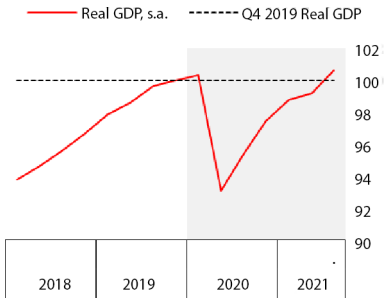

Figure 4. Graph extracted from World Bank report: "Kazakhstan Economic Update Winter 2021/2022" (The World Bank, 2022)

As regards the services sector (which includes the cryptocurrency mining activity), between the end of 2020 and the first nine months of 2021, there is a surge (3.0 points) due to the recovery following the softening of the measures to contain the global health emergency; however, without this representing a necessary causal link, this recovery coincides with the timing of the relocation of mining farms from China.

Therefore, as regards the productive sector, the country's economy is certainly growing following the reopening of the government, and the sector in which the greatest increase is recorded is that of services. So, comparing this data to the parameters provided by the CBECI observed in the subsection 1.2, it is possible to state that the recovery in the services sector coincides with an increase in mining activity in Kazakhstan. The next graph offers an overview of the scenario just described (Figure 5).

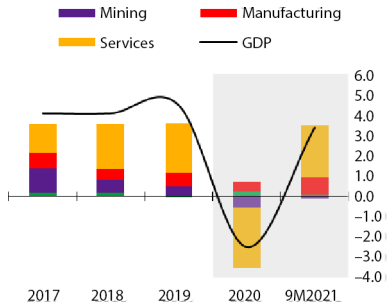

Figure 5. Graph extracted from World Bank report: "Kazakhstan Economic Update Winter 2021/2022" (The World Bank, 2022)

Furthermore, the GDP in Kazakhstan was worth 169.84 billion US dollars in 2020, according to official data from the World Bank; projections show that this value is set to increase also in 2022 (Figure 6).

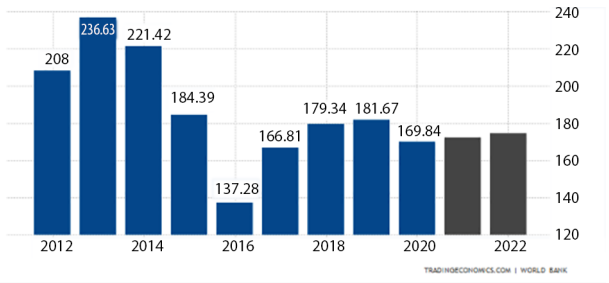

Figure 6. Graph extracted from WB database

On the other hand, the most interesting data is that relating to real GDP. The next graph highlights this parameter (Figure 7): Real GDP in Kazakhstan increased to 81269.23 KZT Billion in the fourth quarter of 2021 from 52676.39 KZT Billion in the third quarter of 2021. A constant increase is expected, at least by the end of 2022, in line with what is observed in Figure 6 about the nominal GDP[3] (Trading Economics, n.d.).

[3] General data can be consulted on the following web page: https://tradingeconomics.com/kazakhstan/gdp

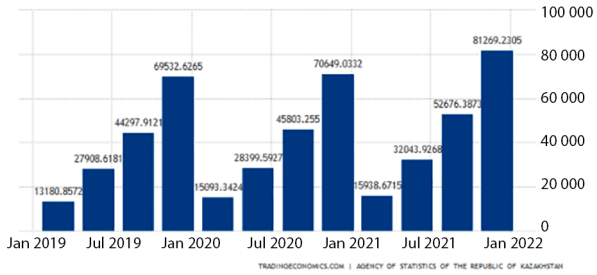

Figure 7. Graph extracted from the Agency of Statistics of the Republic of Kazakhstan

According to the Statistics Agency of the Republic of Kazakhstan, GDP Deflator in Kazakhstan decreased to 103.60 points in 2020 from 107.60 points in 2019. Furthermore, GDP Deflator in Kazakhstan is expected to reach 109.82 points by the end of 2022, considering Trading Economics global macro models and analysts' expectations.

3.2. Increased level of CO_2 emissions

Kazakhstan is highly dependent on aging coal-fired electricity plants, which supply about 70 percent of the country's electricity compared to 37 percent globally, according to the previous WB report and the IEA database (International Energy Agency, n.d.). This data is even more significant when compared to Bondarev's observations (2020), which express the need to improve the quality of energy sources in order for cryptomining to be sustainable. According to the Global Petrol Prices database, in June 2021, the price of electricity in Kazakhstan for the business area was USD 0.049 per kWh. The average world price was USD 0.137 per kWh[4] (Global Petrol Prices, n.d.). This is an advantageous price that has certainly played an important role in the relocation of mining farms from the bordering Chinese provinces.

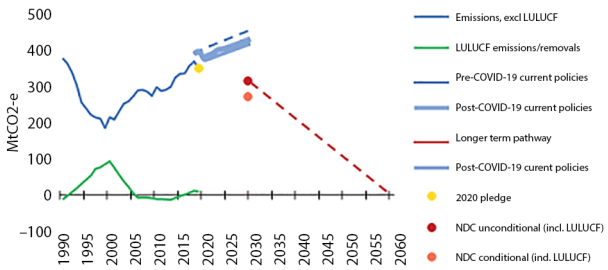

Figure 8. Graph extracted from World Bank report: "Kazakhstan Economic Update Winter 2021/2022" (The World Bank, 2022)

Kazakhstan's emissions (excl. LULUCF) of 355 Mt CO_2-eq in 2019 make it one of the highest emitters regionally and estimated 20th globally (Figure 8). The environmental impact due to the relocation of mining farms to Kazakhstan cannot be quantified in an absolute way, but always in relation to the emissions from mining plants and the footprints left by individual transactions; the fact remains that the data just proposed highlights the specific weight of a mining farm in terms of energy needs and emissions (Badea & Mungiu-Pupazan, 2021).

Conclusions

One of the main problems found in the studies is the following: the absence of a supervisory body – state or international – capable of guaranteeing a certain stability of exchange rates, i.e., the absence of a shared regulation within the same country or within a given political-economic community capable of guaranteeing energy and environmental sustainability.

During the descriptive analysis, the following limits were mainly found: the absence of IEA 2021–22 data relating to final electricity consumption by country and the impossibility of verifying the levels of hashrates provided by the major international institutions; so, considering the arguments presented, it is possible to state that: the relocation of mining farms from the PRC is certainly a contributory cause of the energy crisis that has hit Kazakhstan in 2021; this crisis has shown the dangerous drifts to which deregulated cryptomining leads. Cryptocurrency mining, if not properly regulated in the long term, produces more disadvantages than advantages, and risks being an economic-political element destabilizing the national and international order.

It is proposed to fuel the discussion regarding the need for a supranational institution with the aim of codifying a common international legislation, thus reinforcing the efforts made so far in this direction. This problem does not only concern Kazakhstan or the members of the BRICS, but it concerns both the CIS and the EU, or rather any other interstate or international organization. The lack of common legislation that defines the legal and economic-political limits of cryptocurrencies is an indication that there are no effective countermeasures; just think of the current geopolitical situation – which certainly wasn't born yesterday – in which interstate sanctions can be circumvented, among other ways, using cryptocurrencies managed by private companies that often act within real legal voids.

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[4] General data can be consulted on the following web page: https://it.globalpetrolprices.com/Kazakhstan/electricity_prices/

Disclosure statement

I do not have any competing financial, professional, or personal interests from other parties.

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