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Development Features and Principles of Blockchain Technologies and Real Options as the Main Components of the Digital Economy

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Abstract. The paper shows that the digital economy reveals a huge range of opportunities for various enterprises. It noted its strengths: costs reduction, increasing the level of transactions' security and transparency, close focus of various sectors of the economy. In this regard, for a clear and definite understanding of the problems under consideration, the authors introduced the definition of the digital economy, digital technologies in the economy, and "end-to-end" digital technologies in the economy.

The authors' proposed approach allowed concluding that the digital economy term is distinguished by several subtleties associated with insufficient knowledge, understanding of technical implementation, and flexibility.

The research aims at revealing the development features and principles of the main components of the digital economy: distributed ledger technology (blockchain) and option technologies.

The paper shows that blockchain technology, as a decentralized data ledger, is the most discussed and relevant topic in the development of the digital economy. Its strengths are analyzed, such as cost reduction, increased security and transaction transparency affecting various sectors of the economy.

The conducted research exposes the essence of the main provisions of tactics and strategies when solving the problem of options pricing. At the same time, there is presented a new classification of options contracts allowing to determine the ways of their application and development. Whereas, the analysis of the problem of options contracts pricing demonstrated the relevance of new mathematical methods developed for their reliable and accurate evaluation.

The paper shows that at present, interest in the concept and technique of real options application has significantly increased; as they draw attention as a potentially essential tool for evaluation and improving an enterprise development strategy.

Keywords: digital economy, real options, blockchain, transaction transparency, costs, investments.

1 Introduction

Until recently, the world was organized according to the centralization principles of management, resource allocation, money circulation, and supervisory and regulatory bodies. There are many inefficiency and fragility examples of the centralized government model. The point here is simply the banal centralization ineffectiveness for of long-term stable development. Meanwhile, the centralization can be very effective in solving urgent, critical, and short-term problems. However, in the long term, it is ineffective, as it is not amendable to modernization processes.

The stable and high economic growth of the United States is largely connected with the decentralized system of government. Each state of the United States in terms of legislative and executive power differs little from the states of Europe, each of them has its own laws and, in fact, independent, but mutually integrated economies. At the same time, China, which is often mistakenly perceived as the top of centralization, is in an economic sense very similar to the United States, especially after the start of Deng Xiaoping's reforms [1], who began them precisely with the decentralization of economic management.

There are many other examples in economics and history testifying to the centralization ineffectiveness and, conversely, the decentralization effectiveness. The widespread of modern information and communication technologies presupposes the economy transition to the digital field. That process is directly reflected in management methods both at the macro level and at the level of commercial structures particularly, the transition to a decentralized management system is underway.

The spread of digital technologies for a long period determines the development of the economy and society and has more than once led to dramatic changes in people's lives. The advent of the digital economy is one of the priority areas for most countries, including economic leaders.

The advent of new generation digital technologies, which, due to the scale and depth of their influence, were called “end-to-end” - artificial intelligence, robotics, the Internet, wireless technologies etc caused another rise of business and social models transformation recently. Their implementation can increase labor productivity in companies. Shortly, new digital technologies determine the international competitiveness of individual companies and entire countries that form the infrastructure and legal environment for digitalization.

Note that in international practice, there is still no unambiguous definition of the digital economy. In most sources, when describing the digital economy, the emphasis is on technologies and the changes about their use in the interaction among economic agents. Here one can either mention specific types of technologies or certain forms of changes in economic processes. The digital economy definition is often substituted by listing the directions of its influence on the economy and social sphere. In this regard, the concept of the digital economy and digital technologies is shared. For clarity and concepts definiteness, there can be introduced authors’ understanding of the provisions.

Definition 1. The digital economy is creating, distributing, and applying digital technologies and related products and services.

Definition 2. Digital technologies in the economy are technologies for collecting, storing, processing, searching, transferring, and presenting data electronically.

Definition 3. "End-to-end" digital technologies in the economy are those used to collect, store, process, search, transfer, and present data in digital form, which operation is based on software and hardware tools and systems that are in demand, creating new markets and changing business processes.

Currently, the following components of the digital economy are developing most intensively:

1. Distributed ledger technologies (blockchain) - algorithms and protocols for decentralized storage and processing of transactions structured as a sequence of related blocks that cannot subsequently be changed.

2. Option technologies are one of the most flexible and practical financial instruments on the world market, which is a kind of the equivalent of a contract that gives any buyer the right, but not the obligation, for purchasing or selling a specified asset at a clear cost or for a specified period.

Considering the above, the research highlights the analysis of the main mechanisms of contradictions, arrangement and implementation of blockchain technology, and revealing the principles of organizing real options in the digital economy.

2 Analysis of recent research and publications

In decentralization, an actively discussed hot topic is the possibility of applying blockchain at different managing levels. Blockchain technology is a continuous sequential chain of blocks with information built according to set rules. The use of the blockchain is based on the decentralized storage of the data chain. Herein, data on completed transactions are stored in a specific order and form an invariable sequence of related blocks. Consequently, the information contained in the block is replicated and copied to each node in the network. That algorithm provides the technology with resistance to data changes.

Typically, the blockchain is managed by a peer-to-peer network. Once written, the data in any block cannot be changed without completely changing all subsequent blocks, which requires the majority consent of the network participants. M. Swan in the "Blockchain: Scheme of a New Economy" book [2] identifies three types of blockchain:

1. Blockchain 1.0 is a cryptocurrancy. Including Bitcoin, Ethereum, Litecoin, etc.

2. Blockchain 2.0 is smart contracts. That is a wide class of financial applications that work with stocks, bonds, futures, mortgages and many other financial assets.

3. Blockchain 3.0 - all other applications based on the technology and beyond financial sphere.

The fundamental feature of blockchain technology implies the processing of transactions without intermediaries [3]. Transactions are distributed by nodes that are linked to each other via hash numbers. The miners compute those hash numbers for the block and, based on consensus, the block is accepted into the blockchain network. These blocks contain a register of transactions or smart contracts. This blockchain evolution has changed the way the Internet is viewed as a source of some economic

value [4]. Experts in the digital economy claim that by 2027, 10% of global GDP will be stored in the blockchain [5]. Despite the serious attention to the technology, the blockchain still requires appropriate research and clarifications to solve, e.g., problems related to the processing time of transactions [6] and others.

Blockchain as a decentralized data ledger has a great future. The blockchain allows simplifying the work of registration chambers, notaries, and medical institutions. Moreover, registration chambers will simply become unnecessary if blockchain technology develops. Likewise, there will be no need for registrars of various securities reducing the transaction costs.

The second most important and relevant component of decentralization of management is option technologies.

According to some authors [7,8], the real options theory application to assess projects allows a greater number of key factors in the analysis than creating a discounted cash flow model. Thus a disadvantage of the net present value method is eliminated - the lack of flexibility and the impossibility of a full analysis of the available scenarios in the implementation of most investment projects. Recently, some experts have paid great attention to real options as a new toolkit that has come to the realm of real investments from financial markets.

In the classical sense, an option is an instrument of a financial or commodity derivatives market, which is a paid right to buy (call option) or sell (put option) an underlying asset (usually a standard number of shares or an exchange commodity) at a specified price (strike price) for a certain fixed date in the future (European option) or at any time before a certain fixed date in the future (American option), if the option holder finds it profitable to do so; otherwise, the holder has the right not to carry out the transaction.

Thus, in the general case, an option is a prepaid opportunity (but not an obligation) to take any action if conditions are favorable in the future.

The situation, essentially similar to buying and exercising/not exercising an option, often occurs not only in financial markets but also in other areas of economic life, in particular in the field of corporate finance and real investments. So, e.g., the company shareholders attracting debt financing become the owners of the CALL option for the right to own the company, and they will abandon the company if its value is insufficient, transferring rights to creditors. An example is a land plot, which is a CALL option for its owner to develop that plot if the forecast market conditions are favorable enough and the project's net present value reaches the desired level.

A real option is the ability to make flexible decisions under conditions of uncertainty [9]. At first, there was little interest, mainly of an academic nature, but since the mid-90s of the twentieth century, interest in the concept and technique of real options application increased significantly; as it was a potentially essential tool for assessing and developing strategies, first in the oil and gas sector, and then in other areas related to corporate investments.

The first conference, devoted to theoretical and practical issues related to applying the theory of real options, was held in 1996 and has been held annually ever since in the United States and other countries [10].

Entire books devoted to this issue began to appear, with many academic papers. There was a transition from an average, exclusively academic interest to significant, active scientific and practical attention.

Objectives. Based on the literature review and the above analysis results of the current state of digital economy problems development, there came the intention to analyze the main mechanisms for the blockchain technology implementation, identifying the fundamental problems of its implementation, perform a systematic analysis of the contradictions of blockchain technology and propose ways to eliminate them; study features of the real options application in the digital economy, analyzing the basic requirements of digitalization when using real options and identify the main provisions of tactics and strategy in solving the problem of option pricing.

3. Statement of the main research material

Main mechanisms for the blockchain technology implementation

The main task for which blockchain technology is an appropriate solution is coordinating the actions of system participants united by a single goal but lacking trust in each other.

Among cryptologists, it is known as a classic "task of the Byzantine generals," with the following formulation: "The Byzantine army besieges the city. Generals need to develop a single strategy leading to victory, even if there are traitors among them, deliberately distorting information about the number of their troops and the time of the offensive. " Blockchain solves that problem with consensus mechanisms.

This technology has great potential for those systems, which participants have no mutual trust since it provides reliable storage of personal data, making changes in them inaccessible for fraudulent purposes [11].

The most valuable link in blockchain technology is the algorithms for reaching consensus, as those provide it with reliability.

There are three main mechanisms for achieving agreement.

a) *Proof-of-work* is a system security protocol. Anyone wishing to write a block to a database must perform a certain hard-to-compute task based on the principle of a one-way function. The computation takes a long time, while the receiving party quickly checks the result. Before sending the message, some mark is added to the header, which validity can only be confirmed by brute force. Computations verification on the receiving side is fast - due to a single SHA-1 computation with a pre-prepared label.

At the moment, the proof-of-work algorithm is the most popular among other mechanisms for creating reliable systems. The matter is that the one who can withstand the " Sibyl attacks," which essentially means that the attacker creates many fake participants and thus tilts the consensus in its direction. Running such an attack complicates the proof-of-work algorithm since the fraudster must spend colossal computing power to complete it. Also, most Blockchains charge a fee for participating in the consensus; hence the "Sibyl attack" becomes a very expensive operation. Often, the

proof-of-work algorithm is criticized due to its excessive energy consumption, but so far, this is the only means of resisting such interventions in the system.

b) *Proof-of-stake* is an alternative protection protocol to proof-of-work that requires confirming the storage of a certain amount in the account as proof. With a higher probability, when forming the next block, the system chooses a miner with big funds on the account, while this choice probability does not depend on the processors' power. In order to undermine the system's reliability, one of the participants must collect over 50% of all system funds, which is very costly.

Proof-of-stake has more advantages over proof-of-work. The main thing is lower time costs (there is no need for lengthy computations), but this does not eliminate possible problems. There is also no evidence of effectiveness in protecting against risks arising in cryptocurrencies.

Two significant advantages of this protocol are that an attack on a system is very expensive, and the participant that runs it will significantly suffer since it will violate the system's stability. Arguments against this are that the method motivates accumulating funds in separate accounts, which calls into question decentralization. In the formation of a few participants with the most concentrated funds can own conditions for the system functioning.

c) *Delegated-proof-of-stake* is an improved version of the proof-of-stake protection protocol; which specificity is that blocks are generated by a predefined set of system users (101 delegates) who are rewarded for the duty and punished for misconduct (such as double-spending). The list of users eligible for block signing changes periodically according to certain rules; e.g., in Slasher, delegates are selected based on the stake and blockchain history. Delegates can receive votes from all users; the strength of the vote depends on the share of the voter's currency. Delegated-proof-of-stake has the same advantages and disadvantages as proof-of-stake.

4. Blockchain technology and problems of its implementation

Blockchain is surely an attractive and most promising technology but not suitable for every system. Several prerequisites indicate blockchain implementation:

a) shared database;

b) no trust between the participants;

c) need for the absence of intermediaries;

d) interdependence of operations, the need to create chains.

Nevertheless, it is worth noting that even for those systems where blockchain technology is applicable, its implementation has several obstacles caused by structure and technology principles [11]. Let us consider a few of them.

a) Security and privacy issues. Despite the security solutions using sophisticated encryption algorithms, cybersecurity issues remain one of the most discussed. Any software is written by a person, and therefore imperfect. The more it gets complicated, the faster the number of vulnerabilities grows. In addition, the integrity of the software and the network is vital for the blockchain transformation into an infrastructure technology. If the blockchain gets intertwined with all the world’s major financial systems, the powerful attacks can lead to disastrous consequences.

b) Implementation and integration issues. When an organization adopts technology to modernize its business processes, it challenges migrating its old data to a new format. Here, the blockchain implementation is no simpler than other similar tasks, which means that the issue of planning the transition from current systems to blockchain still stands. The cost savings that blockchain implementation promises are encouraging, but implementation requires high upfront costs that cannot be ignored.

c) Understanding technology. One of the biggest operational risks is that relatively few people understand how it works. If it is planned to introduce blockchain into a system whose users are the population's wide sections, it can lead to unpleasant consequences. The thing is that the blockchain does not protect against the most popular type of fraud - phishing, which essence is to steal confidential user data. Key compromise can result in the permanent loss of cryptographically protected funds. Unfortunately, today not every ordinary user can boast of knowing the basic rules for protecting personal data. A possible solution to identity theft is to associate public keys with an individual or a legal entity, but this mechanism requires additional costs.

d) The operations speed issue. In order to protect against a 51% attack, the block size (e.g., Bitcoin) remains no more than 1 megabyte, which allows maintaining decentralization. However, it significantly limits the transaction speed - 3.3 per second, while the Visa conducts 22 thousand per second. Expanding the throughput to at least ten transactions per second requires an increase in the block size to 1.6 gigabytes, which, firstly, causes problems for low-power miners and, secondly, complicates block distribution across nodes. Today, the Bitcoin blockchain "takes" about 38 GB [12]. Suppose subsequently blockchain systems appear that store information about transactions and other, more voluminous data. In that case, they are likely to fail since forcing miners to store other people's data for free; the developer deprives them of the incentive to maintain the network, i.e., miners' costs will exceed revenues

5. System analysis of blockchain technology contradictions

Blockchain, like any new innovative technology has many problems to be solved for full-scale implementation.

One of the most important is the decentralized data storage problem: Fig. 1 depicts a feature of the problem of decentralized data storage with the main contradictions for the technology under consideration wherein complete data register is stored in each node of the network, it allows restoring the network until the last node of its network is destroyed. However, it should be borne in mind that during the operation, the network is constantly growing, which leads to uncontrolled amounts of data. In addition, to enter the network of a new member, one needs to sync a large amount of data [12].

As an alternative to solve the problem, there could be a standard database that stores exact data in encrypted form and enters only their hash into the blockchain. The obsolete blocks are then archived. However, it is worth mentioning that this is some local solution to the problem.

Nevertheless, the following circumstance must be kept in mind. When using blockchain technology to store data, it is important to remember that modern technologies do not allow storing large amounts of information on the blockchain. Thus, in

essence, blockchain technology in this industry here is practically used as an intermediary and a ledger that enforces the terms of a transaction to provide storage from one person to another (see Fig. 1). The circumstance means that neither blockchain technology, nor smart contracts, nor cryptography protect information in a decentralized storage [13]. Moreover, it can be argued that information has the same protection in such circumstances as in traditional repositories.

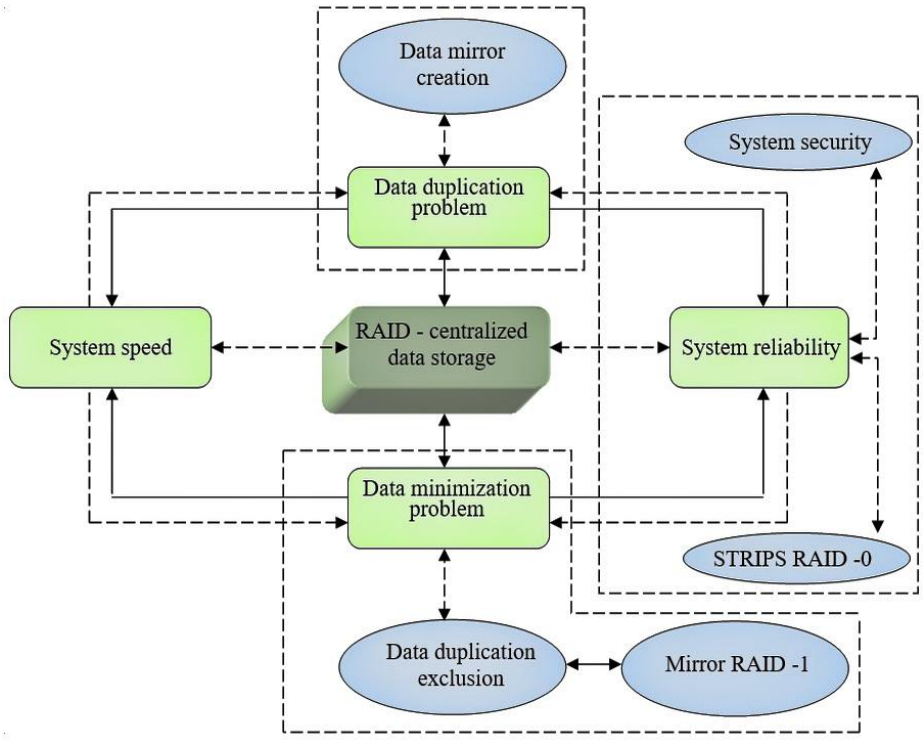

Fig. 1. Contradiction scheme for decentralized data storage in the blockchain system (Source: *Authors' elaboration*)

In connection with the above, it can be assumed that one can apply methods from such technologies as "big data" [14]. The approach was developed in various architectures such as Map Reduce, Shared Memory, Shared Nothing, Shared Disk, etc. It is also focused on working with large amounts of data storage and processing. The main obstacle to integrating big data tools into blockchain is the type of system: blockchain is a decentralized distributed system, which means that computations are distributed among multiple nodes, and there are no nodes that control other nodes' operations. However, another approach can be considered here. It should be borne in mind that, practically, the blockchain is a simple database with significant scalability and no-query languages. However, decentralization, immutability, transparency, and universal data exchange more than compensate for its shortcomings. Referring to the above,

Bigchain DB and IPDB technologies are currently underway, which are becoming global databases with decentralized management.

Another critical task is to ensure trust in the system; the system must be anonymous and transparent for its participants. Fig. 2 shows a diagram of trust contradictions in the system. However, it should be noted that the concept of a distributed ledger is an attempt to create universal tools for solving the problem of trust in the remote implementation of business relations using information and telecommunication systems. The idea of a distributed ledger is embodied in several open, proprietary, and hybrid software platforms, most of which are generic, but some are specialized. The platforms enable the applications' development for many areas of business relationships.

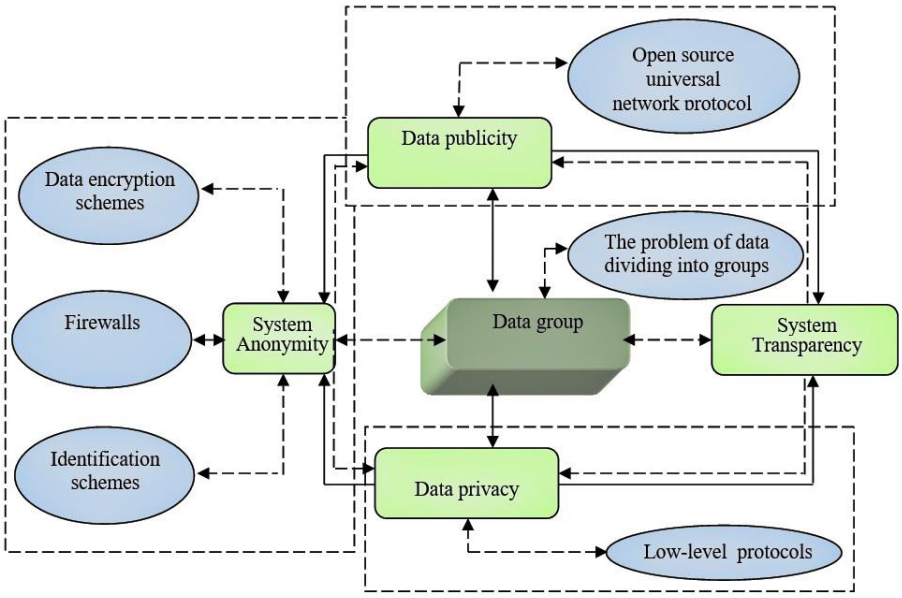

Fig. 2. Diagram of trust contradictions in the blockchain system (Source: *Authors' elaboration*)

It is necessary to consider the following basic aspect. Users want to see the data movement on the web, not to know what they are doing. For this reason, it was decided to apply asymmetric encryption algorithms - thus, each user has a pair of keys: private and public. In this case, Fig. 3 demonstrates the relationship of users' data. The private key is used to sign the blocks that are sent by the user. The user's network address is displayed using the public key. Here are some of the main features of using custom keys. Before a user can conduct any transaction, one needs keys: a public and a private key. It is a string of characters - in the case of a public key, there can be from 26 to 35. Public and private keys are related to each other (Fig. 3) - and the user needs them both to send and receive data via the network.

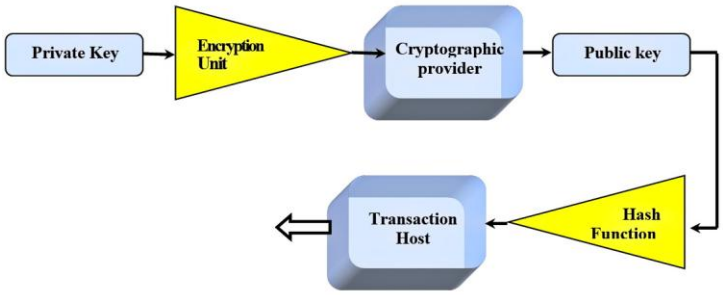

Fig. 3. Interrelation of user keys in the blockchain system (Source: *Authors' elaboration*)

Interestingly, the network always knows that the user's public and private keys are related, without even seeing the private key itself (Fig. 3).

Thus, a custom public key is communicated to senders and recipients. It can be passed on to anyone. The private key, however, is a key that is extremely important to keep completely safe. It is linked to the user's public key using a cryptographic cipher and acts as a digital signature to authorize the transaction. In addition, access to the information sent to the user requires both keys (Fig. 3).

Figuratively, the relationship between public and private keys can be formulated as follows. There is some box, and only one branch can open the public key. Someone puts money in this box and closes it. After closing this compartment, money is transferred to an adjacent compartment, which lid can only be opened with a closed key. Moreover, while someone has only one private key, others will never reach the box. If it is lost, then the money will forever remain in the box; however, some cryptocurrency wallets provide a private key backup feature.

One of the blockchain's main problems is data reliability, which facilitates practical encryption algorithms [15]. Here there the unique algorithms for concurrent access and conflict resolution in the network are considered. Those must guarantee sufficient cryptographic strength of information on the network and allow the implementation of the digital signature [16].

6. Analysis of options as the most flexible financial tool of the digital economy

Options are one of the most flexible and practical financial tools in the global market. Experienced traders often use them in trading strategies.

So, an option is a contract equivalent that gives any buyer the right, but not the obligation for purchasing or selling a specified asset at a clear cost or for a specified period. In this regard, options are a replacement for a standard contract, where the main subject of bargaining is the very possibility of its preferential exercise. Along with bonds, those can serve as an analog of securities, and it is now a legally binding agreement with strict terms and conditions.

The decision to trade options contracts is one of the most sought-after methods of financial activity. That derivative financial tool has a fixed profit and loss, making it the most efficient option against the backdrop of alternative online trading methods.

Note that over the past five years, investors have often used binary options in practice. The average income from such contracts is over 80%. Adjacent, one can conclude deals with a minute expiration, which is also beneficial.

7. Classification of option contracts

There are several classifications of options contracts. The most advanced is based on the period for executing the basic requirements. According to that classification, options are divided into the following types: European and American. Fig. 4 depicts such options classification in more detail.

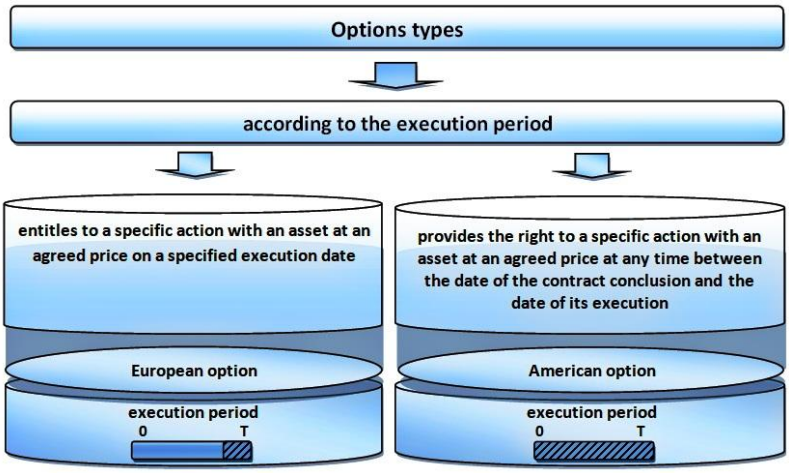

Fig. 4. Classification of options by the length of the exercise period
(Source: *Authors' elaboration*)

Analysis of Fig. 4 shows that if the option is trading according to the European scheme, a derivative provides the right to clear action with an asset at a specified value for a set period, and any attempt to execute the contract before the date leads to penalties. The American option has less stringent conditions, and it is permitted to be executed by the holder before the expiration period. Hence, the repayment is often made the entire time before the set day. Note that both schemes are still in use, so one can argue that those are equally in demand. However, their area application is radically different.

So, during the conclusion of exchanges, the American style is often used: it opens up more opportunities for trading participants and does not interfere with implementing investment strategies planned for the European option. A strict standard is observed only for the premium volume. Moreover, the exchange adjusts parameters such as price and execution period after trading and subsequent clearing.

However, the European format also became widespread when concluding transactions outside the exchange, i.e., directly between investors. It justifies itself by tough conditions, which are negotiated in advance for the sake of the interest of both

parties, and are not subject to daily revision, like contracts from the exchange. Meanwhile, there is no need for constant reassessment of contract and further trading in it.

So, when it comes to American contracts, the expiration dates are determined arbitrarily within the chosen strategy with the necessity to pay extra, and brokers set high commissions.

American style is allowed to close any day prior to expiration. Furthermore, the European one can be redeemed only on a specified date (expiration date, settlement, and maturity).

According to the option pricing method, those can be classified as Asian and exotic. Fig. 5 illustrates such a classification of options in more detail.

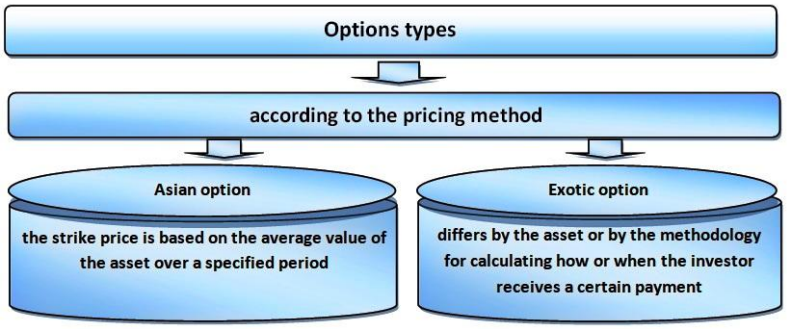

Fig. 5. Classification of options according to the pricing method (Source: *Authors' elaboration*)

An Asian option means an option that is executed at the weighted average cost for the entire duration of the option throughout the entire time from the date of purchase. That is also an independent derivative, where the final execution price is determined based on the average value of the investment asset over a fixed time. In the economic environment, those contracts are also called average price options. They are most often used in markets with the high volatility of investment assets that have to be traded [17, 18]. That mainly applies to commodities such as oil, exchange rates, and stock indices.

A distinctive feature of such a scheme is that the strike or the expiration option price at the time of its conclusion is unknown - sometimes, only the method of its determination is indicated. In most cases, traders who trade futures contracts deal with two options: European (cannot be exercised until expiration) or American (such an option available). Asian options are much less common than the two varieties mentioned above. However, this does not prevent them from enjoying stable demand in Asia and worldwide.

Let us note the main advantages of Asian options:

- less risk as the trader can accept a more rational offer;
- as a rule, Asian options are cheaper than European and American ones.

Exotic options take a special place in the options market. Unfortunately, the exotic option still has no strict definition. There are different points of view explaining the term origin, and here are some of them:

- exotic options are options that a one-factor model cannot value;

Exotic options have two main criteria: the complexity of payments and the rarity of signing.

Exotic options that appeared in the 90s quickly developed and gained great popularity in Western markets since they surpassed classic options in hedging efficiency. Exotic options provide investors with the opportunity to receive guaranteed returns in volatile conditions and additional income at low-interest rates. In most cases, they are very flexible, relatively cheap compared to a combination of simple options.

Option pricing analysis

Note that options are split into buy and sell options. CALL options enable the owner to purchase the asset in the future at a pre-agreed rate. Moreover, the PUT format gives the holder a chance to sell the asset on similar terms. There are also dual schemes: their distinguishing feature is that they are available simultaneously for both operations.

The European option allowed importers and exporters to ensure their work, making payments in different currencies.

Until the contract expiration, the investor can only passively observe what is happening without influencing the situation. Nevertheless, one can use a hedging strategy that automatically compensates for losses when the agreement suddenly becomes unprofitable.

Fig. 6 shows a detailed description of the options classification by the types.

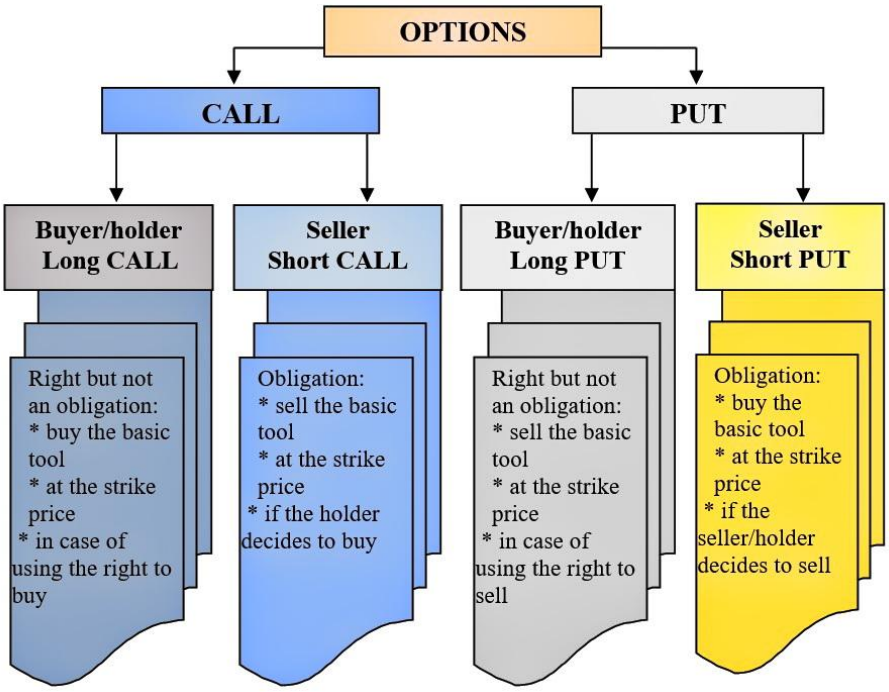

Fig. 6. Classification of options by type of trade (Source: *Authors' elaboration*)

The CALL option provides the owner with a good opportunity to buy the financial asset in the future at a pre-agreed cost. To do this, the trader only needs to pay a fixed transaction fee. Fig. 7 shows the CALL option strategy.

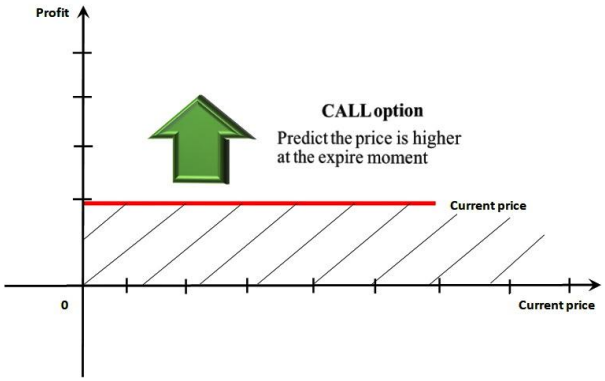

Fig. 7. Call option strategy

So the investor automatically becomes the option holder. Such is acquired when there is confidence in the growth of quotations of a financial asset.

Such options are often used in the case of short market action. The transaction is similar to a long-term position in stocks: the CALL buyer hopes that the price increases strongly before the expiration date. Also, this variant of the scheme is called a BUY option.

The PUT option is a similar tool. However, the main difference is that it is primarily focused on the sale of an asset. To make a profit, it is necessary to follow the price policy dynamics and, if necessary, use the hedging method in parallel.

It turns out that in this way, the investor makes money by forecasting a decrease in the underlying asset value without errors. Fig. 8 shows the PUT option strategy.

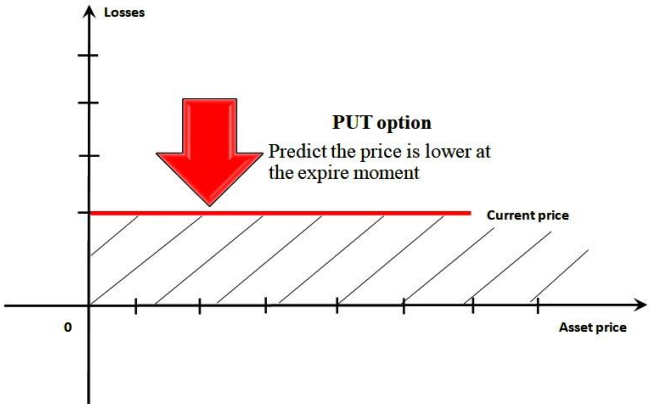

Fig. 8. Put option strategy

Sometimes even a drop of a single point is enough for dramatic changes. It is often advisable to purchase them when the securities owner wishes to protect the finances

from a coming fall. PUT itself gives the option buyer the right to sell the asset at an indicated price within a set time. In its structure, this scheme is similar to a short position: in this way, the buyer hopes that the share price declines before the allocated period ends. Sometimes this option is called a PUT option.

In rare circumstances, the most profitable solution would be to buy PUT and CALL options simultaneously.

Such trading operations have related assets, but in fact, have a different focus. This strategy is also called a double play. However, it makes sense to use the scheme only if there is a well-pronounced cyclicality of the asset's volatility in practice.

Conclusions

This paper demonstrates that the digital economy reveals a huge range of opportunities, ranging from the transfer of money to the transfer of music, from the approval of large government projects to innovations in land regulation, from transparent monitoring of the spending of public funds to the regulation of the salaries receipt. The application of this approach is multifaceted, and in general, it is difficult to predict where humanity will find the application of digital technology in the foreseeable future. It was noted that its strengths, the reducing costs, increasing the level of security, and transparency of transactions drew the attention of various economic sectors. In this regard, for a clear and definite understanding of the problems under consideration, the authors' definition of the digital economy, digital technologies in the economy, and "end-to-end" digital technologies in the economy were introduced.

The approach proposed by the authors allowed concluding that the digital economy is distinguished by several subtleties associated with insufficient knowledge, understanding of technical implementation, and flexibility. Therefore, it is too early to state a complete change in the current appearance of enterprises under its influence.

However, the indisputable fact is that the digital approach can transform its internal structure. However, for the digital economy to become widespread in various fields, it is necessary to address legal legitimacy, regulation, technical viability, standardization, and widespread adoption.

The paper highlights the most intensively developing main components of the digital economy: distributed ledger technologies (blockchain) and real option technologies.

Research has shown that blockchain technology is one of the main directions for the digital economy development. The paper shows that blockchain technology, as a decentralized data registry, is the most discussed and relevant topic in the development of the digital economy. Its strengths are analyzed, such as cost reduction, increased security and transparency of the transaction applicable for various sectors of the economy.

The main mechanisms of contradictions, arrangement and implementation of blockchain technology are highlighted in detail. The author's approach to eliminate the identified contradictions is presented.

Besides, the paper highlights the fundamental features of the option technologies development as one of the essential components of the digital economy. So, the op-

tions analysis is the most flexible and practical financial tool of the digital economy. In addition, the above study highlights the main provisions of tactics and strategies when solving the problem of options pricing. At the same time, a new authors' classification of options contracts is presented, allowing determining the ways of their application, use, and development. At the same time, evaluating the price of options contracts showed the relevance of developing new mathematical methods for their reliable and accurate evaluation [19].

The studies in this paper show that one of the main problems of the studied technologies is in the features of the modeling process, both machine and mathematical. For instance, both for servicing and solving problems of security of these technologies, it is necessary to use not just powerful computing equipment, but high-performance ones. On the other hand, the problem of determining the price of real options can be solved only via up-to-date complex mathematical apparatus. The authors attribute these problems to the prospect of further research.

It should be emphasized that the computing tools has always remained the main factor in the progress development in information technology. The problem of increasing of the computing resources efficiency has long been beyond any doubt and is currently relevant. Moreover, it is known that parallel computing is the most promising approach to increasing the speed and productivity of computing facilities. At the same time, modern practice shows that distributed (parallel) computer modeling can be implemented using the entire spectrum of modern computing technology: supercomputers, cluster computing systems, local and global networks, etc. In addition, distributed modeling allows processing the problems, which solution requires significant expenditures of processor time, integrate mathematical models to work on different (including geographically distant) computing systems.

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