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Cryptocurrencies: Increased Anthropogenic Impact

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ABSTRACT

The emergence of cryptocurrencies is a response of technological development to the loss of trust in fiat money and the global banking settlement system. **The aim** of this study is to review existing ideas about the essence and anthropogenic impact of cryptocurrencies and determine the feasibility of their further use. **Methods** of contextual selection, system analysis, and general scientific methods were employed. **The results** show that the politico-economic contradiction of cryptocurrencies is their unreliability to preserve value concurrently with the high value of their production and use. Cryptocurrencies, having not yet become a mass phenomenon, already have a significant impact on nature, and their mass use conflicts with the transition to a green economy. **The key conclusion** is that increased use of cryptocurrencies will lead to an exponential rise in the use of limited resources. The production and use of cryptocurrencies as goods are associated with both obvious costs and significant negative external effects. Most importantly, governments view cryptocurrency as a threat to public finances rather than an environmental one. A possible solution to these contradictions may be the synthesis of centralized and decentralized currencies.

Keywords: green economy; fiat money; decentralized finance; cryptocurrency; value; carbon footprint; water footprint; regulation; central bank digital currency

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ОРИГИНАЛЬНАЯ СТАТЬЯ

Криптовалюты: усиление антропогенного воздействия

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АННОТАЦИЯ

Появление криптовалют стало результатом реакции технического развития на потерю доверия к фиатным деньгам и глобальной банковской системе расчетов. **Целью** данного исследования является обзор существующих представлений о сущности и антропогенном воздействии криптовалют и определение целесообразности их дальнейшего использования. Были использовали **методы** контекстуального отбора, системного анализа и общенаучные методы. **Результаты** показывают, что политико-экономическое противоречие криптовалют заключается в их ненадежности для сохранения ценности одновременно с высокой стоимостью их производства и использования. Криптовалюты, еще не ставшие массовым явлением, уже оказывают значительное влияние на природу, и их массовое использование противоречит переходу к зеленой экономике. **Основной вывод** заключается в том, что более широкое использование криптовалют приведет к экспоненциальному росту использования ограниченных ресурсов. Производство и использование криптовалют в качестве товаров сопряжено как с очевидными издержками, так и со значительными негативными внешними эффектами. Прежде всего правительства считают криптовалюты серьезной опасностью для государственных финансов и не столько угрозой окружающей среде. Возможным решением этих противоречий может стать синтез централизованных и децентрализованных валют.

Ключевые слова: зеленая экономика; фиатные деньги; децентрализованные финансы; криптовалюта; ценность; углеродный след; водный след; регулирование; цифровая валюта центрального банка

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Introduction

"Green economy" has been proposed as a means for catalyzing renewed national policy development and international cooperation and support for sustainable development.[1] Negative externalities [1], such as a market failure, lead to the fact that the transition to an environmentally friendly economy is carried out politically, not economically. At the same time, the global contradiction of the green economy is that economically developed countries have taken care of the problem of long-term survival, while poor countries, the so-called "Global South," solve the problems of short-term survival.

Another contradiction of the green economy is the reduction of emissions into the atmosphere due to the increased consumption of limited earth fossil resources and the environmental burden associated with the disposal of elements necessary for green energy: batteries, solar panels, wind turbines, electric vehicles, etc.

In parallel with the process of finding solutions to reduce the global impact on nature, the process of deglobalization and deregulation of global settlements based on the US dollar is underway. The world community is looking for effective tools to preserve value and make payments [2–6] in the face of compromising the centralized global payment system [7–9] and the falling value of the US dollar. There is a process of building not only geopolitical but also financial multipolarity: the dichotomy of centralized (CeFi) and decentralized finance (DeFi) [10].

This led to the emergence of currencies based on the functioning of computer programs — digital or cryptocurrencies. Their value content is determined by their limitations, which are caused by the complexity and cost of their production process. The main difference between digital and cryptocurrencies is designated as the sign of the presence or absence of centralization of the management of their emission and use.

The digital currencies of central banks and private currencies, by accelerating interaction, reducing transaction costs, and facilitating cross-border transactions, can ensure the transition to a more diversified multicurrency system [11, p. 16].

Like any human activity, cryptocurrency production and use impact the world around them. The purpose of this study is to review existing ideas about the essence and anthropogenic impact of cryptocurrencies and determine the feasibility of their further production and use.

Literature review

Cryptocurrency researchers can be subdivided into supporters and opponents of cryptocurrencies. Supporters of cryptocurrencies are usually journalists and business researchers, while opponents or cautious supporters are usually economists conducting basic research.

Works that substantiate the economic opportunities and positive prospects for the development of cryptocurrencies [12–13] are opposed by studies that assert the negative consequences and critical economic dangers of cryptocurrencies for society [2–4; 14–16].

A particular area of cryptocurrency research is represented by works that explore the natural and social consequences [17–26].

Methods

This study was based on a systematic approach to economic phenomena analysis. The first step was to analyze the value of a cryptocurrency. This analysis used classical principles of production costs and neo-institutional principles of transaction costs. In the second step, the social costs of cryptocurrencies were defined as anthropogenic impact. Finally, the regulation of cryptocurrencies was analyzed.

The methods used in this study include contextual selection of research and review articles, system analysis, and general scientific methods. Legislative acts and periodical articles were used as sources as well.

Results

Politico-economic contradictions of decentralized currencies

Friedrich Hayek laid the foundations of the decentralized or private money theory and justified the possibility of money competition. Hayek pointed out that the advocates of "Free Banking" in the early 19th century and the agitators for "Free Money" — Silvio Gesell, Heinrich Rittershausen, Henry Meulen, and others — supported free issue because they wanted more money and did not recognize that government, more often than any private enterprise, had provided us with the "Schwundgeld" (shrinking money) that S. Gesell had recommended.

[1] Green Economy. The United Nations Department of Economic and Social Affairs. URL: https://sdgs.un.org/topics/green-economy (accessed on 11.04.2024).

He also criticized a single international currency, saying that if it is not adequately managed, it is worse than a national currency [27, p. 14].

Hayek advocated allowing private companies to issue fiat money, mainly on the basis that a system of competitive issuers would be more effective at ensuring price stability than a central bank. Thus, his theory of private money is relevant in relation to cryptocurrencies [28].

Cryptocurrencies have neither the properties of a tangible commodity nor the inherent guarantee of the money issued by central banks. At the same time, their competitive advantages are anonymity and lack of credit expansion (in some cases, it is technically feasible with regard to cryptocurrencies). Cryptocurrencies are becoming a savings tool in the face of constant global inflation and growing distrust of fiat money. The rarity of cryptocurrencies is due to the complex mechanism of their issuance as compared to fiat money. The halving, as a process that limits the issuance of new units of a cryptocurrency, creates scarcity and can influence its price, occurs at regular intervals, determined by the number of blocks created. Thus, unlike fiat currencies, cryptocurrencies are not regulated by the need for growth or decrease in commodity value.

However, this is a relative rarity because there are many types of cryptocurrencies, and their diversity is constantly increasing. V.P. Bauer and V.V. Smirnov [29] examined in detail the logic of blockchain consensus algorithms, which makes one of the main contributions to ensuring the competitiveness of cryptocurrencies. Historically, the first consensus algorithm was the Proof of Work (PoW), a proof of network algorithm. It is implemented in a variety of cryptocurrencies that are in the top 10 of the cryptocurrency rating. Its competitor, the Proof of Stake (PoS) algorithm for proof of ownership in the common pool of cryptocurrencies, which requires fewer computing expenses but is less reliable, is already gaining its share among cryptocurrencies. Hybrid algorithms are promising.

Another feature of decentralizing the circulation of cryptocurrencies is the lack of guarantees to ensure transactions. If, when issuing a cryptocurrency, its producer (miner) receives the main reward for the production itself and not for transactions, then with the reduction and achievement of a complete cessation of the issue, only those miners who will be satisfied with a relatively low reward for transactions will remain. A decrease in the number of participants in the exchange system will inevitably lead to a decrease in its stability.

This is fully explained by K. Marx's theory of capital [30]. With each subsequent stage in the production of cryptocurrencies, the share of permanent capital increases (indirect labor) in the form of computer technology, and the share of variable capital (direct labor), due to which income is created, decreases. At some time, the capital owner's income (profit) will cease to suit the owner, and the last one will transfer the capital to another sphere of use.

Historically, the first PoW-based cryptocurrency and the one most discussed is Bitcoin. In 2023, Bitcoin's dominance exceeded 52.17% in the cryptocurrency market, indicating its significant influence on most of it [15]. In June 2021, the five largest mining pools mined 62.35 percent of Bitcoin blocks [17]. According to the TradingView platform dominance index, calculated as the ratio of coins' market capitalization to the base market capitalization of the top 125 coins, Bitcoin has been confidently holding its position for 10 years with an index measurement of more than 50%.[2] Like an unregulated market with a monopolistic tendency, Bitcoin has become an oligopolistic commodity. Centralization is beginning to take over the proclaimed decentralization.

A comparison of the main characteristics of fiat and cryptocurrencies is presented in *Table 1*.

These characteristics do not allow us to consider cryptocurrencies as full-bodied money. At their core, they are speculative financial assets.

Analyzed from the perspective of the Marxist political economy, digital currency is the result of the development of a commodity economy, a new form of commodity value with a unique credit-building mechanism [18].

The paradox is the simultaneous combination of significant material costs for their production (labor costs) and the absence of a tangible product, physicals, or having a value that, like gold, can be preserved in time and space. This is confirmed by the significant fluctuations in the valuation of cryptocurrencies, expressed in units of traditional sovereign currencies. The data from January 2018 to November 2023 shows, in terms of average monthly absolute price volatility, Dogecoin's and Ether's absolute price volatility of 489% and 126%, respectively [18].

[2] Market Cap BTC Dominance. URL: https://www.tradingview.com/symbols/BTC.D (accessed on 10.02.2025).

Table 1
The main characteristics of fiat and cryptocurrencies

Fiat currency	Cryptocurrency
Directive entity	Voluntary entity
The issue and quantity are controlled by the central bank	The release and quantity are pre-programmed and limited
The value content is regulated by a central bank, and its sharp fluctuations are generally controlled	The value content is regulated exclusively by the market, and its constant sharp fluctuations are possible
It can have a material (physical) form	There is no material (physical) form
It can be used without electricity and internet	It cannot be used without electricity and internet
It has territorial restrictions on their use	It can be used in any country
Cash and non-cash payments (transfers)	Non-cash payments (transfers)
Payments are made by banks that are responsible as an intermediary	Transfers are anonymous, all risks are borne by the direct participants of the exchange
Mass transfers, economies of scale, developed infrastructure of payments	The cost of transfers varies significantly, the infrastructure is just being formed
Historically established legislation	Formation of legislation

Source: Compiled by the author.

Thus, we find similarities between fiat and cryptocurrencies in value virtualization. At first, gold as money began to be replaced by a cheaper analog of value — paper money. The time is ripe for cryptocurrencies, which also do not represent real value, but unlike paper and electronic money, significant resources are spent on their production. This should concern both practitioners and financial regulators alike since the decentralized nature of this technology causes severe misusage and waste of electricity that can be used more efficiently elsewhere, and for potentially more useful purposes [19].

Although cryptocurrencies perform the money function as a means of payment today, they are still mainly used as an investment tool like securities. Significant trading activity in Bitcoin/US dollar, particularly during speculative attacks and short squeezes, can substantially impact the US dollar/EUR market, increasing price volatility as traders adjust their strategies [16]. However, unlike financial instruments, cryptocurrencies require significant resources for their production and circulation system maintenance that could be used in real (physical) production.

It is also worth noting that according to the survey researchers,[3] the average cryptocurrency trader is under 40 (mean age is 38) and does not have a college degree (55 percent). We assume that this financial instrument is used by people who have already achieved a certain degree of material wealth but are not armed with systems thinking.

The environmental impact of cryptocurrencies

The issue of the anthropogenic impact of the creation and usage of cryptocurrencies is pervasive and pertinent to the agenda of climate change and efforts to make the economy more environmentally friendly. The main factors of the adverse impact of cryptocurrencies on the environment are as follows:

1. High energy intensity, both in the production and subsequent use of cryptocurrencies.

Blockchain technology involves the constant use of computing resources, both in the process of generating the code of the crypto unit itself and in the process of its transactions. Cryptocurrencies whose developers use a less energy-intensive type of transaction, like Ethereum, lose out in terms of transaction security, which means they have lower demand and cost [20]. The average Ethereum electricity consumed per transaction ranges from 0.8 to 14.7 Wt, while a Mastercard transaction consumes only 0.7 Wt on average [20]. In comparison, the energy footprint per Bitcoin transaction was estimated in 2021 to be 619 kWt, which is equivalent to 350,000 VISA transactions [19]. The problem is that the next transaction is more energy wasting, and in 2024, a Bitcoin transaction was estimated to be 838 kWt — the equivalent of 77,932 hours YouTube watching.[4] The Bitcoin

[3] NORC AmeriSpeak Omnibus Survey: Spotlight on Cryptocurrency. 2021. URL: https://www.norc.org/content/dam/norc-org/pdfs/Spotlight%20on%20cryptocurrency%20Topline.pdf (accessed on 22.11.2024).

[4] Bitcoin Energy Consumption Index. Digiconomist. URL: https://digiconomist.net/bitcoin-energy-consumption (accessed on 22.11.2024).

network power demand is monitored daily by the Cambridge Bitcoin Electricity Consumption Index (CBECI), the project of the Cambridge Centre for Alternative Finance.[5] The estimated global carbon footprint in November 2024 was 97.64 Mt — equivalent to the carbon footprint of Qatar.

There are studies claiming that Bitcoin investments can be less carbon intensive than standard equity investments and thus reduce the total carbon footprint of a portfolio [2]. However, this would be justified if the authors took into account the fact that standard investments are associated with the production of real value, not fictitious (virtual).

2. The use of polluting energy sources.

Since cryptocurrencies involve high energy costs, cheap energy from fossil sources, primarily coal, is used to produce crypto units. Until 2022, China, due to cheap coal-based electricity, occupied a leading position in the production of Bitcoins — about 63%, while miners used regions with thermal energy for most of the year. According to the study [21], in less than five years in the sample period, Bitcoin mining in China has generated 77.84 million tons of carbon dioxide emissions, equivalent to one year's carbon emissions of Greece (79.91 million tons). Bitcoin mining has profoundly impacted China's regional power supply. A larger ratio of intra-provincial electricity consumption to inter-provincial electricity transmission indicates less external power transmission and more intra-provincial consumption. This trend indicates a reduction in China's proportion of hydropower supply and an augmentation in coal-fired power supply, leading to an increased "carbon footprint" in the electricity supply.

There is a strong positive, significant relationship between Bitcoin returns and both Chinese and Russian electricity company price volatility, indicating that there exists evidence of interactions between Bitcoin and electricity companies in these key mining pool regions [19].

Initiatives to use alternative energy sources for the production and use of cryptocurrencies should be critically evaluated since short-term benefits are outweighed by long-term losses to society from the costs of recycling "green" generation (solar panels, wind turbines, nuclear fuel).

The causality result shows bidirectional causality between bitcoin and climate policy uncertainty, while unidirectional causality runs from the price of the energy index to bitcoin [22].

3. The expenditure of a vital resource — water.

Bitcoin's expanding water footprint must be considered in the context of escalating water scarcity [23]. The direct water footprint of Bitcoin miners is the water consumption of the data centers (systems cooling and air humidification). The indirect water footprint is the water consumption of electricity generation. The total water footprint of US Bitcoin miners could be equivalent to the average annual water consumption of around 300,000 US households, comparable with a city such as Washington, DC. The estimated water footprint of Bitcoin mining in Kazakhstan alone was 997.9 GL in 2021, while the nation's capital could face a water shortage of 75 GL per year by 2030.

4. The expenditure of computing resources and the growth of computer recycling costs.

In 2009, competing Bitcoin miners were able to successfully win blocks with an average laptop. Minimum viable mining operations today require several hundred tailored computers in the form of Application Specific Integrated Circuit (ASIC) units [24]. Redundant units create around 30,400 tonnes of e-waste each year [25].

The problem of electronic waste is compounded by the desire of owners of capital used in the production of computing equipment to constantly expand demand to maintain return on capital:

- a consistent shift in the consumption pattern which pushes replace over repair;
- software upgrades are pushing the hardware upgrades [31].

Thus, the production and use of cryptocurrencies as goods are associated with both obvious costs and significant negative external effects. The authors [24] argue that the deceptive and/or clandestine appropriations of energy, water, and land (and excretions of noise, heat, electronic and other wastes) by crypto miners create a parasitic relationship between the cryptocurrency software and local communities. There are the disingenuous development credentials used by blockchain projects to colonize places and displace the locals, usually in the Global South. Despite their professed decentralized architectures, blockchain projects inevitably tend to centralize power, rather than redistribute it or bring it down.

Policymakers need to be concerned about the environmental challenge of using cryptocurrencies and introduce sufficient regulation in this area.

[5] Electricity Consumption Index. Cambridge Centre for Alternative Finance. URL: https://ccaf.io/cbnsi/cbeci (accessed on 22.11 2024).

Regulation of the issue and circulation of cryptocurrencies

The current regulation of cryptocurrencies is less related to their anthropogenic impact and external effects than to competition with centralized finance and a lack of energy capacity. Cryptocurrency negative externalities, like others, are difficult to quantify. The decentralized model has made regulatory efforts difficult, so determining who ought to be responsible for taxes or charges, and how a state may implement them, is problematic [26].

However, the complete lack of regulation of cryptocurrencies means that the country is going against global efforts to reduce anthropogenic impact and decarbonize the planet. The main directions in internalizing the costs of cryptocurrencies are as follows:

- stimulating the transition to less energy-intensive production and transaction technologies by taxing participants in the cryptocurrency system;
- stimulating the transition to less energy-intensive equipment by taxing not only cryptocurrency producers but also equipment manufacturers.

In several countries — China, Algeria, Egypt, Morocco, Afghanistan, Bangladesh, Nepal, etc.,— cryptocurrencies are completely illegal. They are seen as a serious obstacle to fiat money and as a tool to circumvent laws. A serious blow to cryptocurrencies was the ban on their mining and circulation in the world's largest economy (according to purchasing power parity) — China.[6] It has led to the migration of miners to other countries with low electricity costs, due to the availability of natural resources or government subsidies: Kazakhstan, Russia, Moldova, Abkhazia, Canada, as well as some US states [24].

The main reason for banning cryptocurrencies in China was the introduction of the digital yuan. Central bank digital currency (CBDC) or digital fiat currency, as well as cryptocurrencies, are issued using computer programs. But they are issued by the central bank as fiat money. The question of the possibility of competition between CBDC and cryptocurrencies is whether the CBDC release will use blockchain technology and transaction decentralization. Opponents of the CBDC argue that while maintaining the centralization of settlements, the CBDC will be used as a tool to control public spending, as well as the implementation of limits or a complete ban on economic exchange.[7] According to the European Central Bank research, the CBDC unconstrained demand is between 3% and 28% of total household liquid assets, but with an illustrative € 3,000 holding limit per person, the aggregate digital euro take-up could range only between 2% and 9% of total household liquid assets in a steady state [32].

The Russian Federation, with its rich natural resources and low energy costs, is an attractive place for cryptocurrency miners. On November 1, 2024, mining was legitimized by amending several existing laws.[8] Miners are to provide information about the mined cryptocurrency and the addresses of their crypto wallets and mining pool if they are individuals who exceed the energy consumption limit of 6000 kW a month or legal entities. At the same time, advertising and digital currency payments are prohibited, except for foreign trade settlements. Taxation is carried out similarly to the taxation of foreign exchange transactions. The government may also ban or restrict mining in certain regions.

Based on the introduced norm of 6,000 kW, the owner of no more than 2–3 mining computers is considered a small miner in Russia (based on the average consumption of 1 mining machine of 2,160 kW, excluding air conditioning[9]).

To reduce energy consumption, including the production of cryptocurrencies, Russia has begun switching to a three-tariff electricity payment system, which should be completed by January 1, 2026.[10] Consumption from 3,600 to 6,000 kW per month belongs to the second most expensive category, and more than 6,000 kW per month belongs to the third, most expensive one. Thus, large miners will incur increased energy costs, which may reduce the production and use of cryptocurrencies.

For comparison, before this switching, the border of the social norm (low tariff) in the Irkutsk

[6] The People's Bank of China. Notification of further prevention and control of speculative risks in virtual currency transactions. 24.09.2021. (In Chinese). URL: http://www.pbc.gov.cn/goutongjiaoliu/113456/113469/4348556/index.html (accessed on 23.11.2024).

[7] Snowden E. Your money and your life. 2021. URL: https://edwardsnowden.substack.com/p/cbdcs. (accessed on 23.11.2024).

[8] Federal Law of the Russian Federation "On amendments to certain legislative acts of the Russian Federation". 08.08.2024, No. 221. (In Russ.). URL: http://publication.pravo.gov.ru/document/0001202408080016 (accessed on 22.11.2024).

[9] Analysts have named the cheapest regions of Russia for mining. Eksklyuzivy RBK. 18.11.2024. (In Russ.) URL: https://www.rbc.ru/business/18/11/2024/6738c61d9a79471b919f75a9 (accessed on 23.11.2024).

[10] The Government of the Russian Federation. Government Decree No. 1469. 11.11.2024. URL: http://publication.pravo.gov.ru/document/0001202411010020 (accessed on 23.11.2024).

region was 25,000 kW; by means of it, as well as its proximity to China, which banned mining, this Russian region became a Mecca for crypto miners. More than 50% of the energy consumption by manners in the unified energy system of Siberia falls on the Irkutsk region.[11] The planned data centers capacity is 1,245 megawatts, more than the capacity of large industrial enterprises. The tax return from 1 megawatt of connected power from legitimate mining is 220 times less than that from conventional industrial enterprises in this region. The result was a shortage of electricity in this and adjacent regions (the Republic of Buryatia and the Trans-Baikal Territory) and a ban on mining during the heating period.

At the same time, the norm of 6,000 kW is contestant to the climatic conditions of Siberia, where electricity is consumed more than this norm in winter for household heating. An alternative would be natural gas-based heating, but many regions of Siberia are poorly gasified, unlike the European part of the country. Thus, by trying to impose restrictions on miners, the state affects the interests of ordinary consumers.

After China's exit as a strong player from the cryptocurrency market, Russia and the United States became the primary competing platforms for cryptocurrency production.[12] The introduction of US sanctions against Russian IT companies is a confirmation of the intensification of this competitive struggle.[13]

Cryptocurrency regulation should be comprehensive, given the involvement of the IT sector in this process. The negative impact of the IT sector on the environment could be reduced to a certain extent by adopting the responsible practices of the circular economy, which signifies reusing some of the raw materials of the disposed equipment for a more sustainable approach to consumption. The governments and local authorities also have larger responsibilities by legislating the circular economy model, promoting eco-friendly manufacturing and adopting a responsible way of sustainable consumption [31].

Discussion

Our research has shown that the problem of the growing environmental impact of cryptocurrencies co-exists with the political and economic difficulty of the contradiction between the costs of creating and preserving the value of cryptocurrencies and the benefits of using them as a decentralized financial instrument. Both the principles of the green economy implementation and reducing the anthropogenic impact of cryptocurrencies require government regulation. The latter one demands the proposal of an alternative that limits the use of decentralized cryptocurrencies. This alternative and the subject of further research is the combination of the principles of functioning of centralized and decentralized finance: the synthesis of an administrative mechanism and a clean market as coordination systems. DeCeFi: decentralization with accompanying elements of centralization, but not vice versa, since the ideology of cryptocurrencies, albeit in a modified form, must be preserved [33].

Every central bank will eventually have to confront the looming challenges from cryptocurrencies, stablecoins such as Libra, and broader fintech developments [34]. The country whose currency will be the first to become a successful embodiment of DeCeFi with well-developed legislation, technical support, and guarantees of uninterrupted payment system operation can become a new global financial leader.

Conclusion

Cryptocurrencies, despite their resource consumption, do not have the property of preserving commodity value, like fiat money. The technology of using cryptocurrencies (PoW, especially) does not contribute to reducing the employment of resources but rather to increasing it considerably. Resource consumption, especially the energy consumption of cryptocurrencies, is becoming a significant problem in reducing the effects of human impact on nature and climate change. Regulators are more concerned about the financial losses from cryptocurrencies production than their anthropogenic impact and impact on sustainable development.

An alternative to regulatory restrictions could be the development of CBDC with elements of decentralization.

[11] In the Irkutsk region, mining is going to be banned throughout the territory during the heating season. IRK.RU. 18.11.2024. (In Russ.). URL: http://www.irk.ru/news/20241119/mining/ (accessed on 26.11.2024).

[12] Mingazov S. Russia has taken the second place in the world in mining cryptocurrencies. Forbes. 07.04.2023. (In Russ.). URL: https://www.forbes.ru/finansy/487282-rossia-vysla-na-vtoroe-mesto-v-mire-po-majningu-kriptovalut (accessed on 23.11.2024).

[13] Department of the Treasury. Prohibition on Certain Information Technology and Software Services. 06.06.2024. URL: https://ofac.treasury.gov/media/932951/download?inline (accessed on 20.11.2024).

REFERENCES

1. Pigou A.S. The Economics of Welfare. London: MacMillan and Co., Ltd.; 1920. xxxvi +976 p.
2. Baur D.G., Dimpfl Th., Kuck K. Bitcoin, gold and the US dollar — A replication and extension. *Finance Research Letters*. 2018;25:103–110. URL: https://doi.org/10.1016/j.frl.2017.10.012
3. Hung J.-Ch., Liu H.-Ch., Yang J.J. The economic value of Bitcoin: A volatility timing perspective with portfolio rebalancing. *The North American Journal of Economics and Finance.* 2024;74:102260. URL: https://doi.org/10.1016/j.najef.2024.102260
4. Karau S. (2023). Monetary policy and Bitcoin. *Journal of International Money and Finance*. 2023;137:102880. URL: https://doi.org/10.1016/j.jimonfin.2023.102880
5. Kuehnlenz S., Orsi B., Kaltenbrunner A. Central bank digital currencies and the international payment system: The demise of the US dollar? *Research in International Business and Finance*. 2023;64:101834. URL: https://doi.org/10.1016/j.ribaf.2022.101834
6. Reboredo J.C., Rivera-Castro M.A. Can gold hedge and preserve value when the US dollar depreciates? *Economic Modelling*. 2014;39:168–173. URL: https://doi.org/10.1016/j.econmod.2014.02.038
7. Conlon Th., Corbet S., Goodell J.W., Hou Y. (G.), Oxley L. Financial market information flows when counteracting rogue states: The indirect effects of targeted sanction packages. *Journal of Economic Behavior and Organization*. 2024;217:32–62. URL: https://doi.org/10.1016/j.jebo.2023.10.036
8. Liu X.-Y., He W., Duan Y.-P., Fan R. The impact of financial sanctions on economic policy uncertainty: Global evidence. *Pacific-Basin Finance Journal*. 2024;88:102558. URL: https://doi.org/10.1016/j.pacfin.2024.102558
9. Syropoulos C., Felbermayr G., Kirilakha A., Yalcin E., Yotov Y.V. The Global Sanctions Data Base — Release 3: COVID-19, Russia, and Multilateral Sanctions. *Review of International Economics*. 2024;32(1):12–48. URL: https://doi.org/10.1111/roie.12691
10. Abramova M.A. Research on the development of decentralized finance in the context of banking business. *Izvestiya Sankt-Peterburgskogo gosudarstvennogo ekonomicheskogo universiteta*. 2024;3(147):14–18. (In Russ.). URL: https://unecon.ru/wp-content/uploads/2024/07/izvestiya-3–2024.pdf
11. Krinichanskij K.V., Rubtsov B.B., Genkin A.S. et al. Financial markets in the light of the modern digital agenda. Moscow: KnoRus; 2024. 260 p. (In Russ.).
12. Antonopoulos A.M. The Internet of Money: A collection of talks by Andreas M. Antonopoulos: Vol. 1. MerkleBloom LLC; 2016. 152 p.
13. Tapscott D., Tapscott A. The Blockchain Revolution: How the Technology Behind Bitcoin is Changing Money, Business, and the World. Penguin Books; 2016. 348 p.
14. Prasad E.S. The future of money: how the digital revolution is transforming currencies and finance. Cambridge London: The Belknap Press of Harvard University Press; 2021. 485 p.
15. M'bakob G.B. Bubbles in Bitcoin and Ethereum: The role of halving in the formation of super cycles. *Sustainable Futures.* 2024;7:100178. URL: https://doi.org/10.1016/j.sftr.2024.100178
16. Alaminos D., Belén Salas-Compás M., Fernández-Gámez M.Á. Can Bitcoin trigger speculative pressures on the US Dollar? A novel ARIMA-EGARCH-Wavelet Neural Networks. *Physica A: Statistical Mechanics and its Applications*. 2024;654:130140. URL: https://doi.org/10.1016/j.physa.2024.130140
17. Atkins E. Populist ecologies of Bitcoin. *Political Geography.* 2022;94:102535. URL: https://doi.org/10.1016/j.polgeo.2021.102535
18. Xu Q. Adaptation of Marxian Economic Theory in Digital Currency System Based on Blockchain Technology. *Applied Mathematics and Nonlinear Sciences*. 2024;9(1):1–16. URL: https://doi.org/10.2478/amns-2024–2683
19. Corbet S., Lucey B., Yarovaya L. Bitcoin-energy markets interrelationships — New evidence. *Resources Policy*. 2021;70:101916. URL: https://doi.org/10.1016/j.resourpol.2020.101916
20. de Vries A. Cryptocurrencies on the road to sustainability: Ethereum paving the way for Bitcoin. *Patterns*. 2023;4(1):100633. URL: https://doi.org/10.1016/j.patter.2022.100633
21. Xiao Z., Cui S., Xiang L., Liu P.J., Zhang Y. The environmental cost of cryptocurrency: Assessing carbon emissions from bitcoin mining in China. *Journal of Digital Economy*. 2023;2:119–136. URL: https://doi.org/10.1016/j.jdec.2023.11.001
22. Sarker P.K., Lau C.K. M., Pradhan A.K. Asymmetric effects of climate policy uncertainty and energy prices on bitcoin prices. *Innovation and Green Development*. 2023;2(2):100048. URL: https://doi.org/10.1016/j.igd.2023.100048

23. de Vries A. Bitcoin's growing water footprint. *Cell Reports Sustainability*. 2024;1(1):100004. URL: https://doi.org/10.1016/j.crsus.2023.100004
24. Howson P., Rosales A., Jutel O., Gloerich I., Llorens M.G., de Vries A., Crandall J., Dolan, P. Crypto/Space: Computational parasitism, virtual land grabs, and the production of Web3 Exit zones. *Political Geography*. 2024;115:103210. URL: https://doi.org/10.1016/j.polgeo.2024.103210
25. de Vries A., Stoll C. Bitcoin's growing e-waste problem. *Resources, Conservation and Recycling*. 2021;175:105901. URL: https://doi.org/10.1016/j.resconrec.2021.105901
26. Truby J. Decarbonizing Bitcoin: Law and policy choices for reducing the energy consumption of Blockchain technologies and digital currencies. *Energy Research & Social Science*. 2018;44:399–410. URL: https://doi.org/10.1016/j.erss.2018.06.009
27. Hayek F.A. Denationalisation of Money: An Analysis of the Theory and Practice of Concurrent Currencies. London: Institute of Economic Affairs; 1976. 108 p.
28. Mihajlov A.Y. Development of Friedrich von Hayek's theory of private money and economic implications for digital currencies. *Terra Economicus*. 2021;19(1):53–62. (In Russ.). URL: https://doi.org/10.18522/2073–6606–2021–19–1–53–62
29. Bauer V.P., Smirnov V.V. Institutional Features of the Development of Competitive Cryptocurrency. *Finance: Theory and Practice*. 2020;24(5):84–99. URL: https://doi.org/10.26794/2587–5671–2020–24–5–84–99
30. Marx K. Das Kapital: Kritik der politischen Oekonomie; herausgegeben von Friedrich Engels. Vol. 3: Der Gesamtprozess der kapitalistischen Produktion (1 ed.). Hamburg: Verlag von Otto Meissner; 1894. XXVIII, 422p. URL: https://doi.org/10.3931/e-rara-25739
31. Dwivedi Y.K., Hughes L., Kar A.K., Baabdullah A.M., et al. Climate change and COP26: Are digital technologies and information management part of the problem or the solution? An editorial reflection and call to action. *International Journal of Information Management*. 2022;63:102456. URL: https://doi.org/10.1016/j.ijinfomgt.2021.102456
32. Lambert C., Larkou C., Pancaro C., Pellicani A. et al. Digital euro demand — Design, individuals' payment preferences and socioeconomic factors. European Central Bank; 2024. URL: https://doi.org/10.2866/397241
33. Abramova M.A., Dyudikova E.I. In the modern discourse about the digital ruble: DeCeFi vs CeDeFi. *Bankovskie uslugi = Banking services.* 2024;5:2–11. (In Russ.). URL: https://finvector.ru/wp-content/uploads/2024/06/bu-5–2024-rus.pdf
34. Prasad E.S. The Case for Central Bank Digital Currencies. *The Cato Journal*. 2021; Spring-Summer. URL: https://www.cato.org/cato-journal/spring/summer-2021/case-central-bank-digital-currencies

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