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## Article

# Cryptocurrency market analysis from the open innovation perspective

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Article

# Cryptocurrency Market Analysis from the Open Innovation Perspective

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**Abstract:** The paper focuses on the analysis of the cryptocurrency open innovation market to predict sustainable growth in the future. The nature of cryptocurrencies ‘development leads to the rapid increase in their popularity and spread of trading at this new market. The high volatility of these assets is encouraging to understand and predict their price in ever changing market environment. The paper proposed the pool complexity approach to choose optimal technology using social activity in the internet, trading parameters, technical indicators and other cryptocurrency data. According to the results of the analysis, the most effective and promising cryptocurrency is EOS cryptocurrency, which has the lowest complexity and commission level among the analyzed digital currencies and allows you to implement third-party applications in the system.

**Keywords:** cryptocurrency; data selection; EOS; Bitcoin; ethereum

## 1. Introduction

The period from the 20th until the early 21st century has been characterized by intensive development of the global financial sector. Financial systems are actively developing, transforming, and adjusting to certain economic and technological requirements, creating an environment for the effective functioning of commodity-money and financial relations, as they are the circulatory system of world economies. The main catalysts for financial open innovations have recently been actively developing processes of globalization and digitalization of world economies. In such conditions, increased regulatory requirements are imposed on payment systems and tools since risks are shared between world economies [1,2].

This study fills the gap in the analysis of the prospects and risks of developing cryptocurrency as an element of the financial system. The paper creates a theoretical base for crypto market prices prediction.

Digital currencies are capable of developing existing payment systems and financial institutions, as they represent a new understanding of the form of money and the security of transactions. For example, one of the world financial leaders—the United States—has been actively conducting research and actions to introduce cryptocurrencies into the internal payment system since 2019. At the end of 2019, the US Congress passed a bill for consideration called the “Crypto-Currency Act of 2020”. It reviewed the procedure for the recognition, licensing, and registration of digital currencies as a form of payment, and also established a list of state institutions responsible for the regulation and control of the new currency [1,3,4]. Today it is difficult to assess and evaluate the significance of this technology and the prospects for its development. However, digital currencies can become a new generally accepted means of payment, replacing the usual fiat money. In this case, the most successful cryptocurrency system owned by a particular country can gain a significant advantage in the race of financial “arms” and leadership in the financial arena. This makes it difficult to analyze the potential of cryptocurrency development in Russia and other global economies at the present time. In addition, the transparency of data flow in the network of cryptocurrency systems can potentially solve the

problems of corruption and the shadow or underground sectors of the economy that exist in each state, to one degree or another [5,6].

The goal of this work is to analyze the prospects and risks of developing cryptocurrency as an element of the financial system.

To achieve this goal, the following tasks must be completed:

1. the study of digital currencies' theoretical basis.
2. consideration of the chronology of blockchain technology and cryptocurrency development.
3. analysis of the current state of the market and comparison of cryptocurrencies.
4. evaluating the possible threats and prospects for the development of cryptocurrencies within the global financial system.

## 2. Literature Review

### 2.1. The Innovation in Cryptocurrency Market

At this stage in the development of payment systems and technologies, cryptocurrencies are something new—an asset unsuitable for widespread use. The concept of cryptocurrencies in domestic and foreign literature is often equated with other similar names, such as virtual currency, digital currency, electronic money and digital gold, but in practice it has a number of distinctive properties that do not fully define these concepts as synonyms [2].

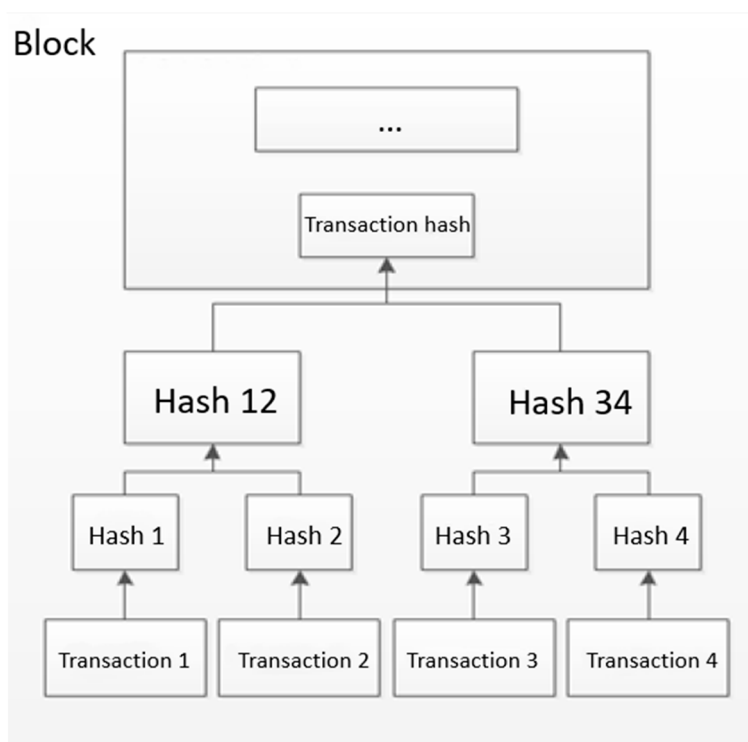
The term “digital currency” is the most generalized concept, which implies a special non-material form of existence of currency in a digital (electronic) form. Since the data on cash flows is stored on remote servers, access to the Internet or another network that provides for the interaction of electronic wallets is required to perform operations and interact with this type of currency. Digital currencies have no intrinsic value—they only reflect the equivalent of funds deposited on the issuer's balance sheet, or, otherwise, the right to claim against the provision of funds. However, this type of currency is often intended to pay for goods and services on certain online stores, sites, and social networks [3–5].

The name “cryptocurrency” itself came from the science called cryptography. Cryptographers study methods to ensure confidentiality of information and has deep roots, being more than four thousand years old. The modern interpretation of cryptography is based on elements of mathematics and computer science and is a method of encrypting data with a certain key that provides access to the decryption of the data. Cryptography has developed in several subspecies over its long history: symmetric encryption—the recipient and the sender of the data have the same keys to decrypt the information exchanged with each other; and asymmetric encryption—each of the network participants has a public key confirming the participant's status. Meanwhile, the sender of the data has a secret key to decrypt the information being sent, which he shares with the desired recipient.

Hashing is a method that involves converting an array of data into a specific code that stores information about this very data. This transformation is called a hash function, and the result of the encryption is called a hash code. Each hash code is unique, and its decryption leads to the receipt of the original data. It is this subspecies of cryptography—hashing—that is the basis for the formation of cryptocurrency systems, reflecting their essence: the technological nature of creation and the security inherent in these systems. The scheme for obtaining a hash of transactions is shown in the figure below. This technology increases the level of confidentiality and reliability of transaction data. The process of hashing an array of data is as follows: information about the individual operations performed is converted by a hash function, and separate hashes are formed. This encrypted data is combined and modified by the following hash function, and, as a result, the largest combination of functions will be the transaction hash, with which the data will be decrypted. As a result, information data blocks are formed [4–8].

Furthermore, the hashed data formed in blocks create a single stream of interconnected information, protected using blockchain technology (Figure 1). Due to this, transactions cannot be reversed, and it is impossible to change the degenerated data. Each generated block in the blockchain network contains

information about the previous block, including a key—a hash function. Information about the network is stored on the computers of all participants simultaneously.



**Figure 1.** The scheme of obtaining a hash of transactions in cryptocurrencies. Source: <https://www.blockchain.com>.

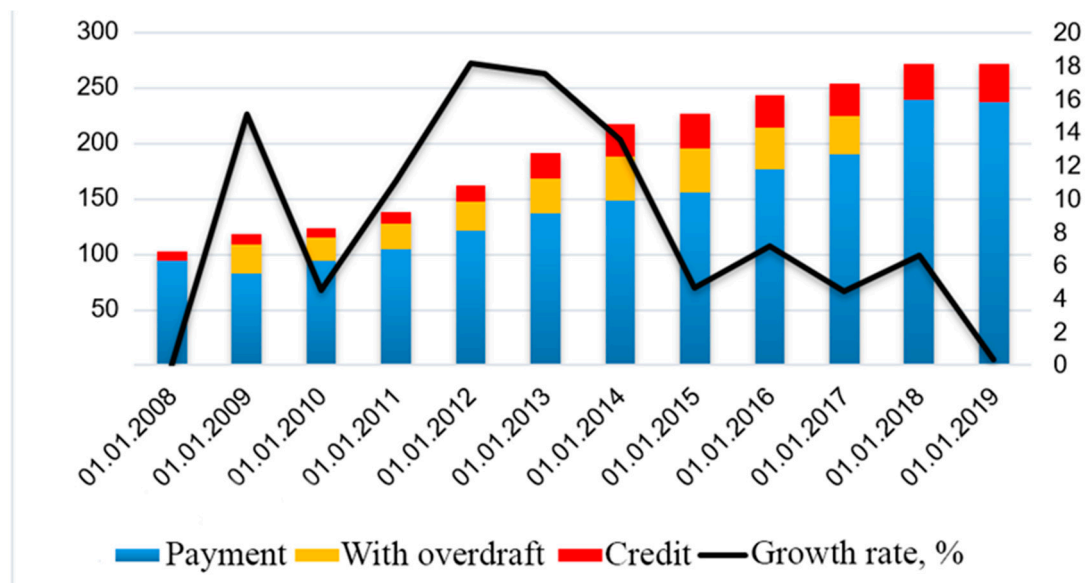
## 2.2. The Emergence of Cryptocurrency and the Chronology of Its Development

Money has been actively evolving from its very inception, changing its form but still performing all the same basic functions: medium of exchange, a store of value and a unit of account. So today, money is one of the most important tools for social and financial interactions. It is very difficult to imagine everyday life without the usual cash money or noncash. It cannot be said that noncash money is replacing cash, but the growth rate of their turnover is noticeably higher than that of cash. This fact is associated with the ease of use of modern payment systems and the current level of technological progress, which makes it possible to perform contactless transactions via the terminal or online transactions over the Internet. The appearance of plastic cards in the 20th century significantly simplified money circulation, allowing individuals to pay for goods or take out a loan without leaving their home. The charts below show the volumes of demand for plastic cards and transactions with plastic cards over the past 10 years [5–7].

Plastic cards and noncash payment systems are the main reference point and at the same time the main competitors of digital currencies (Figure 2). The technology of plastic bank cards is widespread all over the world, however, is still not risk-free. So, for example, according to the Central Bank of the Russian Federation for 2019, cyber fraudsters and criminals withdrew 1.3 billion rubles from card accounts—this figure exceeds the data of the previous period by 50%. The threats to the security of plastic cards include:

1. Telephone and SMS fraud. The criminal introduces himself as a bank representative and, having won the client's trust, learns his personal data.
2. Mobile banking. If the owner loses their phone, an attacker can use the program to perform transactions.

3. ATM skimming and trapping. Methods of installing special equipment that allow you to read data from an ATM and find out the owner's data [6,7].



**Figure 2.** Number of payment cards issued by credit institutions, millions (left scale), percent (right scale).

Source: <https://www.blockchain.com>.

Blockchain technology has not reached its final form—it is constantly evolving. Along with this, one can note the five most significant open innovations and features that characterize the blockchain today. The first open innovation based on blockchain technology was the emergence of Bitcoin in 2008—the first cryptocurrency peer-to-peer network and internal digital currency. This network was a computer system in which each unit of the network performed the same function. Each participant in the system was both a client and a server [8].

The second feature is the ubiquity of blockchain's use. In other words, the understanding that this mechanism can be applied not only to the payment system and digital currencies but also to increase the efficiency and security of most internal and inter-organizational operations of companies.

The emergence of “smart contracts” can be considered the third stage in the development of blockchain. Their concept involves an algorithm for executing built-in transactions between counterparties. This is one of the most important open innovations introduced by blockchain technology and cryptocurrencies, since the mechanism of “smart contracts” allows you to project the system of financial instruments into the cryptocurrency market, opening up opportunities for credit transactions, bonded loans, and deferred payment [9].

The fourth open innovation is the emergence of a Proof-of-Stake or POS system. This system is designed to identify miners in the chain—the participants with the highest computing power. Groups of miners provide the main data flow and provide the system with security in exchange for making payment transactions with cryptocurrency.

The fifth feature is the scalability of the technology. This point is one of the most compromised, since colossal computing power is required to expand the system while maintaining its security [10].

### 2.3. Forms of Cryptocurrency

In order to successfully introduce a new type of currency into mass use, a detailed study of the theoretical basis of the issue is required, which later flows into legal research. At this stage, the following countries and regions have already introduced a regulatory framework confirming the status of cryptocurrencies: Malta, Japan, Germany, China, Belarus, Georgia, Estonia, Slovenia,

Gibraltar, Switzerland, and Singapore. These countries welcome the business and organizational capabilities of cryptocurrencies. To date, there is no generally accepted system for the classification of digital currencies, but the systematization of the data obtained will allow for a more thorough study of this phenomenon. To determine the possible future of cryptocurrencies, it is necessary to distinguish between their nature of origin, purpose, functions, and properties [11].

Cryptocurrencies can be classified depending on their purpose of creation. The following types are distinguished:

1. Target cryptocurrencies, the nature of origin of which is a specific intention of the developers. These digital currencies have an original purpose.
2. Non-targeted—the creation of such cryptocurrencies most often occurs involuntarily, as a result of software failure and a branch of the development scheme of the indigenous digital currency. This rebuilding of the system is called a fork.

By the original code, they are distinguished as:

1. Original digital currencies—the process of their creation began with a completely new system and code, different from the previously used cryptocurrencies.
2. Forks—modernization or strong change in the source code of a certain existing cryptocurrency to create a new one—a subsidiary [12,13].

One of the most essential classification features is by the type of regulation:

Centralized cryptocurrency system—control and regulation of operations within the blockchain is carried out by a certain body (administrator) of the system, which can be one or more processing units. Such an administrator is able to make adjustments to the emission process to manage the stability of the system; decentralized system—lack of a single regulator in the chain and control hierarchy.

The mining method is a technical method of extracting currency based on the use of computers to form and calculate blocks of information [14–16]. Mining, in turn, is divided into:

1. Independent mining: the principle is the same as that of an individual entrepreneur: one participant of the system works and receives full profit from the work done.
2. mining pools or joint mining: there are more than one participant. The computing power of technology is added up and accumulated into a more powerful single system, where each member receives a share of the profit equal to the share of the contribution to the computing power of the pool.
3. cloud mining is the use of remote computing power under a lease or lease agreement, where operations are performed on behalf of the client.

#### 2.4. Open Innovation with Cryptocurrency

Many researchers include the deep learning techniques in selection approaches for Open Innovation with cryptocurrency [17–19]. However, this paper proposes that autonomous learning of open innovation for sustainable artificial intelligence is the optimal approach for novel features selection, in particular the hybrid clustering analysis using an improved krill herd algorithm [20], an unsupervised text feature selection technique based on hybrid particle swarm optimization algorithm with genetic operators for the text clustering [21], and a feature selection method to improve the document clustering using particle swarm optimization algorithm.

Many firms in the world, including Russian firms, have understood their mission in business development and spend a substantial part of their funds for this purpose [22,23].

The role of firms in implementation of the emerging innovation management paradigms become important: a big difference between Russian and Western venture funds is that Russian funds use simple spending rules, spending all current income (net management fees) for various purposes, including business development [24–30].



Thus, as the managing experience of firms has grown and as new challenges have emerged, giftedness techniques have improved the calculation of the spending rate. Initially, the firms had to assess the viability of spending, compensate for payments, and cover inflation. Many firms have not yet joined the fight against methods of charity expenses that are widely recognized abroad, choosing simplified solutions, as they lag behind modern management technologies [5,31–33].

As a rule, the flows in open innovation projects are available to improve digital academic entrepreneurship level and research activity of preserving staff, students, and funds [34–37].

In Russia, the development of open innovation is hindering internal barriers:

1. The lack of interesting research programs that universities would be ready to sell or show sponsors in order to attract means.
2. The high initial maintenance costs in effective management team.
3. High business standards culture.

Despite the existence of these barriers, availability and performance of the development of open innovation can become objective criteria for assessing the effectiveness of open innovation entrepreneurship and research activities [38–40].

Thus, as the managing experience of firm has grown and as new challenges have emerged, giftedness techniques have improved the calculation of the spending rate. Initially, the firms had to assess the viability of spending, compensate for payments, and cover inflation [41–46].

When introducing the concept of open innovation for the improvement of digital business it should consider possible difficulties associated with the paradox of openness [47–52].

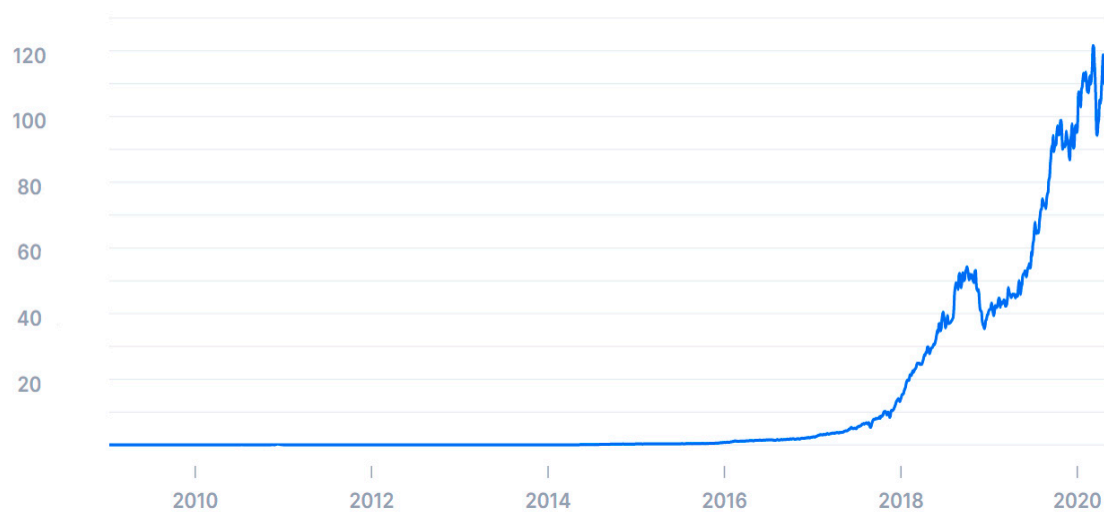
The cultural aspect is the willingness of the company's staff to accept new things, to use the test and learn approach [53–56]. It often becomes an unsolvable task. The implementation of several small projects before the full-scale deployment of the program reduces the fear of failure in management and staff distrust of the new tools [57–60].

### 3. Data

As of today, digital currencies are not a reliable store of value and, moreover, a measure of value, due to the exchange rate's high volatility. The main factors affecting the value of cryptocurrencies are the supply and demand ratio, investor sentiment and market factors. Only a small fraction of the value of digital currencies is backed up—the cost of generating them. Another important factor that distinguishes cryptocurrency from fiat money is the limited supply and, as a result, the complexity of elastic market expansion. For example, the most popular cryptocurrency—Bitcoin—has an emission limit of 21 million coins: at the end of 2019, slightly more than 18 million pieces were mined. According to the calculations of the system algorithms of Bitcoin, the last coin should be mined in 2140. Due to the increasing complexity of cryptocurrency mining, the cost of its creation will constantly grow; therefore, the Bitcoin rate will also increase. To assess the complexity of mining, there are two specific indicators—the hash rate and the complexity of the pool [61,62].

The hash rate reflects the total computing power of the mining equipment involved in the cryptocurrency system and is expressed in hash/sec (H/s). The complexity of mining is constantly growing. This fact is explained by the continuous increase in information stored in each subsequent block, so it is already quite difficult to see the designation H/s: it would be a number with at least eighteen zeros. The following designations are mainly used: terahash/sec (TH/s) and exahash/sec (EH/s), where TH/s = 1,000,000,000,000 H/s, and EH/s = 1,000,000 TH/s [63–65].

After analyzing the graph, we can conclude that there is a geometric progression in the development of the complexity and speed of information processing by all members of the Bitcoin system. The generation of each block of information requires more and more resources in the form of electricity and increased technical requirements for participants (Figure 3). The formation of each block requires the generation of a larger number of hashes—hence the tremendous growth in the network hash rate.



**Figure 3.** Bitcoin hashrate, EH/s. Source: <https://www.blockchain.com>.

The second indicator—the complexity of the pool—has a specific calculation formula:

$$D = DIF1(target) / CUR(target) \quad (1)$$

where

$D$  is the pool's complexity;

$DIF1(target)$  is the number of symbols in the hash;

$CUR(target)$  is a standard 256-bit number.

Since the complexity has a large spread in the analyzed period, we take the logarithm of the pool complexity in order to track the relative change in the indicator relative to the previous periods.

Still, cryptocurrencies have some of the characteristics of financial assets and fiat money, but today they cannot be equated with them (Figure 4). Many countries are actively promoting the development of payments using cryptocurrencies, so digital currencies are already partially a means of payment. If we break away from the standards and rules of the existing global payment system, then the existence of agreements between paying agents about the method of payment in practice may be more important than the legal security of this issue, especially if the terms of such transactions are mutually beneficial for the participants. Comparative characteristics of digital currencies as money and financial assets are given below (Table 1).



**Figure 4.** Logarithm scale of a block's formation complexity. Source: <https://www.btc.com>.



**Table 1.** Comparative analysis of cryptocurrencies, money and assets.

Characteristic	Fiat Money	Assets	Financial Assets	Cryptocurrency
Store of value	Yes	Yes	Yes	Her
Medium of exchange	Yes	No	No	Partially
Unit of account	Yes	No	No	No
Property right	No	Yes	Yes	Possible
Economic benefits from ownership	Possible	Yes	Yes	Possible
Is a liability from a third-party	Yes	No	Yes	No
Information transfer and storage function	No	No	No	Yes

However, cryptocurrencies have one important feature that distinguishes them from fiat money and financial assets: they have a unique function for processing massive amounts of information: as previously noted, cryptocurrencies operate on blockchain networks.

#### 4. Analysis

##### 4.1. Price Stability

Bitcoin price dynamics over the past 10 years are presented in the chart below [66,67].

At the beginning of 2020, Bitcoin reached the price of \$7700 per coin—this indicates that the price of this currency for the analyzed period from 2010 to 2020 increased by almost 1,000,000 times. Thus, the high risks of this instrument can be noted not only within the framework of payment systems, but also as an investment. High profitability is also associated with the high risks of cryptocurrency: the maximum decline in absolute value was in the period from the end of 2017 to the end of 2018, and it amounted to \$10,350 or 73%. This volatility is explained by the sensitivity of investors and currency holders to market news: in addition to all the main market factors, such as the political situation in the world, the investment climate and the regulatory framework, the internal factors associated with changes in technologies and various processes in the system influence the cryptocurrency. This preposition is about forks.

As a result, such a strong drop in the cryptocurrency rate can be explained by the slowdown in the development of the industry during this period, the absence of a news background about growth in the market, as well as a hard fork that led to the formation of a new currency—the altcoin BITCOIN SV [19–22]. All these factors negatively affected investor sentiment and affected the value of Bitcoin. For a more objective assessment of the dynamics of the value of a cryptocurrency, it is necessary to provide a graph of the logarithm of the price, since the spread of prices in the analyzed interval is large.

In contrast to the first figure, the second graph shows the relative price change. As a result, we can conclude that the most rapid growth of the crypto asset was observed at the beginning of its appearance on the market. This is again related to the future expectations of investors and the prospects for this cryptocurrency. It should be noted that although Bitcoin is the very first cryptocurrency, it is not very stable. That is why, at this stage, it is difficult to imagine Bitcoin as a payment alternative to existing currencies, but this asset can be used as an investment object. A more detailed comparison will be discussed in the second section of this chapter.

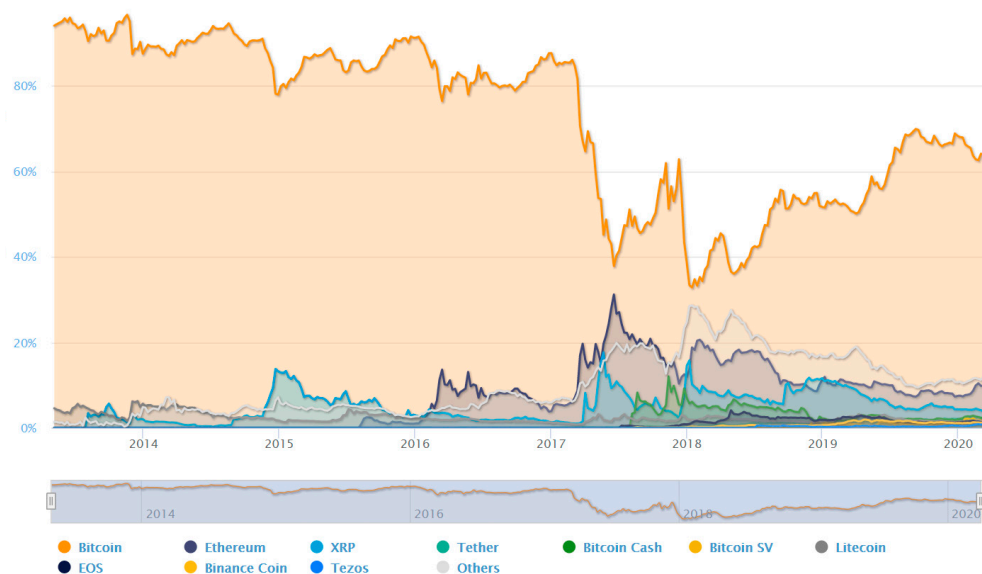
As has already been mentioned, the cryptocurrency market is constantly evolving, and it would not be a market if there was only one cryptocurrency. As of April 2020, there are more than 2850 active digital currencies, with constant ICOs (initial coin offerings) occurring, and new platforms and cryptocurrency systems being created. Each developer tries to bring something new, eliminating

the shortcomings of existing systems. There is strong competition in the market, which constantly stimulates the industry and improves it. To assess the state of the market, it is necessary to consider the dynamics of market capitalization, as well as the volume of daily trading [68–70].

Analyzing the graph, we can conclude that the peak of market capitalization was in January 2018 at \$742 billion: this is explained by the high demand for cryptocurrency. In the beginning of 2020, the capitalization fell to 220 billion. Now this financial instrument is in a state of limbo: speculative players are mainly sitting in the cryptocurrency, trying to make money in a highly volatile market.

The cryptocurrency market is relatively young, with Bitcoin being its “founder”. This asset class is extremely specific and unique, so standard market metrics cannot be applied to it. That is why unique indicators are being actively developed for market analysis, which help to assess the cryptocurrency market. One of them is the BITCOIN dominance index. For a long time, until 2017, Bitcoin had the status of the absolute dominant of the market with a share of over 80% in terms of capitalization (see the figure below). The dominance index measures the share of Bitcoin in the total capacity of the cryptocurrency market. The calculation is based on data for all digital currencies, including newly formed [71–75].

From the data presented in the graph, we can conclude that, starting in 2017, the situation of Bitcoin’s dominance over all altcoins is gradually changing due to the development of such large competitors as etherium, EOS, and other altcoins. It is also worth noting that the market became more volatile in the period from 2017 to the end of March 2020 (Figure 5). Bitcoin still maintains its leadership in the market, but this leadership is no longer undeniable. Until 2017, Bitcoin’s market share varied between 77 and 96 percent of total capacity, but from 2017 to 2020 it ranged from 33 to 67 percent.

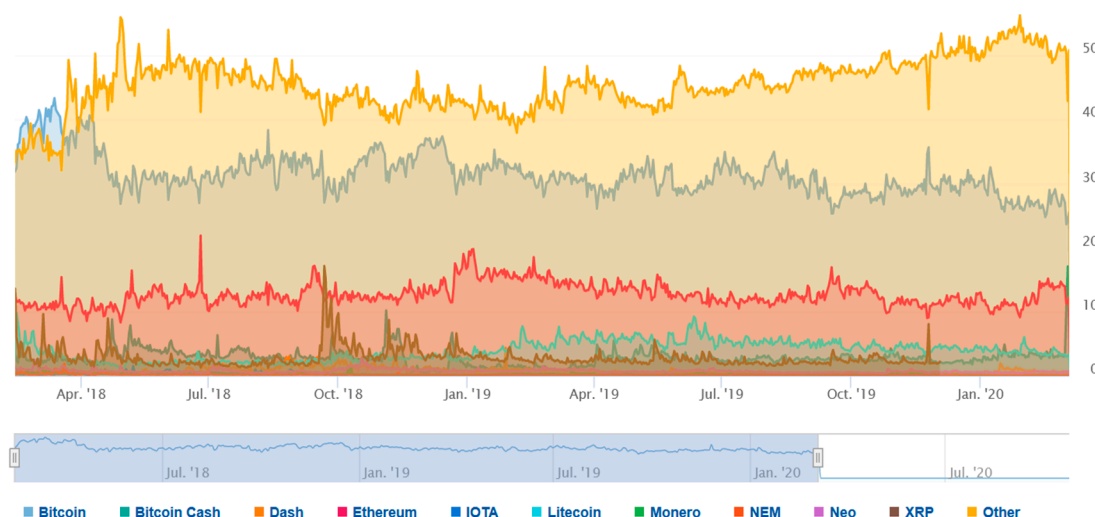


**Figure 5.** Bitcoin dominance index, %. Source: <https://ru.investing.com/crypto/charts>.

For an objective assessment of activity in the cryptocurrency market, one should study the dynamics of the daily turnover of this sector. An increase in market turnover, as a rule, indicates an increase in the liquidity of cryptocurrencies, which should have a positive effect on their rate, as well as their value as a means of payment. However, due to the strong volatility of most cryptocurrencies, they are often used for speculative purposes, which in no way contributes to their development and formation as participants in the payment system. Such capital is considered to be fictional capital, which does not contribute to the development of the economy, but only participates in the redistribution of capital [76–78].

This chart directly confirms the interest of speculators in the cryptocurrency market: since January 2019, there has been active growth in the daily turnover of digital currencies (Figure 6). Also, after the latest news about the epidemic caused by the coronavirus, the volatility of the cryptocurrency

market has increased—an ideal time to enter the market for speculators. From here, you can see that at the beginning of April 2020, the average daily turnover for cryptocurrencies is \$150 billion. This means that the asset is extremely liquid. The market has developed confidence in the oldest cryptocurrency—Bitcoin: despite the high level of risk, investors are confident in the longevity of this asset, which is why, when prices fall against the background of news about the virus, the society of traders and investors begins to buy the asset at a more attractive price. The figure below shows the structure of daily turnovers by digital currencies.



**Figure 6.** Structure of the daily turnover of the cryptocurrency market, billion USD. Source: <https://ru.investing.com/crypto/charts>.

It can be seen from the graph above that BITCOIN and ETHEREUM hold the leading positions in the trading volume with shares in terms of turnover of 26.27% and 14.06%, respectively. The main features of these currencies are their long history of existence in the market, high capitalization and high volatility. BITCOIN CASH, despite the fact that it is an altcoin and was formed as a result of the Bitcoin hard fork, has a more stable exchange rate and is not so interesting for market speculators. Accordingly, we can conclude that a potential investor is looking for high-risk and highly profitable assets in the cryptocurrency market to carry out speculative transactions [79,80].

Based on the analysis, we can conclude that the cryptocurrency market is interesting and in demand not only from the side of developers, but also from the side of investors. The market is constantly seeing the introduction of new cryptocurrency systems. Therefore, the constantly growing competition contributes to the active development of the market. Until 2017, Bitcoin was the absolute market leader with a market share of over 80%. However, due to the growing demand for existing digital currencies and the emergence of new ones, the Bitcoin dominance index has been steadily declining, which reflects the weakening of the leadership position of this cryptocurrency in recent years. The market specifics include high volatility caused by the sector's sensitivity to different factors. This is very attractive for potential investors who are willing to accept the market risk. This, however, causes the utility of the cryptocurrency to be lost. It begins to act as a tool for speculative transactions and capital redistribution but becomes less suitable for participation in the global payment and financial system.

#### 4.2. Cryptocurrency Comparative Analysis

At the present stage of social development, it is difficult to imagine its functioning and activity without money. Money is a special commodity, which at the same time stands out strongly from the commodity world: it plays the role of a universal equivalent expressing the value of all resources, goods and services, and is also capable of being exchanged for any of them. Accordingly, the essence

of money consists in the performance of the following functions as well: a medium of exchange, a unit of account, a store of value, and a standard of deferred payments. It is these functions that should be the most important characteristic in the formation of a cryptocurrency as a full-fledged participant in the payment system and the financial sector. However, at this stage, most cryptocurrencies are predominantly investment objects and are more similar to financial assets than a new type of money, since they do not differ in high stability, security, and liquidity [81].

Financial assets are a specific form of ownership, property values that can be in cash or in the form of financial instruments. The exclusive advantage of cryptocurrency in terms of its use in financial markets as an asset and a tool for capital redistribution is the use of blockchain technologies in the system, which will increase the efficiency and safety of investments.

In circulation cryptocurrency can be used as a system of exchange, transfer, and storage of information in different aspects of public activity [82]. So, firstly, blockchain networks process information about transactions, which is stored in an encrypted form, without the possibility of identifying users, for example, in the Bitcoin network. The data on transfers are always reliable, without the possibility of changing them, since they go through the process of confirmation by all participants in the chain. Secondly, the blockchain system using smart contracts allows one to completely get rid of intermediaries, as well as reduce the time and money costs of transaction participants. These contracts have increased reliability and safety for the participants, since unscrupulous counterparties have no opportunity to change the terms of the transaction [83].

Cryptocurrencies are unique and specific regarding their potential as a financial investment—an asset. According to information provided by the Organization for Economic Co-operation and Development (OECD), an asset is a certain property that allows its owner to retain the value of the valuables, and also provides the right to receive economic and other benefits from its storage and use. However, while not being a reliable store of value, cryptocurrencies do not have a stable purchasing power, unlike fiat money, over a long period of time. In addition, digital currencies are not able to ensure that the owner receives a stream of payments, unlike other investment objects such as real estate, stocks or bonds. It is the inability to bring money from the possession of this digital asset that explains the lack of intrinsic value in cryptocurrencies. On the other hand, cryptocurrency is able to generate income for depositors due to changes in market value—this factor is one of the dominant factors in the formation of demand in the market for a particular cryptocurrency [84].

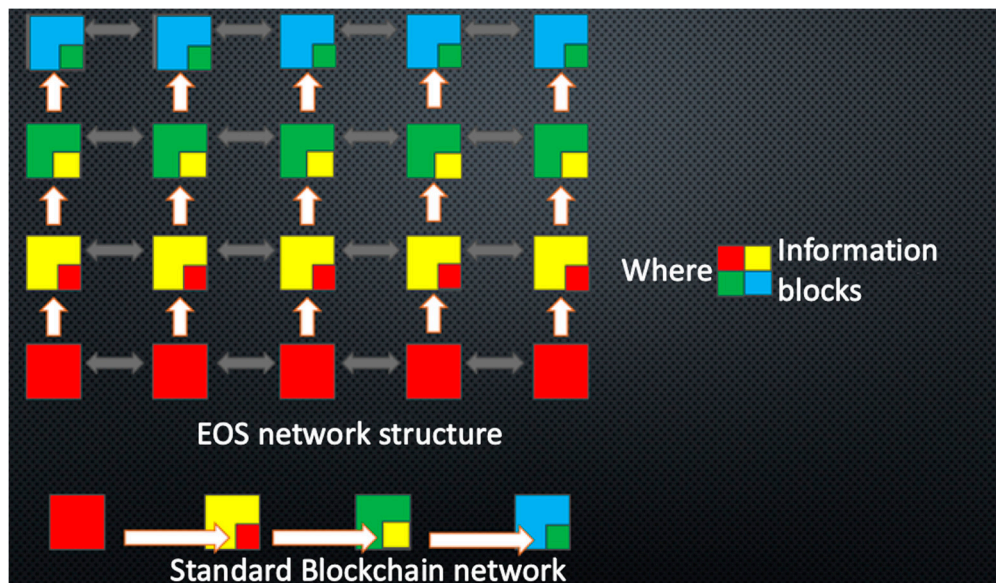
#### *4.3. Competition on the Cryptocurrency Market*

From the analysis carried out in the previous section, it can be concluded that at the current stage, it is quite difficult for cryptocurrencies to compete with financial assets and fiat money in terms of efficiency, since digital currencies have not yet gained the appropriate global recognition and regulatory foundation for their widespread implementation and use. However, within their own industry, digital coins and cryptocurrency platforms are actively competing with each other: new systems appear, and existing ones are subject to further development. It should be noted that it is mainly market types of cryptocurrencies that are competing, which are not tied to specific social networks, computer games, commodity networks, etc.

The features of competition in the cryptocurrency market include uninterrupted trading and mining, as well as a high potential market capacity. This is due to the fact that when they enter the market, cryptocurrencies do not take money from competing cryptocurrencies, but create and attract additional funds, contributing to the constant growth of the market. Each cryptocurrency platform tries to capture its share of the market by introducing technological and methodological open innovations into their systems. EOS offers the most innovative system to date, with huge potential for scalability and modernization of technical equipment. The main criterion when buying a cryptocurrency is the ratio of possible risks and potential benefits for investors from ownership. The material benefit or safety of property is provided not only by the exchange rate difference of the digital currency, but also by minimizing the costs associated with using the system.



The innovative EOS system is built on the principle of horizontal and vertical formation of a chain of blocks—in fact, allowing transaction flows to be processed in parallel without losing security properties (Figure 7). However, due to high technical requirements, partial centralization appeared in the system with twenty nodes that confirm transactions [85].



**Figure 7.** Schematic representation of the system building chains in cryptocurrencies. Source: <https://ru.tradingview.com>.

The commission system is also different from other cryptocurrencies and is a payment for the RAM in the system. In other words, without adding new information to the system, without creating new wallets, a potential participant in the system does not pay for the use of cryptocurrency and can make money transfers around the world without additional expenses.

If we compare the three parameters—costs, performance, and scalability, the EOS system is one of the most effective projects on the cryptocurrency market. Such a cryptocurrency system is able to compete not only in the domestic crypt market, but also become a “rival” to existing payment systems and cross-border transfer systems. This can be achieved due to the system having the same favorable conditions for companies, potentially using it due to the speed of operations, the availability of free software code, and low costs when registering a company in this network, and also citizens who can use this platform for daily payments and money transfers across the border with a minimum commission.

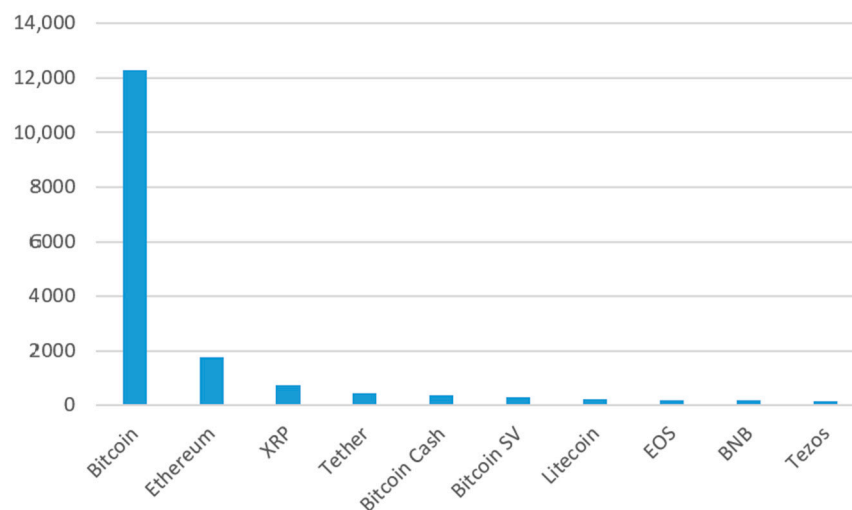
From this presented graph, we can make conclusions about the disproportionately greater potential of the EOS currency: in the absence of commission for operations, this cryptocurrency has a potential of 50,000 transactions per second, according to the developers, against 10 and 25 tr/s for Bitcoin and Ethereum, respectively. But even with the current average system throughput of 1200 transactions per second, this platform is the market leader.

## 5. Discussion: Cryptocurrency and Open Innovation

After this study the find that Bitcoin is the very first representative of the cryptocurrency sector. The system appeared in 2008 with the aim of developing the asset as a global means of payment. Nobody owns or controls the Bitcoin network, the system has an open system code, and thus everyone can become its participant [85]. Unlike Bitcoin, the goal of Ethereum was to develop a smart contract platform. The network began operations in 2015, the main feature of which was the presence of open source, suitable for the development of third-party decentralized applications. Ethereum is a pioneer in the development of blockchain-based smart contracts. When launched on the blockchain, a smart contract becomes like a self-acting computer program that is automatically executed when certain

conditions are met. The open source code allows developers to implement this system in their business processes, which gives a strong competitive advantage [85].

Autonomous learning approaches for open innovation study is optimal for sustainable artificial intelligence for EOS (Figure 8). The EOS protocol emulates most of the attributes of a real computer, including hardware (CPU(s) and GPU(s) for processing, local/RAM, hard disk storage) with computing resources equally distributed among holders of the EOS cryptocurrency. An important feature of this system is the absence of commissions and a huge data processing speed. It has a centralized management [85].



**Figure 8.** Cryptocurrency capitalization, billion rubles. Source: <https://ru.tradingview.com>.

Summarizing the characteristics described above, the following three most important functional features can be noted as fundamental in developing cryptocurrencies.

1. Similarity with the most popular large-scale currency—Bitcoin. This characteristic is due to the high credit of investor confidence in the Bitcoin platform and all its hard forks.
2. Support for smart contracts. This property is new on the market, but it is this concept and open innovation that can fully reveal the potential of using cryptocurrencies in the modern world. Accordingly, investors believe in this technology and invest in the corresponding coins and digital assets.
3. Availability of open source for application development. This property of cryptocurrencies makes it possible to expand the range of use of blockchain protocols and enables third-party developers to create programs that are integrated into sectors of the economy and social activities in general.

A relatively new classification feature based on implementing the emerging innovation management paradigm:

1. State cryptocurrencies—this digital currency is controlled by an authorized government body. This scheme does not maintain the main advantage of cryptocurrency—decentralization and data confidentiality. In this type of cryptocurrency, the interests of the state about full awareness of operations carried out in the system collide with the interests of network users in complete security and privacy of data.
2. Cryptocurrency systems founded by private organizations. The main purpose of their creation is to generate profit in the form of commissions from network users. For this, the tasks of maximum satisfaction of consumer interests were set: the more extensive the use of cryptocurrency, the more money the organizers receive for it [86].

By architectural design and open innovation symbiosis, cryptocurrencies are distinguished as:



1. Bitcoin and altcoins. This group of digital currencies includes the first cryptocurrency is Bitcoin, which is still the most recognized cryptocurrency and its counterparts are altcoins. These are cryptocurrencies built on a platform related to Bitcoin's and have a similar set of characteristics and properties. These cryptocurrencies are most often used as a financial asset and traded on exchanges.
2. Stablecoins are a cryptocurrency backed by a third-party asset, which is the basis for pricing for this type of currency. The issuer of such a cryptocurrency stores an asset that provides the value of a stablecoin in bank accounts. Traditional currencies are most often used as such an asset. These cryptocurrencies are intended for making payment transactions, since their volatility is much lower and comparable to the volatility of the underlying asset. Such coins differ significantly in characteristics from altcoins.
3. Tokens are both a unit of value and a unit of calculation that is used within one project. Accordingly, ICOs are carried out to attract investments in the issuing company. The cost of such coins may increase depending on the performance indicators of the issuer, and after that the tokens can be traded on the exchange. This type of coins can be compared to venture investments, since they have a minimum intrinsic value at the start, and the risk of not receiving income is very high [87].

By the issued volume and cyclical dynamics of open innovation, there are:

1. Cryptocurrencies with limited and cyclical emission, for which an upper level of release is determined at the launch of the system, which may be artificially or technically limited. This classification feature is extremely important because it determines the cryptocurrency's ability to be used as a ubiquitous payment method. With an increase in the emission of such a digital currency, its cost often grows, as well as the complexity of computing processes and requirements to the technology.
2. Cryptocurrencies without emission but with cyclical restrictions. The issuance of such coins is not limited by the actions of the administration or the bandwidth of the system. Such cryptocurrency systems are innovative and often have the ability to scale freely or have high technological resources. If we consider digital currency as a potential replacement for existing fiat money, then cryptocurrency systems of this type are the most promising.

Innovation performance of the digital currencies is based solely on analysis of the features of existing cryptocurrencies, as well as foreign experience of regulation. Moreover, there are no legal foundations that fully disclose the concept of cryptocurrencies in Russia today, as well as any legal norms governing this market. Based on scientific literature and foreign experience regarding this matter, it can be concluded that there is a close relationship between the science of cryptography and the essence of cryptocurrency [88].

Digital currencies were created as a result of an offshoot in cryptography's development into hashing, and later into the blockchain—an ordered chain of encrypted streaming data. It was this technology that became the catalyst for the emergence of the cryptocurrency market. Together with the active crypto sector and technologies in general, new currency systems began to appear, both similar and different from the first cryptocurrency—Bitcoin. And at this stage, it became possible to classify digital currencies depending on the intended purpose, degree of the system's open innovation, the issuer, the order of production, properties, characteristics, and output volumes by the source of the platform. As a result, a feature of all cryptocurrencies is their security, cross-border nature, as well as temporary freedom of circulation, transactions and mining. Thus, as the managing experience of firm has grown and as new challenges have emerged, giftedness techniques have improved the calculation of the spending rate. Initially, the firms had to assess the viability of spending, compensate for payments, and cover inflation.

Regarding the dynamic growth of firms based on the appropriability, external search, and collaboration in the era of the digitalization and computerization of all areas of society, including countries' payment systems, there is an acute problem of maintaining the confidentiality of information

and the reliability of operations. Economic and financial progress required an increase in the sustainability of the technological component of operations, as well as a new mechanism capable of protecting data transferred through payment systems and the Internet. Blockchain became the open innovation fulfilling this precondition.

This technology had its roots planted in the 90s of the last century but received a lot of attention from the financial sector in 2008. Blockchain has been actively developing ever since but is not directly related to cryptocurrency: it is used in many other industries as well. Representatives of the real sector of the economy are exploring this mechanism for the possibility of its implementation and functioning in business. Nevertheless, blockchain receives special attention from the financial sector.

The peculiarity of this technology is revealed in the distributed storage of information. Data on money transfers, issued loans, paid fines and other transactions are stored simultaneously on all devices connected to this network. The information content of these blocks in the chain can be any record that can be written on a sheet of paper, but it is almost impossible to change the information that has entered the chain. This feature can significantly increase the reliability of data and the security of transactions since the data registry is distributed among many devices, making it decentralized.

Alibaba went from being a small firm to a large enterprise that uses full-fledged implementation programs. It is possible to formulate the main components of the success of Alibaba by implementing artificial intelligence. The first is the corporate culture and readiness to work with new tools. A special role belongs to the management team: the chances of success are increased if the top management is familiar with modern digital technologies firsthand. Successful companies give priority to sustainability conditions in projects. Another basis for success is the right organizational model.

Successful programs necessarily include talent management—hiring employees with new competencies—and the development of existing staff. In addition, the open innovation systems must meet the requirements of data processing and storage professionals. Finally, the data itself, which should be useful, meaningful, and sufficient to process.

## 6. Conclusions

It can be concluded that the cryptocurrency market is constantly sustainable, developing both technical and technological aspects of its systems. New digital currencies are appearing, and existing ones are being improved. The competition in the digital currency market is segmented and only market currencies designed for use outside the framework of one system can compete. Three main directions of sustainable development of cryptocurrencies with internal competition have been formed: altcoins, which copy Bitcoin by their properties, stablecoins, which are “pegged” to a certain legal currency, and cryptocurrency systems that allow developers to create applications for using these platforms in various industries. According to the results of the analysis, the most effective and promising cryptocurrency is EOS with the platform of the same name, which has the lowest commission among the analyzed digital currencies and allows you to integrate third-party applications into the system. In terms of daily turnover in the market, operations with Bitcoin are also in the lead. This is due to high volatility in the market, which allows for the use of cryptocurrency as a tool for speculative operations. Despite its investment attractiveness for investors and speculators, cryptocurrency has a number of features that distinguish it from fiat money and financial assets. The main disadvantage of cryptocurrency on this side is the complexity of its forecasting and the impossibility of using it as a means of accumulation or payment as freely as legal currency. The main implications of this paper are a theoretical base for future research in cryptocurrencies. Further studies will concentrate on incorporating other factors into the similar theoretical base and developing new approaches to model combination in crypto market prediction.

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## References

1. Zhang, H.; Ho, T.B.; Lin, M.S. A Non-Parametric Wavelet Feature Extractor for Time Series Classification. In *Advances in Knowledge Discovery and Data Mining*; Springer: Berlin/Heidelberg, Germany, 2004; pp. 595–603.
2. Yan, R.J.; Ling, C.X. Machine Learning for Stock Selection. In Proceedings of the KDD07: The 13th ACM SIGKDD International Conference on Knowledge Discovery and Data Mining, San Jose, CA, USA, 12–15 August 2007; pp. 1038–1042.
3. Wei, L.; Keogh, E. Semi-supervised time series classification. In Proceedings of the KDD06: 12th ACM SIGKDD International Conference on Knowledge Discovery and Data Mining, Philadelphia, PA, USA, 20–23 August 2006; Association Computer Machinery: New York, NY, USA, 2014. Available online: <https://dl.acm.org/doi/proceedings/10.1145/1150402> (accessed on 2 March 2020).
4. Vejačka, M. Basic Aspects of Cryptocurrencies. *J. Econ. Bus. Financ.* **2014**, *2*, 75–83.
5. Uematsu, Y.; Tanaka, S. High-dimensional macroeconomic forecasting and variable selection via penalized regression. *Econ. J.* **2019**, *22*, 34–56. [\[CrossRef\]](#)
6. Tinbergen, J. *Shaping the World Economy; Suggestions for an International Economic Policy*; Twentieth Century Fund: New York, NY, USA, 1962; p. 113.
7. Tasca, P.; Liu, S.; Hayes, A. The Evolution of the Bitcoin Economy: Extracting and Analyzing the Network of Payment Relationships. *SSRN Electron. J.* **2018**, *19*, 94–126. [\[CrossRef\]](#)
8. Portmann, E. *Blockchain: Blueprint for a New Economy*; O'Reilly Media, Inc.: Newton, MA, USA, 2015; p. 23.
9. Maini, S.S.; Govinda, K. Stock Market Prediction using Data Mining Techniques. In Proceedings of the ICISS 2017: IEEE International Conference on Intelligent Sustainable Systems (ICISS) 2017, Tirupur, India, 7–8 December 2017.
10. Silva, J.S.; Tenreiro, S. The log of gravity. *Rev. Econ. Stat.* **2006**, *88*, 641–658. [\[CrossRef\]](#)
11. Shahrivari, S. Beyond Batch Processing: Towards Real-Time and Streaming Big Data. *Computer* **2014**, *3*, 117–129. [\[CrossRef\]](#)
12. Remy, C.; Rym, B.; Matthieu, L. Tracking Bitcoin Users Activity Using Community Detection on a Network of Weak Signals. In Proceedings of the International Conference on Complex Networks and Their Applications, Lyon, France, 29 November–1 December 2017; Springer: Cham, Switzerland, 2017; pp. 166–177.
13. Reid, F.; Harrigan, M. An Analysis of Anonymity in the Bitcoin System. In *Security and Privacy in Social Networks*; Springer: New York, NY, USA, 2013; pp. 197–223.
14. Puri, V. Decrypting Bitcoin Prices and Adoption Rates Using Google Search. Bachelor's Thesis, Claremont McKenna College, Claremont, CA, USA, April 2016. Available online: [http://scholarship.claremont.edu/cmc\\_theses/1418](http://scholarship.claremont.edu/cmc_theses/1418) (accessed on 2 March 2020).
15. Nyangarika, A.; Mikhaylov, A.; Richter, U. Oil Price Factors: Forecasting on the Base of Modified Auto-regressive Integrated Moving Average Model. *Int. J. Energy Econ. Policy* **2019**, *1*, 149–160.
16. Meynkhard, A. Long-Term Prospects for the Development Energy Complex of Russia. *Int. J. Energy Econ. Policy* **2020**, *10*, 224–232. [\[CrossRef\]](#)
17. DeStefano, M. Stock Returns and the Business Cycle. *Financ. Rev.* **2004**, *39*, 527–547. [\[CrossRef\]](#)
18. Baker, S.R.; Bloom, N.; Davis, S. Measuring economic policy uncertainty. *Q. J. Econ.* **2016**, *131*, 1593–1636. [\[CrossRef\]](#)
19. Antonakakis, N.; Chatziantoniou, I.; Filis, G. Dynamic co-movements of stock market returns, implied volatility and policy uncertainty. *Econ. Lett.* **2013**, *120*, 87–92. [\[CrossRef\]](#)
20. Ko, J.-H.; Lee, C.-M. International economic policy uncertainty and stock prices: Wavelet approach. *Econ. Lett.* **2015**, *134*, 118–122. [\[CrossRef\]](#)
21. Li, T.; Ma, F.; Zhang, X.; Zhang, Y. Economic policy uncertainty and the Chinese stock market volatility: Novel evidence. *Econ. Model.* **2020**, *87*, 24–33. [\[CrossRef\]](#)
22. Christou, C.; Cunado, J.; Gupta, R.; Hassapis, C. Economic policy uncertainty and stock market returns in PacificRim countries: Evidence based on a Bayesian panel VAR model. *J. Multinat. Financ. Manag.* **2017**, *40*, 92–102. [\[CrossRef\]](#)
23. Kühnhausen, F. *Financial Innovation and Financial Fragility*; Munich Discussion Paper No. 2014-37; Taylor & Francis, Ltd.: Abingdon, UK, 2014; Available online: <https://epub.ub.uni-muenchen.de/21173/> (accessed on 10 March 2020).

24. Orlowski, L. *Stages of the 2007/2008 Global Financial Crisis Is There a Wandering Asset-Price Bubble?* Economics Discussion Papers No. 2008-43; SSRN: Rochester, NY, USA, 2008; Available online: <https://www.econstor.eu/handle/10419/27479> (accessed on 2 March 2020).
25. Julio, B.; Yook, Y. Corporate Financial Policy under Political Uncertainty: International Evidence from National Elections. *J. Financ.* **2012**, *7*, 121. [\[CrossRef\]](#)
26. Gulen, H.; Ion, M. Policy Uncertainty and Corporate Investment. *Rev. Financ. Stud.* **2016**, *29*, 523–564. [\[CrossRef\]](#)
27. Arouri, M.; Estay, C.; Rault, C.; Roubaud, D. Economic policy uncertainty and stock markets: Long-run evidence from the US. *Financ. Res. Lett.* **2016**, *18*, 136–141. [\[CrossRef\]](#)
28. Pastor, L.; Veronesi, P. Political Uncertainty and Risk Premia. *J. Financ. Econ.* **2013**, *110*, 520–545. [\[CrossRef\]](#)
29. Kang, W.; Ratti, R.A. Oil shocks, policy uncertainty and stock market return. *J. Int. Financ. Mark. Inst. Money* **2013**, *26*, 305–318. [\[CrossRef\]](#)
30. Backus, D.K.; Routledge, B.R.; Zin, S.E. *Asset Prices in Business Cycle Analysis*; Paper 414; Tepper School of Business: Pittsburgh, PA, USA, 2007; Available online: <http://repository.cmu.edu/tepper/414> (accessed on 15 February 2020).
31. Campa, J.M.; Fernandes, N. Sources of gains from international portfolio diversification. *J. Empir. Financ.* **2006**, *13*, 417–443. [\[CrossRef\]](#)
32. An, J.; Dorofeev, M.; Zhu, S. Development of energy cooperation between Russia and China. *Int. J. Energy Econ. Policy* **2020**, *10*, 134–139. [\[CrossRef\]](#)
33. Meynkhard, A. Fair market value of bitcoin: Halving effect. *Investig. Manag. Financ. Innov.* **2019**, *16*, 72–85. [\[CrossRef\]](#)
34. Graham, M.; Peltomäki, J.; Piljak, V. Global economic activity as an explicator of emerging market equity returns. *Res. Int. Bus. Financ.* **2016**, *36*, 424–435. [\[CrossRef\]](#)
35. Bartman, S.; Brown, G.; Stulz, R.M. Why do Foreign Firms have Less Idiosyncratic Risk than U.S. Firms? 2009. Available online: <https://www.nber.org/papers/w14931> (accessed on 26 August 2020).
36. Mehl, A. Large Global Volatility Shocks, Equity Markets and Globalisation: 1885–2011. *Fed. Reserv. Bank Dallas Glob. Monet. Policy Inst. Work. Pap.* **2013**, *2013*. [\[CrossRef\]](#)
37. Das, D.; Kumar, S.B. International economic policy uncertainty and stock prices revisited: Multiple and Partial wavelet approach. *Econ. Lett.* **2018**, *164*, 100–108. [\[CrossRef\]](#)
38. Sugimoto, K.; Matsuki, T.; Yoshida, Y. The global financial crisis: An analysis of the spillover effects on African stock markets. *Emerg. Mark. Rev.* **2014**, *21*, 201–233. [\[CrossRef\]](#)
39. Diebold, F.X.; Yilmaz, K. Better to give than to receive: Predictive directional measurement of volatility spillovers. *Int. J. Forecast.* **2012**, *28*, 57–66. [\[CrossRef\]](#)
40. Schreiber, T. Measuring Information Transfer. *Phys. Rev. Lett.* **2000**, *85*, 461–464. [\[CrossRef\]](#)
41. Shannon, C.E. A mathematical theory of communication. *Bell Labs Tech. J.* **1948**, *27*, 379–423. [\[CrossRef\]](#)
42. Marschinski, R.; Kantz, H. Analysing the information flow between financial time series. *Eur. Phys. J. B* **2002**, *30*, 275–281. [\[CrossRef\]](#)
43. Sensoy, A.; Sobaci, C.; Sensoy, S.; Alali, F. Effective transfer entropy approach to information flow between exchange rates and stock markets. *Chaos Solitons Fractals* **2014**, *68*, 180–185. [\[CrossRef\]](#)
44. Chunxia, Y.; Xueshuai, Z.; Luoluo, J.; Sen, H.; He, L. Study on the contagion among American industries. *Phys. A Stat. Mech. Appl.* **2016**, *444*, 601–612. [\[CrossRef\]](#)
45. Behrendt, S.; Dimpfl, T.; Peter, F.J.; Zimmermann, D.J. RTransferEntropy—Quantifying information flow between different time series using effective transfer entropy. *SoftwareX* **2019**, *10*, 100265. [\[CrossRef\]](#)
46. Dimpfl, T.; Peter, F.J. The impact of the financial crisis on transatlantic information flows: An intraday analysis. *J. Int. Financ. Mark. Inst. Money* **2014**, *31*, 1–13. [\[CrossRef\]](#)
47. Hartley, R.V. Transmission of information. *Bell Labs Tech. J.* **1928**, *7*, 535–563. [\[CrossRef\]](#)
48. Jizba, P.; Kleinert, H.; Shefaat, M. Renyi's information transfer between financial time series. *Phys. A Stat. Mech. Appl.* **2012**, *391*, 2971–2989. [\[CrossRef\]](#)
49. Rényi, A. *Probability Theory*; Dover Publications: New York, NY, USA, 1970.
50. Beck, C.; Schögl, F. Thermodynamics of chaotic systems: An introduction. In *Cambridge Nonlinear Science Series*; Cambridge University Press: Cambridge, UK, 1993; Volume 4.
51. Alqahtani, A.; Martinez, M. US Economic Policy Uncertainty and GCC Stock Market. *Asia-Pac. Financ. Mark.* **2020**, *27*, 415–425. [\[CrossRef\]](#)

52. Istiak, K.; Alam, M.R. US economic policy uncertainty spillover on the stock markets of the GCC countries. *J. Econ. Stud.* **2020**, *47*, 36–50. [\[CrossRef\]](#)
53. Sum, V. How Do Stock Markets in China and Japan Respond to Economic Policy Uncertainty in the United States? 2012. Available online: <https://ssrn.com/abstract=2092346> (accessed on 26 August 2020).
54. Sum, V. The ASEAN stock market performance and economic policy uncertainty in the United States. *Econ. Pap. J. Appl. Econ. Policy* **2013**, *32*, 512. [\[CrossRef\]](#)
55. Yin, L.; Han, L. Spillovers of macroeconomic uncertainty among major economies. *Appl. Econ. Lett.* **2014**, *21*, 938–944. [\[CrossRef\]](#)
56. Finger, M.; Stucki, A. Open Innovation as an Option for Reacting to Reform and Crisis: What Factors Influence the Adoption of Open Innovation. In Proceedings of the 2nd ISPIM Innovation Symposium, New York, NY, USA, 6–9 December 2009.
57. Rauter, R.; Globocnik, D.; Perl-Vorbach, E.; Baumgartner, R.J. Open innovation and its effects on economic and sustainability innovation performance. *J. Innov. Knowl.* **2019**, *4*, 226–233. [\[CrossRef\]](#)
58. Yun, J.J.; Zhao, X.; Jung, K.; Yigitcanlar, T. The Culture for Open Innovation Dynamics. *Sustainability* **2020**, *12*, 5076. [\[CrossRef\]](#)
59. Yun, J.J.; Won, D.; Park, K. Entrepreneurial cyclical dynamics of open innovation. *J. Evol. Econ.* **2018**, *28*, 1151–1174. [\[CrossRef\]](#)
60. Yun, J.J.; Zhao, X.; Yigitcanlar, T.; Lee, D.; Ahn, H. Architectural Design and Open Innovation Symbiosis: Insights from Research Campuses, Manufacturing Systems, and Innovation Districts. *Sustainability* **2018**, *10*, 4495. [\[CrossRef\]](#)
61. Yun, J.J.; Lee, M.; Park, K.; Zhao, X. Open Innovation and Serial Entrepreneurs. *Sustainability* **2019**, *11*, 5055. [\[CrossRef\]](#)
62. Chen, W.; Xu, H.; Jia, L.; Gao, Y. Machine learning model for Bitcoin exchange rate prediction using economic and technology determinants. *Int. J. Forecast.* **2020**, *37*, 28–43. [\[CrossRef\]](#)
63. Chen, Z.; Li, C.; Sun, W. Bitcoin price prediction using machine learning: An approach to sample dimension engineering. *J. Comput. Appl. Math.* **2020**, *365*, 112395. [\[CrossRef\]](#)
64. Abualigah, L.M.; Khader, A.T. Unsupervised text feature selection technique based on hybrid particle swarm optimization algorithm with genetic operators for the text clustering. *J. Supercomput.* **2017**, *73*, 4773–4795. [\[CrossRef\]](#)
65. Abualigah, L.M.; Khader, A.T.; Hanandeh, E.S. A new feature selection method to improve the document clustering using particle swarm optimization algorithm. *J. Comput. Sci.* **2018**, *25*, 456–466. [\[CrossRef\]](#)
66. Abualigah, L.; Khader, A.T.; Hanandeh, E.S. Hybrid clustering analysis using improved krill herd algorithm. *Appl. Intell.* **2018**, *48*, 4047–4071. [\[CrossRef\]](#)
67. Meynkhard, A. Priorities of Russian Energy Policy in Russian-Chinese Relations. *Int. J. Energy Econ. Policy* **2020**, *10*, 65–71. [\[CrossRef\]](#)
68. Meynkhard, A. Energy Efficient Development Model for Regions of the Russian Federation: Evidence of Crypto Mining. *Int. J. Energy Econ. Policy* **2019**, *9*, 16–21. [\[CrossRef\]](#)
69. An, J.; Dorofeev, M. Short-term FX forecasting: Decision making on the base of expert polls. *Investig. Manag. Financ. Innov.* **2019**, *16*, 72–85. [\[CrossRef\]](#)
70. Nyangarika, A.M.; Tang, B.-J. Influence Oil Price towards Economic Indicators in Russia. *IOP Conf. Ser. Earth Environ. Sci.* **2018**, *192*, 012066. [\[CrossRef\]](#)
71. Neudecker, T.; Hartenstein, H. Could Network Information Facilitate Address Clustering in Bitcoin? In Proceedings of the FC2017: International Conference on Financial Cryptography and Data Security, Sliema, Malta, 3–7 April 2017; Springer: Cham, Switzerland, 2017; pp. 155–169.
72. Mikhaylov, A. Volatility Spillover Effect between Stock and Exchange Rate in Oil Exporting Countries. *Int. J. Energy Econ. Policy* **2018**, *8*, 321–326.
73. Hegde, M.S.; Krishna, G.; Srinath, R. An Ensemble Stock Predictor and Recommender System. In Proceedings of the 2018 International Conference on Advances in Computing, Communications and Informatics (ICACCI), Bangalore, India, 19–22 September 2018.
74. Manning, C.D.; Raghavan, P.; Schütze, H. *Introduction to Information Retrieval*; Cambridge University Press: New York, NY, USA, 2008; p. 123.



75. Lukashin, Y.P. Adaptive methods for short-term forecasting. *Finansy i Statistika* 2003. Available online: <https://www.imemo.ru/en/publications/info/adaptive-methods-of-short-term-forecasting-of-temporal-rows-moscow-finansy-i-statistika-publishers-2003> (accessed on 26 August 2020).
76. Louppe, G. *Understanding Random Forests: From Theory to Practice*; University of Liège: Liège, Belgium, 2015; pp. 25–53.
77. Lohrmann, C.; Luukka, P. Classification of intraday S&P500 returns with a Random Forest. *Int. J. Forecast.* **2019**, *35*, 390–407. [[CrossRef](#)]
78. Lischke, M.; Fabian, B. Analyzing the Bitcoin Network: The First Four Years. *Futur. Internet* **2016**, *8*, 7. [[CrossRef](#)]
79. Lewer, J.J.; Van den Berg, H. A gravity model of immigration. *Econ. Lett.* **2008**, *99*, 164–167. [[CrossRef](#)]
80. Lahmiri, S.; Bekiros, S. Cryptocurrency forecasting with deep learning chaotic neural networks. *Chaos Solitons Fractals* **2019**, *118*, 35–40. [[CrossRef](#)]
81. Kroll, J.A.; Davey, I.C.; Felten, E.W. The economics of Bitcoin mining, or Bitcoin in the presence of adversaries. In Proceedings of the WEIS, Washington, DC, USA, 11–12 June 2013; p. 11.
82. Kristoufek, L. What Are the Main Drivers of the Bitcoin Price? Evidence from Wavelet Coherence Analysis. *PLoS ONE* **2015**, *10*, e0123923. [[CrossRef](#)]
83. Kristoufek, L. BitCoin meets Google Trends and Wikipedia: Quantifying the relationship between phenomena of the Internet era. *Sci. Rep.* **2013**, *3*, 3415. [[CrossRef](#)]
84. Koshy, P.; Koshy, D.; McDaniel, P. An Analysis of Anonymity in Bitcoin Using P2P Network Traffic. In Proceedings of the FC 2014: International Conference on Financial Cryptography and Data Security, Christ Church, Barbados, 3–7 March 2014; Springer: Berlin, Germany, 2014; pp. 469–485.
85. Kohavi, R.; John, G. Wrappers for feature selection. *Artif. Intell.* **1997**, *97*, 273–324. [[CrossRef](#)]
86. Kira, K.; Rendell, L.A. A practical approach to feature selection. In *Machine Learning Proceedings 1992*; Sleeman, D., Edwards, P., Eds.; Morgan Kaufmann: San Francisco, CA, USA, 1992; pp. 368–377. [[CrossRef](#)]
87. Kenda, K.; Kazic, B.; Novak, E.; Mladenčić, D. Streaming Data Fusion for the Internet of Things. *Sensors* **2019**, *19*, 1955. [[CrossRef](#)]
88. Kang, Q.; Zhou, H.; Kang, Y. An Asynchronous Advantage Actor-Critic Reinforcement Learning Method for Stock Selection and Portfolio Management. In Proceedings of the ICBDR 2018: 2nd International Conference on Big Data Research, Weihai, China, 27–29 October 2018; pp. 141–145.

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