ORIGINAL PAPER



DOI: 10.26794/2587-5671-2019-23-6-6-25
JEL G30, G39

# Comparative Analysis of ICO, DAOICO, IEO and STO. Case Study

**A.S. Myalo**
National Research University Higher School of Economics, Moscow, Russia
https://orcid.org/0000-0001-5647-5054

## ABSTRACT

The article examines the problem of the ICO (Initial Coin Offering, from English — "initial offer of coins, initial placement of coins"). The information source is the ICO rating data of the return on investment in blockchain startups. The methodological base of the research is a situational comparative analysis of the ICO, DAOICO, IEO and STO and systematization of information. The author analyzes three new ICO models. The first one includes elements of Decentralized Autonomous Organizations (DAO). Its aim is to minimize the difficulties and risks associated with the ICO. The second model (Initial Exchange Offering (IEO), from English — "primary exchange offer") is designed to minimize risks, liquidity problems and a delay in listing tokens at the end of the token sale. The third model — the Security Token Offering (STO, from English — "offer of security token") — was designed to support real assets and comply with the SEC requirements. These models are a new direction for small and medium enterprises and investors. The absence of any scientific work emphasizes the relevance and scientific novelty of the study. The article is a follow-up of the empirical work related to the success of the ICO, as well as the basis for its revision using the case study results.
***Keywords:*** ICO; DAICO; IEO; STO; investment; case study

***For citation:*** **Myalo A.S. Comparative analysis of ICO, DAOICO, IEO and STO. Case study.** ***Finance: Theory and Practice.*** **2019;23(6):6-25. DOI: 10.26794/2587-5671-2019-23-6-6-25**

## INTRODUCTION

Implementing a blockchain, a slow and expensive database, has provided the tools and infrastructure for transferring primitive digital tokens of value via an open, public Internet between independent participants without trusted intermediaries, using each network node. Nodes collect recent transactions signed by a private key to the lists called blocks. After the block is completed, the node applies a special cryptographic hash-function to it. After some technical operations, the node of the required participant receives the block and sends it to the other nodes of the network for verification. Then the block is added to the blockchain and becomes an official record of all transactions. The meaning of membership is that if your node finds a block, then you get a reward in tokens. Blockchain technology allows creating a cryptocurrency that is demonstrated in such a way that transaction authentication improves in proportion to the number of people serving the cryptocurrency.

To create a new token, a cryptocurrency unit, a new blockchain network should be scaled or tokens should be issued relying on the creation of the blockchain platform already in use for Bitcoin. Both methods encounter some difficulties due to the complexity of the deployment, the achievement of network effects for the new block chain, and the difficulty of coding enough information related to the new tokens into raw Bitcoin transactions.

In 2015, Vitalik Buterin presented cryptocurrency Ethereum and the Ethereum platform based on the concept of decentralized smart contracts. Smart contracts are protocols that can be performed by the distributed register technology itself. This allows you to fully comply with the clauses of the contract, without any party verifying or fulfilling the contract. The most commonly used smart contract to attract capital is the ERC-20, creating a new cryptocurrency token and helping transfer a cryptocurrency from one person to another. This unique feature allows developers to create a wide range of innovative applications on top of the Ethereum blockchain, becoming the most popular blockchain for the ICO. Ethereum currently has 90,2%[1] of the market share for ICO platforms. However, Ethereum is relatively slow in its trans-

[1] Compiled by the authors, based on ICObench.com.

actions. In addition to transactions with primitive digital tokens, such an innovation as a smart contract also made it easy to create and autonomously allocate digital tokens of value to users making tokens tradable. This process of creating tokens and their distribution among users in exchange for a primitive digital network token (cryptocurrency) is called the Initial Coin Offering (ICO) process and can be seen as a new asset distribution channel. In the broad sense of the term, any cryptocurrency, other than Bitcoin, can be considered an ICO, as it is a financial tool which is the starting point for every "young" cryptocurrency. In the ICO process, there is a proposal (token sale) of the original coins (tokens) for future holders in the form of blockchain-based cryptocurrency or cryptoactive assets. An ICO may include the issuance of three different types of coins: (i) utility tokens, which offer future access to the campaign service; (ii) security tokens, which operate similarly to security and provide a share of the company's future profits; (iii) cryptocurrencies or payment tokens, which serve as a medium of exchange for investors. However, all three coin offerings can be traded after the initial offer on unregulated platforms and, thus, share the transferability characteristics of shares/bonds. An ICO can be interpreted as a form of collective support for innovative technological projects, one of the types of crowding (crowdselling) in the form of attracting new participants. At the same time, investors (buyers of tokens) do not become owners of the company's shares and there is no government regulation at the cryptocurrency market. For investors, the main motivation to invest in a new project is the hope for an increase in the of tokens after launch due to the successful operation of the currency. The main form of presentation of ICO information is the White Paper, while there are no standards or rules how to prepare this document. As a rule, the White Paper should contain the following sections:

- the description of a business idea or a problem;
- the proposed solution and the description of the relevant project/product;
- the description of a token implementation mechanism (how it interacts with the product, economy, and its technical implementation);
- the project team;
- the parameters and timing of the release of tokens, the plans for future.

The procedure for issuing an ICO is usually the following:

1. Pre-ICO launch — pre-sale of units of a new currency, usually at a reduced price, compared to the one that will be at the first moment of selling an ICO.

2. ICO launch — immediate launch of the initial coin offering. Most purchases are made by investors who plan to resell the currency after its value has increased over time.

**Market overview**

The first token sale was held by Mastercoin in July 2013. Ethereum attracted money from the sale of tokens in 2014, raising 3,700 BTC in the first 12 hours, which at that time was approximately $ 2.3 million. Blockchain is used as a technological base for the ICO. For the last two years, total borrowed funds increased sharply. In April 2017, there was a big leap, ICO expenditures increased from $ 290,000 to $ 1.05 billion for 3 months, and increased by 4 times by November 2017. However, since the end of last year, the ICO market has been falling. For comparison, the market growth in June 2017 was 93%, while in November it was only 23%. Speaking about the geography of ICO projects, most ICOs were conducted in the USA ($ 1.031 billion), China ($ 452 million, including Hong Kong) and Russia ($ 310 million) with respect to regulating and supporting the blockchain industry, leading other countries. The most successful blockchain projects were implemented during the development of the blockchain infrastructure; the second place belongs to finance, the third — to social media, content, and advertising, and the fourth place was taken by the gaming industry and virtual reality.

According to the ICObench analytics, 2018 experienced both positive and negative changes in the whole crypto world. An extraordinary ICO Telegram Open Network took place in 2018. It broke all rules of the ICO market and attracted $ 1.7 billion. In 2018, the total number of ICOs increased by 3.5 times compared to the previous year. The whole ICO market took on new standards of sharing in terms of the increased number of advisors and expert ratings per

an ICO. Projects often set hard and soft limits, which indicates an increasing role of goal setting. Overall, the year of 2018 ended with a lower number of attracted funds compared to the beginning of the year. The total number of attracted funds has increased only by 15% compared to 2017. In 2018, the ICO was 4 times more than investment in blockchain projects ($ 3538 mln vs. $ 21017 mln).

In 2017, there were 718 complete ICOs and only 43 of them remained profitable 1 year later. The 2017 ICO's total market cap was 40% lower than the total amount of funds they raised together. In 2018, the average number of the funds raised by the ICO decreased in comparison to 2017 (*Table 1*). Still, there were projects that raised an impressive number of funds. However, these ICOs have an extremely negative ROI or they are not listed on exchanges now.

According to these statistics, the USA remains a leading ICO destination, reinforced by clear and firm regulatory requirements (e.g. KYC). In Europe, Switzerland stands out as the ICO capital, but in 2018, the UK gained terrain in terms of volumes and numbers. In Asia, Singapore is the main ICO hub, followed by Hong Kong. The Cayman Islands and the British Virgin Islands are among the largest ICO countries in terms of volume since they accepted Unicorn ICOs EOS ($ 4.1 billion) and Telegram ($ 1.7 billion). Other countries, not known for their large financial markets, are also among the leading ICO countries (for example, Estonia, Lithuania, Israel) (*details are given in Fig. 1 and Table 2–4*). In 2017, many planned ICOs did not occur or were not further publicly documented or communicated. The change in the leading countries is due to the change in regulation. The power of regulation at the beginning of 2019 among 95 countries is presented in *Fig. 2*.

## DISADVANTAGES AND LIMITATIONS

Risk is the biggest disadvantage of an ICO investment. The market is volatile, and no one ever knows the real intentions of a new company. The first risk is an ordinary fraud when the project team pursues the only goal: to collect investor money. In addition, since there are currently no laws regulating the behavior of cryptocurrency crowdsales from the perspective of an investor, it cannot be ruled out that the project may not reach the stage of product appearance or disappoint the investor with its implementation. Based on the statistical research provided by Satis Group [2], the premier ICO advisory company, approximately 81% of ICOs are scams, about 6% failed, about 5% had gone dead, and about 8% went on to trade on an exchange.

According to the Wall Street Journal, due to fraudulent crowdfunding campaigns, token holders lost more than a billion dollars. Actually, one of the main reasons for such statistics might be the lack of token holders' control over their investments, the absence of bills and laws regulating the legal field in the sphere of ICO.

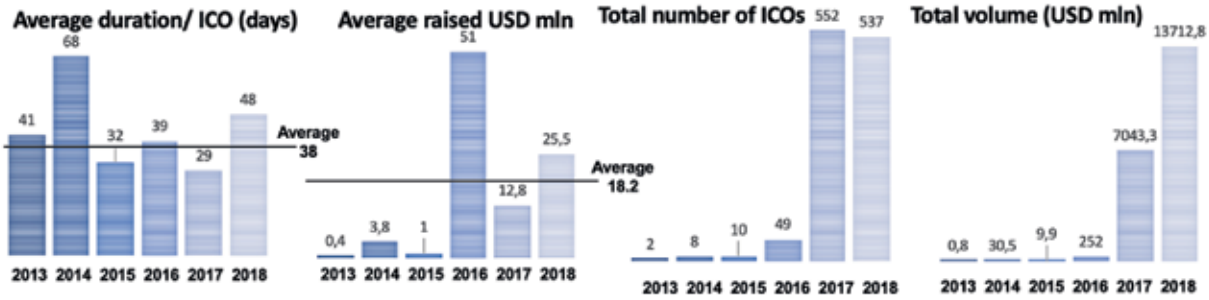
Another serious threat is hacker attacks. A study by Ernst & Young (2017) found that more than 10% of all funds raised by ICOs were stolen by cybercriminals. Analysts examined 372 ICOs conducted between 2015 and 2017. ICO's monthly loss from hackers was $ 1.5 million. Moreover, attackers often manage to gain access to personal data of investors: from their addresses and phone numbers to billing information. This ICO vulnerability is usually caused by errors in the smart contract code that were not specified during the audit. One of the most common types of attacks is a "51% attack". This happens when the attacker, in which a relatively small number of miners can play, has a "controlling share" of the hashrate, that is, processing power. In the result of the attack, miners gain control over the entire network and can create their own blocks. In such a way, hackers can have access to funds and transfer them to third parties.

Before launching an ICO, the development team determines the tasks for which it is necessary and indicates 2 digits in its White Paper: the minimum and maximum, called the Soft Cap and the Hard Cap. The Hard Cap defines the final goal, the upper limit of the amount of money invested, the most desired result. This is a very important indicator, precisely, because many cryptocurrencies have a limit on the total number of units in circulation. This, in turn, is one of the most important factors influencing the value of the coin, in addition to supply and demand. The Soft Cap is the minimum required amount of investment for the team to proceed the project implementation according the plan. If it is not reached

*Table 1*

**Statistics for 2013–2018 [1]**

| Year | Average duration/ ICO (days) | Average raised (USD, mln) | Total number of ICOs | Total volume (USD, mln) |
|---|---|---|---|---|
| 2013 | 41 | 0.4 | 2 | 0.8 |
| 2014 | 68 | 3.8 | 8 | 30.5 |
| 2015 | 32 | 1 | 10 | 9.9 |
| 2016 | 39 | 5.1 | 49 | 252 |
| 2017 | 29 | 12.8 | 552 | 7043.3 |
| 2018 | 48 | 25.5 | 537 | 13712.8 |
| All | 38 | 18.2 | 1158 | 21049.4 |




*Source:* calculated by the author based on EY research and PWC research.

within the specified period, the contract is closed, and it automatically returns all funds raised to the depositors. If the Hard Cap is reached, the sale of tokens stops. However, after overcoming the Soft Cap, investors control only the purchased tokens and cannot control the money invested or withdraw part of the investment.

Another disadvantage is the Gas War. The main ICO payment instrument was Ethereum. To conduct transactions in the Ethereum network, it is necessary to pay a commission to miners so that they confirm operations and enter them into a new unit. The higher the commission (GWEI) is, the more priority your transaction is for miners. Since the cost of ETH cryptocurrency is constantly changing, the developers decided to simplify the task and introduced an additional unit of calculation — Gas. It, in turn, is divided into two components — the limit (gas limit) and the price (gas price). Each miner receives a commission that is calculated in gas and is paid in ETH. The total commission is calculated by the sender, who sets the limit and the gas price and then multiplies one value by another. When the ICO participants use Ethereum token sale to compete and receive coins of new projects, they set high gas limits to increase the speed of transactions and first acquire tokens.

Overall, the main risks are tax risks (there is no agreement on whether the taxes/vat should be paid), regulation and legislation risks (there is no single position on the law and regulation of ICOs between countries, moreover, some location of ICOs may decrease the probability of success even with laws concerning the legal procedure of ICO [3]. An important question to investors is if ICO documents have a legal basis and if they have any rights in court), business (and investors) risks, structural risks (e.g. obfuscation[2] of how the founders will use ICO funds, undeclared salaries, unpublished financial documents, token holders cannot vote out the management of the token issuer, etc), team risks (there is a significant number of unqualified teams (no real business experience) and management quality is a classic factor affecting the financial performance of securities), token risks (they may be stolen/lost or the wallet may be hacked). Finally, the connection

[2] The deliberate act of creating source or machine code that is difficult for humans to understand. URL: https://en.wikipedia.org/wiki/Obfuscation_(software) (accessed on 20.08.2019).

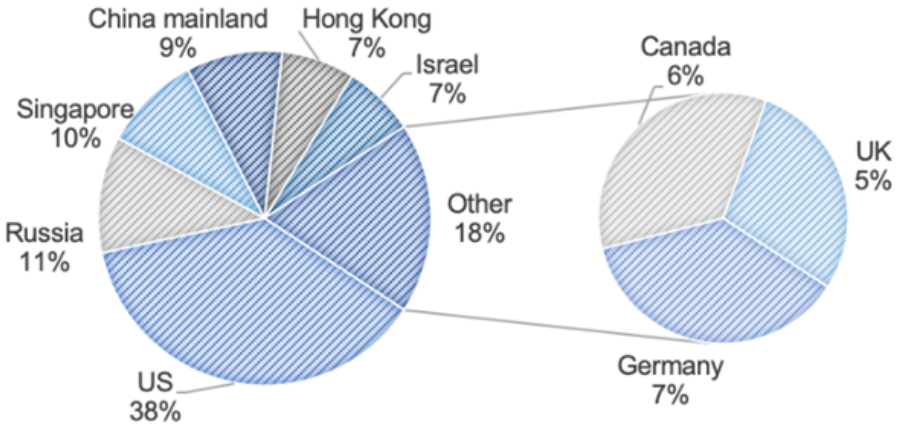



*Fig. 1.* **Geographical distribution of ICO projects (raised USD, mln) in June 2017–2018**

*Source:* calculated by the author based on coindesk.com, EY research, tokenmarket.com.

between the token holders and the holding company is of great concern, and several urgent questions arise. For example, what happens if the company that issued the tokens is sold or the token holders will have any rights under the new management?[3] To overcome this, new models are introduced. They are described in detail in sections 2–4.

## OVERVIEW AND CURRENT STATUS OF DECENTRALIZED AUTONOMOUS INITIAL COIN OFFERING

### Concept

"DAICO" abbreviation stands for Decentralized Autonomous Initial Coin Offering — decentralized autonomous public placement of tokens. A DAICO is a new fundraising model. Founder of Ethereum blockchain Vitalik Buterin proposed this model, combining the advantages of decentralized autonomous organizations (DAO) with the classic ICO. This synergistic model allows making the process of collecting and spending funds as transparent and safe as possible.

The idea of DAO has already existed for several years. However, the possibility of implementation appears only when using the blockchain, since the main goal of decentralized autonomous organizations is to build a decentralized business model for commercial companies. Blockchain technology has a timecode and a distributed registry, allowing a secure registry of contracts, acts and records that record ownership (or voting rights). The simplest explanation is the analogy proposed by Mike Hearn: 'Imagine a taxi without a driver. This taxi is searching for passengers. After the ride is finished, the taxi charges the fee and uses the profit to refuel. The taxi runs the coded algorithm autonomously'[4]. The same is true for DAO, they are coded to do a limited number of actions without any deviations. The main advantage of DAO is low operational costs (which arise due to principal agent problems) and reduced intermediation.

The DAICO is based on a smart contract that regulates all actions to attract and work with funds. From DAO, the concept takes extended control from the token holders. For example, after the public sale of tokens is completed, the contract temporarily blocks their free sale in order to avoid manipulation by the project team, one of the ICOs menace, and also determines how many funds developers can receive on a monthly basis. On the other hand, as in the classic ICO, a project team is working on the project, and not everyone, unlike the traditional DAO.

The difference between the DAICO and the ICO begins after the first stage when a mechanism called "tap" is launched[5]. Tap allows tokens holders to con-

[3] InvestItIn (2017). URL: https://www.investitin.com/ico-risks/ (accessed on 21.08.2019).

[4] (2018). URL: https://talk.bitzlato.com/t/decentralized-autonomous-organization-dao/420 (accessed on 21.08.2019).

[5] (2018). URL: https://hackernoon.com/overview-of-the-daico-crowdfunding-model-c611d55d4365) (accessed on 21.08.2019).

*Table 2*

**Comparison of funding in 2017 and 2018 in top-10 countries**

| Country | Raised in 2018 (USD, mln) | Raised in 2017 (USD, mln) | Change |
|---|---|---|---|
| Cayman Island | 4254 | 162 | 2526% |
| Singapore | 1192 | 641 | 86% |
| USA | 1092 | 1722 | –37% |
| UK | 507 | 275 | 84% |
| Switzerland | 456 | 1462 | –69% |
| Estonia | 323 | 63 | 413% |
| Lithuania | 259 | 51 | 408% |
| Israel | 226 | 192 | 18% |
| Hong Kong | 223 | 196 | 14% |

*Source:* calculated by the author based on coindesk.com, EY research, tokenmarket.com.

*Table 3*

**Top countries in 2018 (based on funding)**

| Country | Raised in 2018 (USD, mln) | Closed ICO, 2018 | Planned ICO, 2018 |
|---|---|---|---|
| Cayman Island | 4254 | 10 | 16 |
| British Virgin Island | 2227 | 16 | 2 |
| Singapore | 1192 | 53 | 52 |
| USA | 1092 | 56 | 50 |
| UK | 507 | 48 | 51 |
| Switzerland | 456 | 28 | 36 |
| Estonia | 323 | 31 | 40 |
| Lithuania | 259 | 6 | 5 |
| Israel | 226 | 5 | 5 |
| Hong Kong | 223 | 20 | 15 |

*Source:* calculated by the author based on coindesk.com, EY research, tokenmarket.com.

*Table 4*

**Top countries in 2017 (based on funding)**

| Country | Raised in 2017 (USD, mln) | Closed ICO, 2017 | Planned ICO, 2017 |
|---|---|---|---|
| USA | 1722 | 87 | 40 |
| Switzerland | 1462 | 33 | 1 |
| Singapore | 641 | 35 | 13 |
| Russia | 438 | 57 | 43 |
| China | 306 | 14 | 2 |
| UK | 275 | 26 | 23 |
| Japan | 195 | 6 | 6 |
| Canada | 163 | 10 | 5 |
| Cayman Island | 162 | 3 | 0 |

*Source:* calculated by the author based on coindesk.com, EY research, tokenmarket.com.

trol how much money is available for the team. The tap determines the amount per second that the development team can withdraw from the contract. Such a tool gives token holders control over the spending of raised funds and guarantees the security of their own investments. Payments to developers are not made once, but gradually, for example, once a month. If they need more than it is written in the smart contract, then this question is put to the vote. Token holders can either approve this proposal or not. So, the DAICO's key advantage over the ICO is that holders have a greater control with a possibility to vote and restrict access to investments, which negates the risk of manipulation of tokens and funds by the team.


*Fig. 2.* **The power of regulation**

*Source:* compiled by the author.

Moreover, such a synergy between DAO and the ICO decreases the possibility of a "51% attack". In the case of a 51% attack that maliciously increases the 'tap', the development team may simply reduce the 'tap' to the actual amount requested, or simply not use the extra money. Then the intruders will not be able to send funds to any other 3rd party chosen by the attacker. Token holders are not allowed to reduce the 'tap' by vote, this can only be carried out by the development or management team, which maintains a stable level of the tap not to keep funds stuck in the contract indefinitely. Even if a "51% attack" happens, the consequences when a hacker sends funds to a selected third party will be limited to the level where the depositors or the development team were allowed to withdraw funds. The DAICO platform reduces the risk and damage of two kinds of "51% attacks" on the ICO since the number of funds released by breaking a smart contract is limited and the 'tap' is strictly controlled.

The issue of extra investment can be solved by the DAICO model. The DAICO, like the ICO, has two goals on charges — the Soft Cap and the Hard Cap. In case of the ICO, developers return funds to investors only if they failed to collect the required amount during the Soft Cap. If the required amount of the Soft Cap is reached, investment cannot be refunded to token holders even if the project is stopped or it is terminated along the way. After the Soft Cap, fundraising continues until the Hard Cap. Sometimes the amount exceeds the set maximum value and continues to increase. In this case, the organizers must terminate the ICO and return the extra funds to investors. Unfortunately, the organizers do not always meet these obligations. Whereas, implementation of the DAICO platform increases the accountability of developers to investors and gives the latter additional guarantees that extra investments will be returned at the initial stage. In general, the DAICO solves the problem of irrevocable overspending of ICOs. In addition, if the token holders are dissatisfied with the development of the project, they can vote for the refund of the funds left on the smart contract at any stage of product development.

## OVERVIEW AND CURRENT STATUS OF INITIAL EXCHANGE OFFERINGS

### Concept

In 2018, an alternative to the ICO appeared — the Initial Exchange Offering (IEO). This is a new way to attract investment for various companies, where the cryptocurrency exchange is directly involved in the selection of projects, organization and sale of tokens. In fact, the IEO is a new ICO, where the exchange becomes the key marketing partner of the project, and the listing of coins is carried out only a couple of days after the campaign ends. Actually, the cryptocurrency exchange distributes digital assets among interested investors, who are verified users of the trading platform.

There are several advantages [4] of the IEO over the disadvantages of the ICO:

1. The risk of scams for investors is lower. The project is launched at the exchange after profound verification. The exchange rejects a dubious project to keep up its reputation.
2. Listing of new tokens is faster.
3. Redistribution of costs becomes available. According to Autonomous Research, listing an ICO token on a cryptocurrency exchange can cost promoters anywhere between $ 1 million and $ 3 million. An IEO project has lower costs for listing.
4. The financing rate is higher. In the ICO, the primary distribution of tokens may last for several days whereas in the IEO it lasts several minutes or even seconds.

5. Investor returns are higher. The value of a listed token is greater than in primary distribution.

6. There is no need to start another wallet.

7. The investment process is simple: investors need to replenish the balance on the exchange, wait for the token to be sold and place a purchase order.

8. Tokens are traded at the same price. This reduces the likelihood of falling rates for early investors who purchased first.

The main advantage of this approach for organizers is the ready-made base of potential IEO participants from a huge number of exchange users, so the marketing costs for the project team are reduced. Not only the IEO saves money, but also creates a synergistic effect, increasing the effectiveness of token promotion on the market. The primary source of income for stock exchanges are the revenues from the transaction fees (commissions) that are charged for each trade carried out on its platform. The more users and coins are in the listing, the more transactions and, accordingly, higher income from commissions are. Conducting the IEO on its own platform gives the exchange the opportunity to attract new users and offer exclusive coins that are not available on other sites. All this increases the trading momentum and, therefore, the income. Another advantage of the IEO for project developers is the absence of a Gas War since exchanges use their own cryptocurrency to sell tokens instead of Ethereum.

At the same time, all these advantages have some drawbacks. For example, due to the high propagation speed, some investors have no time to place an order and buy tokens of big projects. Nowadays there is a limited number of the IEO, and they are not the main way to finance projects. The reason for the decline in popularity is the unwillingness of exchanges to take on additional work. The mentioned verification procedure is very strict, e.g. there is an obligation to verify the identity. The main stop signals for the project developers is the price for the IEO and the same regulatory and legal problem as in the ICO (only South Korea has released a guideline on IEOs, covering the protection of investors, project development planning, technical materials, compliance, and security issues[6]).

**Market overview**

The examples of successful projects are BitTorrent (BTT) (the IEO took place on January 28, 2019 and attracted more than $ 7.2 million in just 18 minutes), Fetch.ai (FET) (attracted $ 6 mln in 22 seconds) and Cellar Network (CELR). The most well-known and reliable exchanges, providing their users with an opportunity to participate in the IEO [5] are Binance — Launchpad, Huobi — Huobi Prime, OKEx — OK JumpStart, Bittrex — Bittrex International, Kucoin — Spotlight, Coineal — Coineal Launchpad, BitForex — BitForex IEO and Bittrex — Bittrex International IEO. Unfortunately, there is a number of restrictions for exchanges in different countries. For instance, OKEx is not available in the USA, Binance restricts the trading opportunities for Albania, Belarus, etc.

According to the ICObench[7], the top countries conducting IEOs are: Singapore — is on the first place (11 projects, $ 58.8 mln)[8], South Korea — is on the second place (8 projects with the total number of funds equaling to $ 31.8 mln) and the third place belongs to Estonia (7 projects, $ 28.7 mln, but all funds were attracted by one IEO (Windhan Energy[9]). The rest important countries are the USA (6 projects, $ 25.8 mln), Hong Kong (4 projects, $ 65.7 mln — is a leader in total funds raised), the Cayman Islands (3 projects, $ 6.4 mln). In 17 countries there is only one IEO with the total amount of funds of $ 48.8 mln. Despite the fact that in the UK and the UAE there are 3 and 2 projects, zero funds were raised. By April 30, 42 projects were completed; by May 2, 60 IEOs were launched at ICObench and only 47 projects reached the Soft Cap.

[6] Countries and regions that currently ban IEOs: Albania, Afghanistan, Ethiopia, Belarus, Bosnia and Herzegovina, Burundi, North Korea, Congo, The Republic of Guinea, Guinea-Bissau, Canada, Zimbabwe, Cote d'Ivoire, Lebanon, Liberia, Libya, Malaysia, Macedonia, Myanmar, South Sudan, Serbia, Sri Lanka, Sudan, Somalia, Thailand, Trinidad and Tobago, Tunisia, Venezuela, Uganda, Ukraine, New Zealand, Syria, Yemen, Iraq, Iran, Central Africa, Mainland China. Exact source: OKEx (2019). URL: https://medium.com/okex-blog/what-is-initial-exchange-offering-ieo-the-evolution-of-ieo-market-9c7492f06df8 (accessed on 20.08.2019).

[7] ICObench Team (2019). URL: https://icobench.com/reports/IEO_Report.pdf (accessed on 10.08.2019).

[8] The data is contradicted to the CoinSchedule. URL: https://www.coinschedule.com/stats/IEO?dates=Jun%2001,%202019%20to%20Aug%2021,%202019. (accessed on 10.08.2019).

[9] Windhan is an ERC 20 standard based Green Energy Platform which uses blockchain technology to create a more meritocratic next generation of renewable energy assets. For more details follow: https://windhanenergy.io (accessed on 10.08.2019).

The biggest IEOs are Percival ($ 35 mln, but only 50% of the Hard Cap reached), Bread ($ 35 mln, 160% of the Hard Cap), CharS ($ 30 mln), GIFTO ($ 30 mln), Windhan ($ 28,7 mln) and ioeX ($ 27,2 mln)[10] (*Table 5*).

Based on the CoinSchedule, the total funds were $ 124.7mln in June 2019, $ 51.8 mln — in July 2019 and $ 9.5 mln — by August 21. The leading industries are shown in *Table 6*.

## OVERVIEW AND CURRENT STATUS OF SECURITY TOKEN OFFERINGS

### Concept

The popular utility tokens used in the ICO have a major disadvantage: investors are not compensated in case of failure of the ICO, since utility tokens are not securities, which leads to the absence of any obligations to create favorable conditions for investors. The solution of this problem is the security token. Security tokens represent real capital in the enterprise. At the same time, such a token is not necessarily tied to a share in the company, it can be used to separate property rights. In fact, they can provide the owner with a number of rights: ownership of shares, periodic dividends, cashflows, payment of debts, voting rights, etc. All these rights are secured by a smart contract. Due to the nature of these tokens, their value is supported by securities, therefore they are considered an investment. The issue of security tokens requires serious regulatory oversight. This oversight leads to the protection of investments and gives investors more rights, thus restoring the balance of power from the point of view of stakeholders. Additional regulation may include tax reporting, compliance monitoring, and additional transparency of information. Failure to comply with these laws by the company may result in severe penalties.

A Security Token Offering (STO) is an initial offer of security tokens. There is a similarity between the STO and the ICO: both of them issue tokens for investors. The main reason for purchasing a security token is dividends or voting rights. The STO ecosystem consists of 4 parts [6]: legal (to ensure that the STO is compliant, a company needs to work within the country's existing regulatory frameworks), an issuance platform (to issue a security token and to attract a range of potential investors, a company may choose to seek out the support of an issuance platform designed for STOs[11]), a custodian and exchanges.

An STO project meets all the requirements of the SEC meaning that the investor's money is protected by law. In the case of a dispute, the investor may file a complaint with the appropriate authority, since this type of token is subject to the securities law. The legal basis of a startup, government control and availability for institutional investors are factors of user confidence in the viability and investment potential of the company. To issue a security, it must be registered with the SEC, which is a complex and expensive process, but there is a way to avoid the laborious process. Since 2012, projects can use JOBS ACT. For example, in the USA, issuers can apply 3 types: Reg S, Reg D, Reg A+ and Reg CF [7]. The disadvantages relate to the cost of the project and the right to invest. Legal support of the STO project, the release of a security token and the development of its functionality will cost higher than in the ICO. Moreover, only qualified investors will be able to participate in the STO. They must have large private capital or be very active in the financial market for a certain period. For example, in Russia it is necessary to conduct at least 10 transactions totaling 300 thousand rubles over the past year; in the US, investors should have an income of $ 200,000 in each of the last two years [8]. Finally, the STO is a very slow procedure, e.g. Overstock's tZERO, which was officially launched in January, has not had an STO pipeline yet. The advantage of the STO is the ability to create "white" and "black" lists of investors, as a result of which they meet the requirements of KYC (know your client) and AML (anti-money laundering). The information transparency requirements increase corporate responsibility, reduce the likelihood of fraud and protect depositors in the event of bankruptcy. This makes the STO similar to the IPO. As a result, this leads to possibility to be presented at NASDAQ [9][12]

[10] ICObench Team (2019). URL: https://icobench.com/reports/IEO_Report.pdf (accessed on 10.08.2019).

[11] Some of the leading STO issuing platforms include Polymath, Swarm, Securitize, Harbor, and Securrency.

[12] Actually, NASDAQ uses blockchain technology when making a margin call through a distributed network among the deposit provider, the recipient, and other intermediaries. The distrib-

*Table 5*

**Token sales by funds raised**

| | Name | Amount Raised (mln $) | Start Date | End Date | Duration (days) | Description |
|---|---|---|---|---|---|---|
| 1 | Tron Game Global | 80 | 16.4.19 | 14.6.19 | 59 | The project that is currently laying the foundation for Internet decentralization about game blockchain |
| 2 | Opiria & PDATA | 18.4 | 11.5.19 | 15.6.19 | 35 | The decentralized marketplace that helps companies collect and analyze consumer data, enabling them to make better business decisions |
| 3 | Wink | 16 | 30.7.19 | 31.7.19 | 1 | Decentralized DApp platform |
| 4 | Azbit | 9 | 1.10.18 | 30.7.19 | 302 | The main objectives of the project are to meet the needs of cryptocurrency projects and users of traditional financial sector services, and to provide access to investment products and to the cryptocurrency markets |
| 5 | Squeezer | 9 | 14.5.18 | 20.6.19 | 402 | A platform that helps software developers build apps easily without tackling the entire blockchain infrastructure |
| 6 | 1irstcoin | 7.5 | 22.7.19 | 11.8.19 | 20 | One of the fastest, safest and most innovative trading site for cryptocurrencies |
| 7 | MixMarvel | 7.2 | 10.6.19 | 10.6.19 | 0 | A global game publishing platform powered by blockchain |
| 8 | Bitsdaq | 6.5 | 9.6.19 | 11.6.19 | 2 | The AsiaGlobal Exchange Network |
| 9 | Ultra | 5 | 16.7.19 | 16.7.19 | 0 | A protocol and platform positioned to disrupt the $ 140bn gaming industry using blockchain technology to allow anyone to build and operate their own game distribution platform or virtual goods trading service |
| 10 | Neutro | 4.7 | 15.6.19 | 31.7.19 | 46 | A protocol solves the trilemma of scalability, security and decentralization, allows for anonymous transactions and eradicates the need for centralized oracles |

*Source:* calculated by the author based on coinschedule.com.

*Table 6*

**Industries by amount raised and token sales**

| Industry | % of market by amount raised | % of market by token sales |
|---|---|---|
| Payments | 44.4% | 8.7% |
| Marketplace | 11.6% | 8.7% |
| Gambling & Betting | 11.3% | 8.7% |
| Finance | 8.5% | 13% |
| Trading & Investing | 7.5% | 8.7% |
| Infrastructure | 7.4% | 8.7% |
| Gaming &VR | 3.9% | 4.3% |

| Industry | % of market by amount raised | % of market by token sales |
|---|---|---|
| Social Network | 1.5% | 4.3% |
| Privacy & Security | 1.4% | 8.7% |
| Drugs & Healthcare | 0.8% | 4.3% |
| Recruitment | 0.8% | 4.3% |
| Data Analytics | 0.5% | 4.3% |
| Communication | 0.3% | 4.3% |
| Commerce & Advertising | 0.1% | 8.7% |

*Source:* calculated by the author based on coinschedule.com.

or NYSE [10]. There are several characteristics which will strengthen STOs: credibility, micro-investments traded as securities, ownership of underlying assets, high success rate[13], low fees, etc.

According to Chain Partners Research, the security token market forecast is positive: the market will grow to $ 2,000 billion in 2030 with a 59% CAGR between 2019 and 2030, as well as institutions that will be involved in the security token market after 2025. Moreover, security tokens may be divided

uted network of Nasdaq is based on Po W. The established private equity market trading system utilizing Nasdaq Linq is based on private blockchain.

[13] (2018). URL: https://hackernoon.com/will-2019-be-the-year-of-the-sto-understanding-stos-security-tokens-market-potential-over-icos-4d2502227220 based on Source: InWara's STO database. (accessed on 21.08.2019).

*Table 7*

**Top 7 Token sales by funds raised (STO)**

| | Name | Amount Raised (mln $) | Start Date | End Date | Description |
|---|---|---|---|---|---|
| 1 | Bolton Coin | 67.83 | 20.8.18 | 28.2.19 | The platform generates cumulative gains from tangible luxury markets such as gold and diamond mining, and real estate, integrated by eco-sustainable energy |
| 2 | UniCrypt | 8.412 | 21.1.19 | 21.5.19 | The IT company with experience in providing high-performance crypto-mining infrastructures and solutions for customers and clients |
| 3 | SocialRemit | 7.203 | 1.4.19 | 31.5.19 | The platform designed to provide emerging projects with financial and technological tools based on blockchain |
| 4 | GG World Lottery | 6.113 | 1.7.18 | 28.2.19 | First government-regulated national and global online lotteries with the True Random Number Generator technology and blockchain based transparency. The licenses are already secured in 12 countries. It received a lifetime revenue share in form of quarterly paid dividends. |
| 5 | Equitybase | 5.831 | 10.2.19 | 10.5.19 | The platform is designed to reduce entry barriers for issuers to launch security tokens on blockchain. |
| 6 | Faba Invest | 4 | 18.4.18 | 30.6.19 | The venture capital company that invests in viable projects through our STO, where Faba becomes an equity shareholder. |
| 7 | TapJets | 1.5 | 15.3.19 | 13.8.19 | Available for US Accredited Investors and non-US investors worldwide. |

*Source:* calculated by the author based on ICObench and Inwara.

into financing startups and asset backed security tokens (ABST). The last one is similar to ABS (Asset Backed Security) and leads to involving the blockchain in the securitization process. According to the research, estimated ABST market volume in 2030 will be $ 1,900 billion, which accounts for 38% of the ABS market volume in 2018 (the total ABS market volume is $ 4,900 billion based on SIFMA and S&P 500).

### Market overview

By March 20, 2019, 122 STOs were already completed, raising $ 512 million, almost equal to the amount raised by ICOs in January and February 2019[14]. 54 Security Token Offerings are currently listed and ongoing. Only 12 out of 328 STOs launched so far have failed (3.65%) [11]. In total, the STO raised $ 1258 million.

According to the Security Token Network[15], in Q1 of 2019, the USA had 40.7%[16] of the market share with 61 STOs, the UK has 8% (12 projects), the European Union (without the UK) had a total of 27 offerings (the details about top 7 STO is shown in *Table 7*). The share of the Asian region is 5.3%, which is very small, given the fact that the leading crypto exchanges (Binance, Huobi and OKEx) are registered and work from Asian countries (*Table 8*). A possible explanation is that this region has been still focusing in ICOs. At the same time, the appearance of the Asia Security Token Alliance (ASTA) may be a signal of changing Asian involvement into STOs. According to the InWARA's report[17], worldwide the number of STOs showed rapid growth in 2019, growth in Q1 2019

[14] The ICObench Analytics team (2019). URL: https://coin360.com/blog/ico-market-review-and-trend-analysis (accessed on 17.08.2019).

[15] Security Token Network (2019). URL: https://token.security/stn/article/analysis/state-of-the-security-token-ecosystem-part-1-security-token-offerings-q1–2019/ (accessed on 18.08.2019).

[16] The total number of STOs in the Security Token Network research is 150.

[17] InWara research team (2018) URL: https://www.inwara.com/report (accessed on 17.08.2019).

*Table 8*

**Number of STOs and total amount raised by industry and country**

| Industry | Number of STOs | Amount raised (mln $) |
|---|---|---|
| Finance | 37 | 261 |
| Trading & Investing | 31 | 86 |
| Real estate | 28 | |
| Investment | 23 | 173 |
| Cryptocurency | 18 | |
| Blockchain | 15 | 41 |
| Mining | 15 | 27 |
| FinTech | 15 | 154 |

| Country | Number of STOs | Raised amount of funds (mln $) |
|---|---|---|
| USA | 113 | 598 |
| Singapore | 12 | 21 |
| UK | 24 | 19 |
| Switzerland | 26 | 155 |
| Russia | 10 | 48 |
| Estonia | 10 | 57 |
| Germany | 9 | 16 |
| Canada | 7 | 98 |
| Cayman Islands | 6 | 45 |

*Source:* calculated by the author based on Tokens-Economy.com and Inwara.com.

was 130% (Q1'18–14 offerings, Q2'18–26, Q3'18–25, Q4'18–20, Q1'19–47).

## FINAL COMPARISON TABLE OF THE ICO, DAICO, IEO AND STO [11][18]

In order to summarize all information in sections 1–4, Table 9 is presented. By qualitative and measurable characteristics, this table allows investors and projects to simplify the selection process. Based on the great study by Ruben Merre [12], the advantages and disadvantages of the ICO, DAOICO, STO, and IEO have been systemized by main agents (investors, issuers, and exchange/platform) (Table 10).

## CASE STUDY OF PROJECTS

In the previous study [3], the main empirical results on the ICO success factors showed that in all 3 models for determining success, the significant variables are: Ethereum volatility, the ICO duration, a bonus, a White Paper and KYC, team size, number of experts and advisors. The majority of these factors are the external decision of the team and the project management. In order to understand the motives of the team better, the case study method was used. The results are compared by the ICO, IEO, and DAICO.

## EOS ICO AND FILECOIN. SCAM PROJECT

The EOS ICO is the most successful project (based on the amount of funds raised) and is still considered to be thriving. The EOS was able to attract more than $ 4 billion and provided an alternative to Ethereum. The product of the venture is the software that creates a self-sustaining blockchain, capable of processing up to a million various transactions per second, free and easy to implement. It is based on the Ethereum platform where all applications are developed. The ICO was conducted from June 26, 2017 and ended on July 11, 2017 in the U.S. with a token price of $ 0.99. The price of an EOS token by the end of June 2019 was stable, $ 7, while the ROI was 522.22%. The project has 4.1 points in the ICObench rating. In June 2019, 157 people were employed by the project. The EOS ICO was founded by Block.one firm, a software company operating since 2016. The ICO has never had the KYC procedure. Brendan Blumer, the CEO of the EOS, has only 20k followers on Twitter, and 330k followers on the EOS. The CEO had 11 years of work experience when the project started, though it was not connected to blockchain. However, the publicity, in this case, plays a minor role, since the EOS ICO team consists of those who had been involved into blockchain for a long time, therefore, they all have enough experience to be professionals in this field. The ICO is registered in the Cayman Islands, restricting the USA from participation. Moreover, the idea of the project is a novelty and it has an excellent representation

[18] (2019). URL: https://steempeak.com/coingecko/@culgin/ico-sto-and-ieo-which-one-will-dominate-2019 (accessed on 24.08.2019).

*Table 9*

**Differences and similarities between the ICO, DAICO, IEO and STO**

| Criteria | ICO | DAICO | IEO | STO |
|---|---|---|---|---|
| Definition | Crowdfunding by issuing a utility token/coin | The synergy of the DAO and ICO makes ICOs more secure as investor funds are available in a more controlled way. | A modified version of the ICO. Crowdfunding by issuing a utility token/coin by exchanging cryptocurrency without the first ICO step | The type of digital "securities" comparable to the IPO |
| First start date | Early 2013 | Mid 2018 | Early 2017 | The end of 2017, evolution to ETO* at the end of 2018 |
| Fundraising is conducted at | The token issuer website | Similar to the ICO | The exchange platform | The token security platform |
| Crowdsale counterparty | The project development team | The project development team and the mechanism for the investor control | The cryprocurrency exchange | The security token issuer brokered via an STO platform |
| Smart contract managed by | The startup conducting the token sale | Similar to the ICO | The cryprocurrency exchange | The token security platform |
| AML/KYC needed by the token issuer | Yes, it can vary between different projects. Each investor must go through the special KYC/AML verification process provided for by the project. | Each investor must go through the special KYC/AML verification process provided for by the project. | Not necessarily – the exchange conducts AML/KYC on its users. KYC/AML is done on the exchange, so existing exchange account holders do not have to go through it again. | KYC/AML is done on the platform, so existing platform account holders do not have to go through it again. |
| Marketing | The marketing budget needed for funding companies is significantly high, the project will have to invest many resources in order to get the attention of the public | Similar to the ICO | The token issuer can tap on the exchange reach and users. Joint marketing with the exchange | The token issuer has to market to individual investors. It may be possible to provide extra marketing via the platform. |
| Screening required before a startup can launch a crowdsale | No – anyone can launch an ICO (in a country where it is legal) | Similar to the ICO | Yes – the exchange screens the company before it allows it to raise funds on its platform | Probable none |
| Automatic token listing after crowdsale | No – the startup has to reach out the exchange to list its tokens. Not immediate. Listing fees to be negotiated with each exchange. | Similar to the ICO | Yes – the exchange where the IEO list is conducted. The exchange listing is immediate. Included in IEO fees. | Depends. If the selected STO platform is also the exchange, then it is likely to be immediate. |
| Difficulty to set up | Easy | Easy | Medium | High |
| Fundraising cost | Low | Low | Medium | Medium |
| Investor protection | Low (limited) | Medium | Limited-Medium | Strong |
| Investor accessibility | High | High | Low-Medium | Low |
| Regulation level | Low (but the is an improvement) | Low | Low-Medium | High |
| Governance level | Low | Medium-High | Medium | High |
| Liquidity | Medium | Low-Medium | High | Low |
| Centralization level | Relatively centralized | Relatively decentralized: decisions on funds are made by a voting system, thus are democratized. In fact, there is no centralized team that makes all decisions. | Relatively centralized | Relatively centralized |
| Fees | No | No | Fiat fees/ exchange commissions | No |
| Gas | Depends on the choice of a platform and the network load | Depends on the choice of a platform and the network load | Not required | Depends on the choice of a platform and the network load |
| Speed | Several months | Several months | The highest (from weeks to seconds) | Up to a year |

*Source:* calculated by the author based on [11, 12] and steampeak.com.

* The ETO is an equity token offering. The main definition is a token which functions as a traditional stock asset, represents the ownership of a third-party asset or a venture and takes their value from the success or failure of this property. The real analogy is stocks, futures, and options contracts. URL: https://www.bitcoinmarketjournal.com/equity-token (accessed on 24.08.2019).

in the White Paper. The ICO design was also non-trivial, meaning that Block.one made a one-year uncapped token sale, at the same time launching the EOS VC to attract big investors such as Tomorrow Blockchain Opportunities, Galaxy Digital LP, FinLab AG, etc. The marking company was aggressive. Block.one 'made a public relations splash, hosting numerous informational sessions, sponsoring post-conference receptions, giving out free t-shirts and even advertising on a Times Square jumbotron.' [13] The EOS tokens are expensive in comparison to the initial price; it provides employment for more than 150 people and raises more than $ 4 billion during the token sale. Although the right choice of industry influenced the EOS development, the professionalism of the team, the well-considered design of the ICO and the PR campaign allowed the long-term success of the project.

Filecoin allows anybody to create decentralized data storage, meaning that users can share storage on the server in exchange for Filecoin token called Fil. The ICO was registered in the U.S. During one day on August 10, 2017, 200 million tokens were sold for $ 0.75 each, raising a total of $ 257 million. The Fil average cost was estimated at $ 8.73 with the ROI of 1064% in June 2019, though it was rated only 3.1 points on the ICObench. The project was founded by Protocol Labs team who had a big experience in blockchain technology. Filecoin was able to raise $ 52 million during the pre-ICO, and during the second round $ 135 million out of $ 205 million were raised in only one hour. Filecoin accepted US Dollars, Bitcoin and Ethereum. Except for a professional team, Filecoin had conducted a grandiose advertising strategy, where the price of the token at the start of the ICO was $ 1 and rose with every next investment[19]. Thus, investors were rushing to participate as early as possible, attracting attention to the project. Moreover, Filecoin implemented strict entry policy — only investors with an income of $ 200 thousand or more had a right to join. This regulation provided a significant advantage to the business later when Securities and Exchange Commission forced all ICOs to introduce registration laws. According to LinkedIn[20], 77 people are employed in the project. Despite the fact, that Filecoin ICO ended in 2017, in the previous case study of Filecoin [14] in 2018, the authors mentioned that FIL tokens have not yet been delivered to investors. Filecoin futures were traded on Gate.io and Lbank since December 13, 2017, and the futures prices provide an estimate of the value of the underlying FIL tokens. With the sharp decline in prices (from $ 27.66 to $ 3), mirroring that of the overall crypto market since late 2017, the recent prices of Filecoin imply that its $ 200 million outstanding tokens have a fair market value of approximately $ 600 million, substantially more than the $ 206 million that they were sold for in 2017.

Among the disadvantages of the ICO, we have already noticed that the concept of regulation is opposite to the concept of cryptocurrency decentralization, resulting in the regulation paradox. Regulation is impossible without centralization of information, categorizing, creating limits, whereas decentralization means substituting controlled systems with algorithms. This creates a fundamental conflict as regulation minimizes risks at the expense of loss of individuality, while cryptography, on the opposite, is unable to decrease risks, but enhances individual power of users [15]. One of the most famous scam ICOs is the OneCoin case.

OneCoin is a fraudulent ICO founded in Bulgaria, the so-called 'classic Ponzi scheme', meaning that earlier investors were paid funds by more recent investors to attract further attention of the public. Therefore, this scam was not easily comprehensible for individuals, even though the official website contained many misprints and errors and no White Paper was published. The venture positioned itself as an analogue of the Bitcoin system, also, offering an educational resource for finances in cryptocurrency. OneCoin caught attention of many experts and governments which quickly identified it as the Ponzi scheme and 5 countries — Thailand, Croatia, Bulgaria, Finland and Norway — even warned public of the risks that the ICO was posing. In 2016, Chinese authorities investigated the scheme and withdrew $ 30 million from several investors that had been caught [17]. The obvious sign of a fraudulent scheme was the fact that OneCoin offered centralized transactions with their private blockchain, while the cryptography was based on decentralization and it

[19] URL: https://icobench.com/ico/filecoin (accessed on 30.06.2019).
[20] URL: www.linkedin.com/company/protocollabs/about/ (accessed on 30.06.2019).

*Table 10*

**Advantages and disadvantages for issuers, investors and exchanges of the ICO, DAICO, IEO and STO**

| Agent | Type | Advantages | Disadvantages |
|---|---|---|---|
| Issuer | ICO | ▪ All funds raised are available to the project team at the end of the fundraising round. The team can immediately start working and spending all resources<br>▪ No extensive disclosure requirements for the fundraiser | ○ Funds raised are inherently volatile (due to the market instability and the absence of the real provision of cryptocurrency)<br>○ Increasing legal uncertainty and regulatory scrutiny (e.g. by US SEC)<br>○ Full reward / funds are available from the very beginning, which leads to demotivation of the project team to continue working on the project<br>○ Scam projects results in lowering the reputation of the whole market and legitimate projects are unable to raise sufficient funds<br>○ Many projects struggle to maintain the token value and exchange listing |
| | DAICO | ▪ The improved trust mechanisms can increase the interest of more qualified (and quality) contributors / investors who might otherwise (e.g. in the case of a regular ICO) stay away<br>▪ Management of funds and roadmap of the project are done jointly with contributors/investors, which increases the quality and decreases the risk for a less experienced development team | ○ Involvement of contributors/investors has the opposite (negative) effect on the level of freedom.<br>○ The project team depends on the basic voting system, which determines periodically issued investment funds for the project.<br>○ Since depositors / investors play a decisive role in decision making, there is a risk that they make decisions based on emotions, based on the price of the token, and not on the created value of the project. Their emotions, as well as their education in the project should be managed by a development team |
| | IEO | ▪ Decreased costs due to sharing marketing costs with the exchange<br>▪ Access to expertise (exchange listing, marketing, smart contract logic, etc)<br>▪ Additional credibility to the project since the exchange risks its reputation in the listing project<br>▪ Convinient in countries where ICOs are forbidden | ○ Increased costs. The exchange charges high listing fees; even higher than for ICOs, the token marketing costs are considerable.<br>○ Token issuers bear the cost of what are considered benefits for the exchange and the investors (e.g. in the case where investors get a discount on a specific exchange) |
| | STO | ▪ Expansion of a number of companies: off-chain companies (start-ups, private equity) can now be connected to the global cryptoeconomics, dying for the sake of security tokens, rather than utility tokens<br>▪ Lower transaction costs compared to the traditional investment process<br>▪ Clear framework and procedures to ensure thorough due diligence and regulatory compliance throughout the listing process | ○ Potentially higher share valuation carries the risk of higher volatility.<br>○ Despite the fact that STOs typically take regulation into account as much as possible, it remains a new concept that carries its risks of unforeseen surprises |
| | ICO | ▪ ICOs have provided incredible returns at an early stage<br>▪ Custody is possible without intermediaries<br>▪ Limited regulatory audit<br>▪ Same level of anonymity is feasible for cryptocurrencies such as BTC, ETH<br>▪ Contributors/investors are usually the first users of the (utility) token. Unlike holding shares in a company whose products can never be used by an investor / investor, tokens can be more tangible than securities | ○ Failure to fulfill promises at the end of the ICO. Investors still care about their money and are constantly looking for news.<br>○ 'Gas wars' are very real<br>○ No audit increases risks, thus, investors typically have to do their own due diligence leading to investment in low-quality projects<br>○ ICO stages typically include pre-ICO rounds when privileged investors can buy at a discount, diminishing the potential returns for later-stage investors<br>○ Lack of mechanisms to protect investors |

*Table 10 (continued)*

| Agent | Type | Advantages | Disadvantages |
|---|---|---|---|
| | DAICO | ▪ The risk of a scam project is reduced since investors decide (due to the voting rights) when to release the funds via the DAICO tap mechanism. Also, investors can vote for a refund of the remaining finances if the project fails.<br>▪ Voting system leads to the decentralized team<br>▪ Reducing the risk of '51% attack' as the amount of funds that gets released from the Smart Contract is limited and strictly controlled. Even if it happens, the amount is limited to the tap release | ○ Contributors could completely disengage by putting all their trust in the DAICO concept and therefore believe that they do not need to participate in voting and resolutions, which weakens the security of the mechanism.<br>○ In investing, there is usually a psychological aspect. Participants must be properly trained to make informed decisions for the project. This potentially increases project risks in volatile markets.<br>○ If developers have many tokens, they have majority in control and management and potentially have to convince a small percentage of contributors/investors |
| | IEO | ▪ 'Scamming' becomes more difficult: exchanges take the reputational risk of listing a 'bad' token, so they are highly incentivized to do a thorough due diligence<br>▪ Risk of 'Gas wars' is diminished | ○ A high percentage of coins will typically be held by a smaller number of investors, resulting in considerable price manipulation risk. It is advised to avoid investing in coins where circulation supply is small and not evenly distributed.<br>○ Contributors/investors that do not have an account on the listing exchange have to sign up on time.<br>○ Centralized exchanges own the private keys of all wallets and complete transactions, or the transaction occurs only on the exchange, and not on the blockchain. Thus, investors do not own their tokens |
| | STO | ▪ Startups/ private equity become more accessible as investments and vice versa blockchain technology allows for more liquidity for startup/PE shareholders<br>▪ Dividends and voting rights become possible<br>▪ Lower transaction costs<br>▪ Contributors are generally more protected on STOs rather than other crypto-funding forms. Also, they get the same legal rights as conventional company shareholder resolutions on-platform for on-chain investors, while off-chain investors can still vote on paper, and both results are merged | ○ The on-chain activity of buying and selling the on-chain issued tokens may influence the inherent volatility of share valuation and, hence, the artificial value of the company at any given period of time. This could be an unwanted side-effect of the higher liquidity online investment/trading platform that conducts the STOs |
| Exchange/ platform | ICO | ▪ Exchanges request high listing fees for projects that want to get more trading volume / access to a wider base of investors, for example, top-level exchanges require several million fees<br>▪ Exchange can thrive on the ICO initial success, by simply listing ICOs that are already in high demand<br>▪ Exchanges can receive discounts on listed tokens, which further increases cash flows | ○ Historically, many of promising ICO projects are just White Paper and almost zero trading volume, leaving the exchange with near-dead, no-value 'shitcoins'. This pushes the exchange to delist tokens in the end. Scams have a negative reputational impact on the exchange |
| | DAICO | ▪ If done correctly, there is no need for an exchange in this set-up | ○ If done correctly, there is no need for an exchange in this set-up |
| | IEO | ▪ New users, capital inflows, increase in trading volume, additional fees (token/fiat/%), market collaboration, synergy effect of doing, joint marketing with the project, coverage, reputation<br>▪ To be able to assess thoroughly whether projects need multi-disciplinary teams for qualitative due diligence | ○ Limited number of people own the majority of token circulation as only a few exchanges are involved; also, people with no account at the exchanges have to sign up in time to be able to participate in the IEO. This increases the risks of price manipulation, including pump and dump schemes |
| | STO | ▪ Once fully verified by regulatory authorities, there are considerable barriers to enter new competing platforms<br>▪ Once multiple projects are listed, the platform can also offer a tokenized fund, through which investors can buy stakes in a more diversified portfolio of several of the listed projects, further enhancing the platform's revenue potential | ○ Many steps are required from a platform to get to the point where it is completely legal and regulatory verified by relevant supervising authorities. Once achieved a confirmed quality status and regulatory approval to conduct STOs, this also entails considerable barriers for new platform competitors |

*Source:* calculated by the author based on [12].

was technically impossible to realize what the scam was promising. What is more, the price of tokens in OneCoin was claimed to be determined by the amount mined and not by the supply and demand as in usual cryptocurrencies. Overall, the fraudulence of One Coin was incontestable, but the complex detection of such scams among other businesses allowed to have profits of $ 4 billion out of nothing[21].

The enormous number of scams resulted in a ban on advertising all ICOs in Google, Facebook, Twitter and Mailchimp that was supposed to protect less informed users. This policy was adopted because social media is the main channel that connects users with the crowdfunding projects and the frauds actively took advantage of it. Though the move to new platforms like LinkedIn happened, it allowed to protect ordinary people from investing in scams[22].

## IEO BITFINEX, SQUEEZER

The biggest IEO that ended until June 2019 is Bitfinex. This project takes the 1st place by the total amounts raised during an IEO totaling at $ 1billion. Bitfinex is the digital asset exchange, margin trading and funding platform, which includes Bitcoin, Ethereum, EOS, Litecoin, Ripple, NEO, Monero and many more cryptocurrencies in its circulation. The Bitfinex IEO started on May 5, and ended only 8 days later; however, in this short period, the issue of tokens called LEO attracted more than $ 100 million from each private company inside and outside the industry and more than $ 1 million from each user, even though it was conducted only on a private basis. The firm never got it to the stage of the public sale. It was founded by a HongKong firm called iFinex Inc, however, launched in the British Virgin Islands. The project has a White Paper and it accepted cryptocurrency called USDT or Tether. Since Tether is a stable coin, which means that it is almost stable and avoids fluctuations unlike Bitcoin and Ethereum. Although the long-term results are vague for the IEO industry, the current results are impressive, and the industry is assessed to be more trustworthy. According to LinkedIn, in June 2019, 188 people were employed in Bitfinex, while on Twitter it had 501k followers[23]. Therefore, the evident advantage of the IEO over the ICO is the presence of existing user base on the exchange platform that allows to raise tremendous investments even on the private sale stage. Even though the process of buying tokens through the exchange is a bit more complicated than a direct sale in the ICO, the pros of the IEO obviously outweigh the cons as the results of the ended ventures are impressive. The market was capable of resolving the problems of ICOs by institutionalizing the market and creating higher security standards, improving the whole industry of investments in cryptocurrencies.

The Squeezer IEO raised more than $ 9 million. The Squeezer IEO was conducted with the help of Bitforex Launchpad. Squeezer is a useful case study because it has a clear and compelling business model. Also, it is important to note that among the 62 IEO projects, the ICObench ratings (4.6 points for the team; 4.7 points for the vision; 4.5 points for the product; the overall evaluation by the experts is 4.6 points and the ICObench rating is 4.1) and the success ratio of Squeezer (92%) were the closest to the median of each index (4.35 points for the team; 4.3 points for the vision; 4.05 points for the product; the overall evaluation by the experts is 4 and the ICObench rating is 3.85; success ratio is 80%).

Squeezer is a platform that helps software developers easily create applications without affecting the entire blockchain infrastructure. The aim of the project is to integrate blockchain into existent business infrastructures, applying a single universal blockchain "connector", which will allow developers to connect to multiple blockchains (such as BTC, ETH, or LTC). So, such a structure allows conducting blockchain transactions without dealing with blockchain development. Squeezer also provides all tools needed by developers to create a serverless app, to attach smart contracts, to test their applications and to quickly deploy production. By means of platforms such as AWS Lambda and Google Functions, Squeezer uses the power of microservices for applications which means that the autoscale feature is enabled by default. Microservices also support automatic

[21] URL: www.onecoin.eu (accessed on 30.06.2019).

[22] Pw C. URL: https://www.pwc.ch/en/publications/2018/how-do-icos-work-en-pwc.pdf (accessed on 30.06.2019).

[23] URL: icobench.com/ico/bitfinex (accessed on 30.06.2019).

recovery and provide for the silent implementation of the cloud service. Squeezer is the first platform that combines the power of microservices with the immutability of blockchain technology. The Squeezer platform will provide developers with the ability to create and deploy application blockchains at several stages directly from GitHub, among other code repositories without setting up any special environment or advanced blockchain skills, which will make the blockchain look more like a database than a complex entity. Additionally, you can have your app deployed in production with just one simple command and without tackling any service configurations.

The Squeezer's token, which uses an SQR symbol, is a utility token because it is used by developers to build and deploy apps on the Squeezer Platform. It is used in the Squeezer Platform to pay for services such as deployments, inbound and outbound transactions or additional team members to collaborate on your project. SQR is an ERC 20 compatible token and is used to access and deploy applications using the Squeezer infrastructure. Squeezer will be similar to PayPal, but for blockchain transactions, it will provide real-time transaction support on different blockchains, currently the fastest integration in the industry (Squeezer Chainkit)[24]. The main use of the ChainKit is to unify the top blockchains interfaces into a single normalized API interface, so one can easily create dApps for blockchains without going into the complex blockchain infrastructure. Currently, the Squeezer platform is working for web projects, but the organization is working on developing connectors so that microservice can initiate an action in the blockchain. As a result, there is no need to create your own token, except to generate funds for the platform.The Squeezer IEO was capped at 30 million SQR tokens, representing 40% of the ultimate supply limit of 75 million tokens. Of the remaining tokens, 30% are required by the Squeezer Platform to ensure the operation of the platform.

## BIT.GAME DAICO

BIT.GAME DAICO raised more than $ 6.5 million. The DAICO was conducted with the help of Bitforex Launchpad. BIT.GAME is a useful case study because it has a clear and compelling business model. Also, it is important to point out that among 4 DAICO projects, the ICObench ratings (3 points for the team; 3.4 points for the vision; 2.3 points for the product; the overall evaluation by the experts is 3.1 points and the ICObench rating is 3.2) and the success ratio of Squeezer (36%) were the closest to the median of each index (3.5 points for the team; 3.95 points for the vision; 3.65 points for the product; the overall evaluation by the experts is 3.8 points and the ICObench rating is 4.1; the success ratio is 31%). BIT.GAME Platform is based on DAICOs, and it offers technical support, incubation funds and asset trading for all the innovative, high-potential blockchain game projects. BIT.GAME solves the pain points of the game industry by providing game companies blockchain game solutions and build servers in the blockchain vertical domain digital currency exchange. It will become a link between blockchain and the game conversion chain. BIT.GAME is composed of a vertical area exchange, BIT.GAME solutions and an incubation platform for blockchain games. BIT.GAME EXCHANGE will fully support the interconnection between the blockchain game token, the digital currency and the national legal currency. The PLUS version will also add the Blockchain Game props trading of resources and items, and auction and rental services. BIT.GAME SOLUTION provides the traditional game developers with the blockchain game development solution. The game trading interface of public blockchain is based on Ethereum, QTUM, Achain, TrustNote, Gamechain System, etc., which contain Off-Chain Circulation Solution, Single-Public Blockchain Solution, and Multi-Public Blockchain Solution, and will be seamlessly integrated into BIT.GAME EXCHANGE. The BIT.GAME PLATFORM will not only bring together the public blockchain ecosphere, game developers and investors in order to integrate the three resources, but also share benefits through the PoC Mining Pool and Double Repurchase Program with global game players, as well as exchange users. Moreover, the aim of BIT.GAME is to promote the development of blockchain games through the exchange of tokens, so the participants are no longer limited to only

[24] Squeezer White Paper. URL: https://squeezer.io/docs/Squeezer_White_Paper.pdf (accessed on 30.06.2019).

*Table 11*

**Summary of the Squeezer IEO and the DAICO Bit.Game**

| | Squeezer | BIT.GAME |
|---|---|---|
| Total Token Supply | 187,500,000SQR | 10,000,000,000 BGX |
| Total Token Sale Supply | 40% (75,000,000 SQR) | 40% (4,000,000,000 BGX) |
| Private Sale Supply | 24% (45,000,000 SQR) | 10% (1,000,000,000 BGX) |
| Public Sale Supply | 16% (30,000,000 SQR) | 30% (3,000,000,000 BGX) |
| Initial Circulating Supply | 27% (50,791,761 SQR) | 100% (10,000,000,000 BGX) |
| Public Sale Token Price | 1 SQR = 0.20 USD | 1 BGX = 0.01 USD |
| Private Sale Token Price | 1 SQR = 0.17 USD | 1 BGX = 0.01 USD |
| Public Sale Vesting Period | None | None |
| Token Type | ERC-20 | ERC-20 |

*Source:* calculated by the author based on White Papers and ICObench.

one game, but have international reach. In changing the blockchain game mechanism, BIT.GAME also seeks to redirect the profit chain. BIT.GAME will construct the next generation of decentralized exchange — AIDEX, jointly with Achain, Matrix AI Network based on artificial intelligence and blockchain and blockchain technology. BIT.GAME AIDEX will seek the best combination of decentralization and user experience. Ultimate transaction speed, lower transaction costs, sufficient trading depth, and ample liquidity can be achieved by continuously optimizing user experience based on security and transparency. (*Table 11*).

## CONCLUSIONS, LIMITATIONS AND FURTHER RESEARCH

The ICO market is in crisis, but this method of fundraising will not disappear. To get the ICO out of the crisis, the DAICO first appeared, a new form of attracting investments, and then the IEO. They are the ones who will probably arrange a cryptocurrency Renaissance, which will rehabilitate the mechanics of initial placement of tokens. The analysis showed that the success of a fundraising campaign may be pre-determined by the country of origin and its legislation. Subsequently, the experience of the founders, the marketing campaign and the right strategy are the influencing factors. The only way to avoid ICO scams is to develop the regulation against which it is impossible due to decentralized nature of blockchain. Another significant problem of most ICOs is the inability of the founders to maintain a token in the long run. This can only be solved with the constant development of a project that may be achieved only by the factors already mentioned. Thus, the urgent problems of IEOs have been solved, and IEOs are showing impressive results now. The potential of IEOs is giant as it combines the advantages of the ICO and resolves the challenges that it poses. Moreover, STOs are likely to become extremely popular, because they provide security and open new investment horizons for a security coin. Both IEOs and STOs are more regulated, meaning that the number of failures is going to decrease.

There is no doubt that the blockchain investment sector is still rising. This case study is the most complete overview of new financial innovations in the fundraising. The paper provides the concepts of the ICO, DAICO, IEO and STO and examines in detail, systimazes and identifies the advantages and disadvantages of each method. The analysis of the articles and papers allowed us to formulate the factors and criteria that made it possible to compare the levels of success of various models and to identify the reasons for success. In addition, a project database was introduced, which helped compare the ICO, DAICO, IEO and STO. A critical comparative analysis of four fundraising models will give an accurate summary of the projects. Unfortunately, the biggest limitation of the paper is the research method — the case study. However, such a fundamental theoretical research allows continuing further investigation by means of econometric tools.

## REFERENCES


1. Diemers D., Arslanian H., McNamara G., Dobrauz G., Wohlgemuth L. Initial coin offerings: A strategic perspective. Strategy&/PwC. 2018. URL: https://www.pwc.ch/en/publications/2018/20180628_PwC%20S&%20CVA%20ICO%20Report_EN.pdf
2. Sherwin D. Satis Group (2018). URL: https://research.bloomberg.com/pub/res/d28giW28tf6G7T_Wr77aU 0gDgFQ (accessed on 20.08.2019).
3. Myalo A.S., Glukhov N.Y. Factors of success of Initial Coin Offering. The empirical evidence from 2016–2019. *Finance: Theory and Practice*. 2019;23(5):30–49. DOI: 10.26794/2587–5671–2019–23–5–30–49
4. Golubyev S.(2019). URL: https://medium.com/@sergiygolubyev/ieo-initial-exchange-offering-что-за-зверь-такой-760118a45334) (accessed on 20.08.2019).
5. Gorman Anna(2019). URL: https://newconomy.media/market/ieo-on-6-major-platforms-new-point-of-failure-or-new-market-standard/)(accessed on 20.08.2019).
6. Bourgi S. (2019). URL: https://www.ccn.com/what-is-an-sto/ (accessed on 15.08.2019).
7. Zaki I.(2018). URL: https://hackernoon.com/security-token-offerings-stos-what-you-need-to-know-8628574d11e2 (accessed on 30.08.2019).
8. Ignatiev N. (2019). URL: https://www.rbc.ru/crypto/news/5c6fcd1b9a79470fdc068ed2 (accessed on 01.08.2019).
9. Han J., Han D., KC Lee. Chain Partners Research (2019) Security token (STO) analysis. URL: https://www.finyear.com/attachment/1338789/.
10. Didenko D., Klimov K., MIRANIT, Rodriguez N.(2018) URL: https://vc.ru/crypto/44042-chto-takoe-security-token-offering-sto and https://www.chainbits.com/cryptocurrencies/what-is-a-security-token-offering/ (accessed on 22.08.2019).
11. Bahrynovska T.(2019). URL: https://applicature.com/blog/token-offerings/initial-exchange-offerings (accessed on 24.08.2019).
12. Merre R. (2019). URL: https://hackernoon.com/a-comprehensive-guide-to-the-next-generation-of-crypto-funding-v-ico-ieo-daico-eto-sto-939909782da6?source= ––––––2–––––––––– (accessed on 24.08.2019).
13. Freeman O. (2019). URL: www.medium.com/revain/successful-ico-model-a-case-study-766f00908823 (accessed on 30.06.2019).
14. Howell S., Niessner M., Yermack D. Initial coin offerings: Financing growth with cryptocurrency token Sales. NBER Working Paper No. w24774. URL: https://ssrn.com/abstract=3206449.
15. Zhang R., and Raveenthiran A., Mukai J., Naeem R., Dhuna A., Parveen Z. The Regulation Paradox of Initial Coin Offerings: A Case Study Approach (November 14, 2018). URL: https://ssrn.com/abstract=3284337 or http://dx.doi.org/10.2139/ssrn.3284337.
16. Jenkinson G. (2018). URL: cointelegraph.com/news/unpacking-the-5-biggest- cryptocurrency-scams (accessed on 30.06.2019).


## ИНФОРМАЦИЯ ОБ АВТОРЕ

***Alina S. Myalo*** — PhD student of HSE (economics, field of corporate finance), dean of the student at ICEF (international college of economics and finance) HSE National Research University Higher School of Economics, Moscow, Russia
emyalo@yandex.ru, amyalo@hse.ru

*The article was submitted on 30.09.2019; revised on 14.10.2019 and accepted for publication on 28.10.2019. The author read and approved the final version of the manuscript.*

ORIGINAL PAPER



DOI: 10.26794/2587-5671-2019-23-6-26-35
UDC 330.88:004.738.5:336.747.5(045)
JEL O33

# Current State and Development Trends of Blockchain Technology in the Financial Sector

**G.O. Krylov**[a], **V.M. Seleznev**[b]
[a] Financial University, Moscow, Russia; [a] National Research Nuclear University MEPhI, Moscow, Russia; [b] JSC LatCard, Riga, Latvia
[a] https://orcid.org/0000-0001-8145-1994; [b] https://orcid.org/0000-0003-4521-0290

## ABSTRACT

The article analyzes the main reasons for the slow adoption of blockchain technology, in particular, in the financial sector. The authors critically analyzed the main declared properties of blockchain technologies: trust, security, decentralization, immutable data storage, lack of intermediaries, hardware protection against attacks, and openness. The aim of the study are to show that these blockchain properties are overestimated, the expectations of its adoption are inflated, and the delays in its adaptation outside of cryptocurrencies, in particular, in the financial sector, are natural. The article is based on a methodology for the qualitative and quantitative analysis of scientific publications and statistical sources on the blockchain adaptation from the perspective of the theory of diffusion of innovations, the conditions and the specifics of economic and sociological approaches for consensus-building. The study resulted in the following new systemic findings. Blockchain and distributed ledgers are not fundamentally new technologies. In general, they do not have the properties of the immutable data storage, trust, anonymity, low transaction and adoption costs. All current consensus technologies have fundamental faults. Cryptocurrency technology is original, but it was a private experimental solution to a specific ideological problem of the libertarian political agenda. Consensus does not provide trust. Delayed blockchain adoption, in particular in traditional financial institutions, is natural, since the technology does not show better results than current digital solutions, and traditional economic institutions have greater public trust. The practical implications of the findings are that they may be used by investors.

***For citation:*** **Krylov G.O., Seleznev V.M. Current state and development trends of blockchain technology in the financial sector. *Finance: Theory and Practice*. 2019;23(6):26-35. DOI: 10.26794/2587-5671-2019-23-6-26-35**

## INTRODUCTION

The blockchain market entered 2019, the eleventh year since the publication of the Bitcoin manifest, with multidirectional trends. Speculative capital lost interest in blockchain. Since the end of 2018, investment in blockchain startups has fallen by 60%[1]. From January to June 2019, investment in ICOs went down by 17.8 times compared to the same period in 2018 (*the figure* shows the investment schedule in ICOs). At the same time, the corporate sector and strategic investors were keen on supporting blockchain technologies, or, as they say in the corporate segment, distributed registry technologies.

Announcements of technology testing or strategic vision of blockchain technology positively affect the capitalization of large companies [1]. Today, it seems impossible to be a technology leader and not invest in blockchain projects[2]. The above factors might have pointed to blockchain's increased maturity, if there were any signs of mass adaptation of blockchain outside of Bitcoin and cryptocurrencies. In this article, we analyze the reasons for the slow adaptation of blockchain technology (in particular, in the financial sector) and

[1] According to the study by CBInsights (CB Information Services). URL: https://www.cbinsights.com/research/report/blockchain-trends-opportunities/ (accessed on 10.10.2019).

[2] According to the survey of 1386 company executives with a profit of more than $ 0.5 billion conducted by Deloitte in the winter-spring of 2019, 77% of respondents believe that the company will lose its competitive advantage if it does not adopt blockchain technology.URL: https://www2.deloitte.com/us/en/insights/topics/understanding-blockchain-potential/global-blockchain-survey.html (accessed on 10.10.2019).

the justification of expectations from its widespread adoption.

## BLOCKCHAIN'S DECLARED PROPERTIES

In his opus magnum "Blockchain Revolution" [2], one of the most important apologists for blockchain, the godfather of the "digital economy", Don Tapscott formulated most general expectations from blockchain introduction, placing them in the context of global digitalization. According to Tapscott and other technology evangelists [3, 4], blockchain will allow:

- to create a new sharing economy, where all economic activities take place with no intermediaries;
- to create a new, fully inclusive, high-speed financial system with zero overhead costs;
- to protect economic rights around the world;
- to root out corruption and bureaucracy;
- to protect copyrights (in the broad sense, the rights of the creator) and creators to receive remuneration directly;
- to educate a new type of entrepreneur — a blockchain entrepreneur — and to create a new honest capitalism by transforming corporations;
- to make the entire human environment high-tech by "reviving" and connecting all the objects together;
- to realize true democracy from the people and for the people.

According to the apologists, blockchain is the solution to most of the major problems of human civilization. In particular, the following benefits for financial organizations are expected after blockchain implementation:

- a significant reduction in IT infrastructure costs by replacing the back office with blockchain [5];
- cost reduction of interbank payments;
- improving the security of banking data;
- faster transaction processing;
- smart contracts will help to avoid mistakes and provide financial services with a new quality;
- banking will become more open and transparent [6].

These forecasts are based on immanent properties of the technology such as:

- trustlessness;
- peer-to-peer network;
- built-in cryptographic security mechanisms;
- economic inexpediency of attacks on the system;
- anonymity;
- immutable data storage;
- openness and free of charge.

There is no surprise that these promises, supported by information about the success of the first cryptocurrency Bitcoin, have amassed $ 7.5 billion in investment funding since 2012, with $ 4 billion of them invested in 2018[3], which is at least 4 times the total investment in quantum computing for a comparable period[4]. So, why does the implementation of blockchain slow down despite such abundant funding?

## BLOCKCHAIN AS A "FOUNDATIONAL TECHNOLOGY"

One of the most common explanations for this phenomenon is that blockchain is declared as foundational technology [7], because "it has the potential to create a new foundation and principles for our economic and social systems". In this sense, blockchain is compared to the main Internet protocol TCP/IP, and its main application is cryptocurrency with e-mail, the main application of TCP/IP in 1975.

Forecasts for blockchain development are similar to those of the Internet. First, there will come local private solutions, similar to corporate email; then, blockchain applications will replace the traditional ones, similar to Internet applications; finally, quantity will turn into quality, and a new, smart contract-based reality will be created. According to this concept, we should wait for the breakthrough and experi-

[3] Data by Statista.com. URL: https://www.statista.com/statistics/621207/worldwide-blockchain-startup-financing-history/ (accessed on 10.10.2019).

[4] Data by CB Insights CB Insights. URL: https://www.cbinsights.com/research/report/quantum-computing/ (accessed on 10.10.2019).

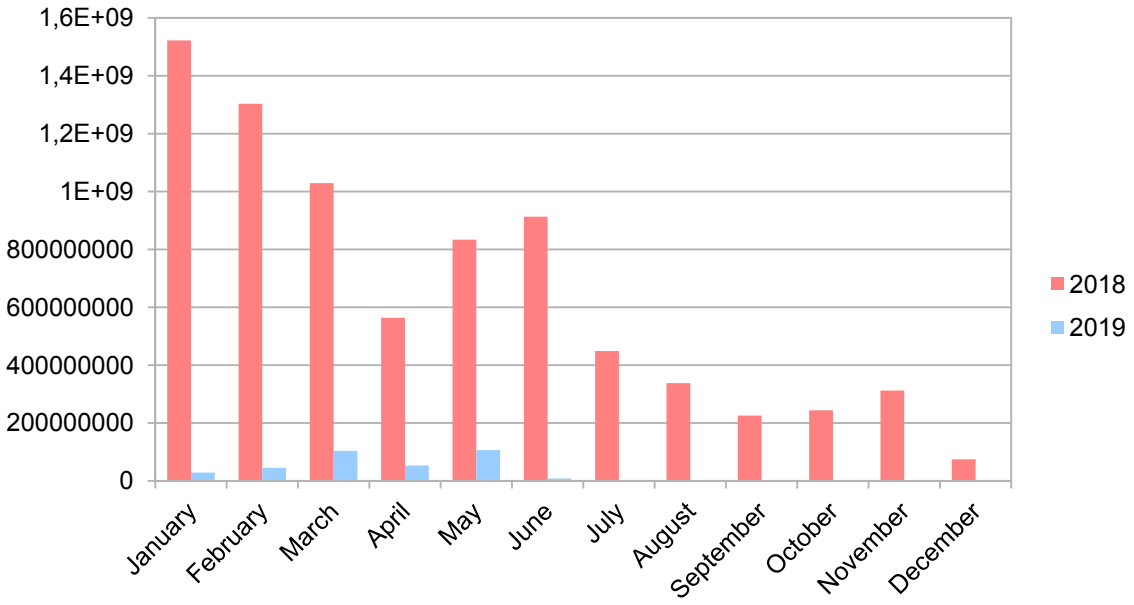



*Fig.* **ICO investments in 2018–2019 (the 1st half)**

*Source:* data visualization by the author based on icodata.io data.

* URL: https://www.icodata.io/stats/2018; https://www.icodata.io/stats/2019 (accessed on 10.10.2019).

ment with applying blockchain in different industries.

However, calling blockchain a potentially foundational technology and "the new Internet" seems to be too simplified. First, it is easy to see (for example, in the relevant Wikipedia articles) that from the very beginning the Internet had numerous practical applications besides e-mail. FTP file transfer protocols and remote access to Telnet systems emerged simultaneously with e-mail and are still widely used. Usenet e-conferences appeared a few years after the e-mail and gained instant worldwide popularity. It was in Usenet where Tim Berners-Lee announced the World Wide Web (www), the present main Internet service. All this happened in less than 10 years after the TCP/IP creation.

The second significant simplification is to call the TCP/IP protocol stack a foundational technology. In historical perspective, the win of this protocol (which, by the way, did not satisfy the theoretical model of network interaction) was largely an accident. Network theorists predicted wins to other protocols. At the same time, it is obvious that the WWW and e-mail could exist on top of the protocols of other networks, for example, X.25. In this case, the packet switching mechanism should be considered the foundational technology.

Although based on the multi-year research and the development of long-established concepts, packet switching was a new technology at the time of creation. The novelty of blockchain is doubtful. Actually, there is not a single new technology in the Bitcoin manifest (the first blockchain document). All the technologies used for blockchain had been long known. Databases based on consensus algorithms (for example, Paxos) have been used since 1989. The binary hash tree was patented by Ralph Merkle in 1979. The Hashcash algorithm was published in 1997 already as a reward system, albeit to protect against e-mail spam. Smart contracts, the fundamental element of modern blockchain technologies, were proposed only in 2015 in connection with the Etherium cryptocurrency. At the same time, smart contracts have existed outside the context of blockchain since 1998. On the average, the technologies underlying blockchain have existed for more than 25 years. Whether they are truly foundational, it is a long enough period to find wide application.

## THE THEORY OF DIFFUSION OF INNOVATIONS AND BLOCKCHAIN IMPLEMENTATION

Another argument against the fundamental nature of technology is the analysis based on the theory of diffusion of innovations. It is generally recognized that over the past century, the rates of technology introduction and adoption have been speeding up [8]. It took the Internet 10 years to reach 50% of US households. It took 8 years for cellphones to accomplish 90% penetration. Over the same 10 years, 5% of Americans have hold Bitcoin[5], and in the rest of the world, less than 0.5% of the population uses cryptocurrencies[6]. As noted above, the total global investment in blockchain is quite large. Using the innovation curve by Everett Rogers [9], we note a paradox: investments already correspond to the development level of the "early majority" technology [10, 11] with the level of practical penetration of the "innovators" technology. In other words, investment does not lead to technology penetration. What is this but the evidence of the lack of a sign of the core technology at blockchain?

The final argument against the fact that blockchain is a foundational technology is that it is not based on a scientific breakthrough [12]. A foundational technology always follows a scientific breakthrough: in mathematics or science. Of course, blockchain technology uses a mathematical basis, but it is not based on a breakthrough solution of mathematical problems. Moreover, its development encounters precisely the unresolved mathematical consensus problem.

## THE CONSENSUS PROBLEM IN THE SUSTAINABLE SYSTEMS THEORY AND THE SOCIO-ECONOMIC APPROACH TO OVERCOME IT

We will take a closer look at the consensus problems, the base for decentralization — a blockchain's advantage. When analyzing the stability problems of computer systems, Leslie Lamport formulated the main problem, called the "the Byzantine Generals Problem", or the "Byzantine Fault Tolerant" (BFT) [13]. The problem research showed that there are solutions only for particular cases. A consensus, or "Byzantine agreement", is only possible with a finite number of participants, provided that there are fewer intruders in the network than a third of the participants. In any asynchronous system, a consensus is not guaranteed [14].

It was proved that if there are possibilities for quantum computation, the time to reach a consensus using the quantum algorithm will be constant [15]. Therefore, practical algorithms to reach a consensus in computer systems can only be approximate and probabilistic. The paradox is that the solutions of the most popular blockchains to reach a consensus are not strictly mathematical. Consensus-building methods are based on socioeconomic assumptions. The Proof of work (PoW) method used by Bitcoin and Etherium [16] relies on the hypothesis that people interested in the "honest" system functioning will always have more computing power than each attacker individually. At the same time, the interest in honesty among the participants will be determined by the basic human properties of rational selfishness (aka greed), since double-spend attacks will be more expensive than the potential benefits. Finally, it is assumed that 51% of the "non-greedy" miners necessary for the attack will not be able to collude, since the processing power is distributed among thousands of anonymous miners who consider anonymity to be the basic value. Unfortunately, the practice of using Bitcoin proved that these assumptions are not true. Double-spend attacks and a combination of double-spending and Sibyl attacks can be economically feasible [17, 18]. There was a small finite number of miners, and their anonymity was not a value; all the main mining pools are known. Moreover, only 6 companies control 70% of mining, five of them are from the Peo-

[5] According to the data by Bitcoin Market Journal. URL: https://www.bitcoinmarketjournal.com/how-many-people-use-bitcoin/ (accessed on 10.10.2019).

[6] Data by statista.com. URL: https://www.statista.com/statistics/647374/worldwideblockchain-wallet-users/ (accessed on 10.10.2019).

ple's Republic of China[7]. Thus, conspiracy is not only possible, but is quite likely.

Realizing the proof of work challenges, the blockchain community is actively seeking for alternatives to this protocol. For example, Ethereum plans to switch to the Proof-of-Stake consensus algorithm. Unfortunately, this protocol also has drawbacks: it destroys the decentralised network and the fair remuneration system, the richest owners of crypto tokens are privileged to make decisions, and it is impossible to determine the "true" transaction history without an additional source of trust [19]. There are many other practical consensus protocols: Proof of Elapsed Time, Proof of Capacity, Delegated Proof-of-Stake. However, all of them have drawbacks inherent in empirical solutions to complex mathematical problems [20, 21].

## BLOCKCHAIN: THE PROBLEM OF DEFINITION

The complexity and unsolved mathematical problems associated with blockchain provides active proponents of the technology with another explanation for the delay in its widespread adoption. In their opinion, the principal challenge is a lack of awareness of the technology and a widespread lack of understanding of how it works. [22]. We agree that some elements of the technology require understanding of the basics of applied mathematics. However, practice shows that it is not too difficult to explain the principles of Bitcoin. Difficulties begin when they try to explain an abstract blockchain. Unfortunately, there is still no good definition of blockchain. Most definitions relate to the fact that a blockchain is a decentralized distributed transaction log with a consensus based on the principle of economic rewards in the form of cryptocurrency. However, today, not all blockchains are decentralized, transaction logs or based on cryptoeconomic principles.

The current tendency to introduce a generalized definition of "distributed ledger" for proprietary, non-public exclusive blockchains (or not blockchains by the new definition) contributes to the confusion. Indeed, it is difficult to explain a technology that has no clear definition.

## BLOCKCHAIN AS A DATABASE WITH SPECIAL PROPERTIES

Considering blockchain a distributed database contributes even more to the confusion. Strictly speaking, in the vast majority of cases, blockchain (given the fuzziness of the definition) is not a database at all. First, it does not record the current state of the system (i.e. it is not consistent), and second, it does not ensure data availability [23]. Blockchain is a historical log of all events that changed that status. In the Bitcoin system, for example the current balances are recorded separately. For optimization, in the vast majority of cases, blockchains keep at most the headers of the blocks, not the full blocks. The use of a blockchain does not ensure, per se, that the past history of the system will always be available for checking. For example, the Ripple blockchain is missing approximately 32 thousand blocks at its beginning — because no one felt necessary to save them at the time!

Admitting that blockchain is not a database, but a log, would make it easier to explain it is append-only and does not change data. This property is not so useful. (What will be the cost of the error?). Fortunately (or unfortunately), contrary to claims of many suporters, the blockchain data is not constant per se. Regarding the data in public blockchains, transactions may be cancelled by agreement of the parties or during a limited period, while in exclusive distributed ledgers — by decision of the moderating party.

It is possible to change blockchain both by an external mechanism, a group of attackers who may profit from the attack, and by an internal mechanism, collusion of most legal miners. Moreover, the "legal" kickbacks of Bitcoin occurred at least three times.

In general, blockchain technologies are not so complicated as they are confusing due to simplifications and incorrect analogies. Poor definitions and omissions in explanations endow the tech-

[7] According to the data by BTC.com. URL: https://btc.com/stats/pool?pool_mode=year (accessed on 10.10.2019).

nology with properties that it does not possess, while its fundamental flaws are hidden behind the info noise.

## BLOCKCHAIN AS A PRIVATE SOLUTION OF THE IDEOLOGICAL PROBLEM OF LIBERTARIANITY

The next most important argument explaining what holds blockchain back from large scale adoption is the need to train both "blockchain specialists" and masses, which, of course, takes time [24]. In other words, for the mass adoption, literally everyone should understand the basics of discrete mathematics, applied cryptography and learn how to write smart contracts. Finally, the dream of the personal computer development pioneer, Steve Wozniak, must come true, and everybody will become programmers. In the real world, this dream is probably as realistic as the belief that with real democracy any person can be their own lawyer and successfully defend himself or herself in court. In reality, even professional programmers, blockchain specialists who tried to use smart contracts for the first time, made a mistake when creating The DAO investment consortium. The mistake of ambiguity in code execution cost $ 60 million [25]. Education, even in the broadest sense, is unlikely to promote the technology to the masses.

Can an initially experimental, not claiming universality technology become mass? Declaring anonymity and decentralization as the basic properties, Bitcoin was a private solution to the purely ideological problem of crypto-anarchism. This is a radical trend of the libertarian ideology, which for a long time has studied the possibility of the existence of non-governmental payment and monetary systems with private emission centers [26]. At the same time, people have had no payment problems since the sixth century BC, after cash was invented. It is not surprising that, being an ideological product, cryptocurrency as money with its high volatility turned out to be quite doubtful [27].

## MAIN PROBLEMS OF CURRENT BLOCKCHAIN INTRODUCTION

Besides high volatility, the problems of the technology are slow transaction speed, high energy consumption, poor scalability [28, 29]. Indeed, in 2018, Bitcoin consumed 47 Tw/hour, which is twice as much as Ireland's electrical consumption. Bitcoin transaction speed is about 7 t/sec, and the average waiting time of transaction confirmation is 55 minutes. To compare, the Visa payment system processes 24,000 t/sec, and the average waiting time is 3 seconds. It is hardly possible to overcome these problems while maintaining blockchain's decentralization and openness, since the only practical method that provides these properties is the energy-consuming Po W. Therefore, the appeal to blockchain's high speed is a bold claim. In the United States, it might be considered fast regarding the processing of payment checks, which still account for 25% of retail payments there[8], because the US national clearing system NACHA ACH accepted same day payments only in 2016.

Given the above problems, one can doubt the declared cost savings when implementing blockchain [30]. Consulting firms tout cost savings of 70% for systems and infrastructure. They do this in the context of general digitalization, modernization and abandoning obsolete systems, which will obviously reduce costs regardless of distributed ledgers. The data storage in a distributed ledger is expensive even at relatively high corporate prices for classic databases. Moving to the "free" IBM Hyperledger will cost a mid-sized enterprise about $ 140,000[9], not including implementation costs.

## THE PROBLEM OF TRUST IN SYSTEMS WITH NO TRUSTED PARTY

Finally, the most ironic factor, which is a brake for the technology penetration. A study conducted by PwC consultants showed that the main limiting factor in implementing blockchain is the lack of trust [31]! The world does

[8] According to the data by creditcards.com. URL: https://www.creditcards.com/credit-card-news/payment-method-statistics-1276.php (accessed on 10.10.2019).

[9] According to the data by EY, Total cost ownership for blockchain solutions. 2019; Apr. URL: https://www.ey.com/Publication/vwLUAssets/ey-total-cost-of-ownership-for-blockchain-solutions/$File/ey-total-cost-of-ownership-for-blockchain-solutions.pdf (accessed on 10.10.2019).

not trust the technology with the "inbuilt trust". That makes sense. From a philosophical point of view, a consensus indeed is not trust. Consensus decisions can be arbitrarily wrong and unfair. Moreover, the genesis of the technology comes from the ideology by radical revolutionaries who want to rebuild the world and destroy modern capitalism. Can we trust the anonymous majority of greedy anarchists? Neither government institutions nor the corporate world trust technology, aiming to destroy the modern world.

It is getting more interesting when it comes to exclusive blockchains. The very fact of creating private exclusive blockchains means distrust to public blockchains, with trust in the technology. Trust in established institutions is always higher than in an anonymous crowd. However, if we trust an imaginary IBM and its affiliates, the questions arise: why do we need a significantly more expensive and limited distributed ledger? why not just put your data in the cloud of a trusted company and assign a trusted company a cryptographic certificate service provider? This solution will definitely be faster and costs are better forecasted. If there is no trust, how can we participate in a proprietary distributed ledger that ensures trust by the participation of a party we do not trust?

The US Senate hearings on Facebook's plans to introduce Libra cryptocurrency are quite indicative. "I don't trust you guys," said Senator Martha McSally (R-Arizona) to Facebook representative David Marcus[10]. Trust is fragile; in this regard, even the flagship of the national economy cannot expect special treatment.

To summarize, blockchain actually:

- is not a "new Internet";
- is likely to provide a consensus, not trust;
- popular consensus algorithms have drawbacks allowing attackers to take advantage;
- does not provide equal participation;
- is not a database and does not provide immutable data storage.

[10] Quoted from: Katz M. The U.S. Senate really doesn't like Facebook's Libra cryptocurrency plans // digitaltrends.com, 2019;16 Jul. URL: https://www.digitaltrends.com/news/senate-facebook-libra-hearing-david-marcus/ (accessed on 10.10.2019).

## ANONYMOUS AND FREE BLOCKCHAIN

Is it possible that blockchain is really anonymous and free? In general, no and no. Most systems based on blockchain, e.g. Bitcoin, are pseudo anonymous. The fact that the crypto wallet is not linked to the personal data does not make the system "anonymous". Even with anonymizers and the Tor network, real users can be detected by metadata with a very high degree of confidence both by special services and by private specialists. In the case of illegal activities, blockchain's complete transparency provides justice with cogent evidence [32].

Free blockchain is also just a declaration. There are more than 1,000 patents for distributed ledgers registered in the USA[11]. It is unlikely that leading financial and technology companies patent the technology for altruistic reasons. Even "free" technologies are a source of profit for such companies. There are corporate wars for control over the technological context even in the field of open source ledgers, for example, between Intel and IBM to control Hyperledger.

## BLOCKCHAIN AND TRADITIONAL INSTITUTIONS

Despite the fact that blockchain's only significant use is cryptocurrencies, they do not shake the authority of classic financial institutions. Traditional banks with traditional trust in the financial system of the traditional state are still better in every aspect[12]. Attempts to implement distributed ledger technologies in the traditional financial sector, as elsewhere, have naturally been unsuccessful: contrary to expectations, the technology in no way reduces IT infrastructure costs, cost of interbank payments or speeds up transactions. The advantages of blockchain such as smart

[11] According to the data by bitcoinmarketjournal.com. URL: https://www.bitcoinmarketjournal.com/blockchain-patents/ (accessed on 10.10.2019).

[12] According to the Edelman Trust Barometer, in 2019, trust in banks /blockchain /cryptocurrencies on average among the entire population of the Earth, was respectively: 61 (trust) / 55 (neutral ratio) / 35 (distrust). URL: https://www.edelman.com/trust-barometer (accessed on 10.10.2019).

contracts, encryption, and distributed ledger are separate concepts. The three are independent of blockchain, they do not need to be implemented together in the IT infrastructure of financial organizations [33]. This is probably why Ripple, the most successful company declaring "interbank payments on blockchain", turned out to use traditional instruments for interbank payments, not blockchain[13].

Regulatory measures in banking and financial market are to protect investors. This is not "greed", but the result of the long development of state institutions.

No blockchain will replace or strengthen the institution of democratic elections. A blockchain voting system is not protected from "stuffing", similar to traditional ballot boxes. How can blockchain help if a potential candidate is simply not allowed to have a democratic will?

A blockchain logistics system is the same as any system — it is "garbage in, garbage out". For example, in 2006, Walmart launched a system to track its fruit from producer to buyer. In 2009, they abandoned it, and in 2017, they re-launched it on blockchain [34]. In 2006, the main problem of the system was that the manufacturers did not want to enter the data. Obviously, blockchain implementation did not solve the problem. The problem of food labeling can easily be solved by traditional means, for example, by the Russian EGAIS and Mercury systems.

## CONCLUSIONS

In conclusion, it is worth noting that the social and cultural aspects of hype around blockchain are extremely interesting. How has blockchain mania embraced serious business? How did a social order come about on blockchain? How did an experimental technological solution generate a virtually sectarian belief system with features of a destructive cult?[14] Future researchers have yet to answer these questions, but now there is reason to believe that blockchain is more a social phenomenon [35] than a rational one [36].

Blockchain and distributed ledgers are not a foundational technology. In general, they do not have the properties of the immutable data storage, trust, anonymity, low transaction and adoption costs. All current consensus technologies have fundamental flaws. Cryptocurrency technology is original, but it was a private experimental solution to a specific ideological problem of the libertarian political agenda. Consensus does not provide trust. Delayed blockchain adoption, in particular in traditional financial institutions, is natural, since the technology does not show better results than current digital solutions. Traditional economic institutions have greater public trust. Significant investment in blockchain and distributed ledgers are unlikely to pay off soon. De facto, they guarantee further search for application of the technology in various fields of human activity, including the financial sector.

[13] According to the data by Financial Times: Kelly J. Blockchain insiders tell us why we don't need blockchain. 2018; May 2. URL: https://ftalphaville.ft.com/2018/05/02/1525253799000/Blockchain-insiders-tell-us-why-we-don-t-need-blockchain/ (accessed on 10.10.2019).

[14] In May 2018, the entrepreneur launched a religious cult based on blockchain called "0xΩ". URL: https://www.americamagazine.org/politics-society/2019/06/14/can-technology-behind-bitcoin-be-used-build-belief-system (accessed on 10.10.2019).

## REFERENCES


1. Autore D.M., Clarke N., Jiang D. Bitcoin speculation or value creation? Corporate Blockchain investments and stock market reactions. *SSRN Electronic Journal*. 2019. DOI: 10.2139/ssrn.3385162
2. Tapscott D., Tapscott A. Blockchain revolution: How the technology behind Bitcoin and other cryptocurrencies is changing the world. New York: Portfolio; 2018. 432 p.
3. Swan M. Blockchain: Blueprint for a new economy. Sebastopol, CA: O'Reilly Media, Inc.; 2015. 152 p.
4. Mougayar W. The business Blockchain: Promise, practice, and application of the next Internet technology. Hoboken, NJ: John Wiley & Sons, Inc.; 2016. 209 p.
5. Fanning K., Centers D.P. Blockchain and its coming impact on financial services. *The Journal of Corporate Accounting & Finance*. 2016;27(5):53–57. DOI: 10.1002/jcaf.22179

6. Hassani H., Huang X., Silva E. Banking with Blockchain-ed big data. *Journal of Management Analytics*. 2018;5(4):256–275. DOI: 0.1080/23270012.2018.1528900
7. Iansiti M., Lakhani K.R. The truth about Blockchain. *Harvard Business Review*. 2017;95(1):118–127. URL: https://enterprisersproject.com/sites/default/files/the_truth_about_blockchain.pdf
8. McGrath R.G. The pace of technology adoption is speeding up. *Harvard Business Review*. 2013;(Nov.). URL: https://hbr.org/2013/11/the-pace-of-technology-adoption-is-speeding-up
9. Rogers E.M. Diffusion of innovations. 3rd ed. New York, London: The Free Press; 1983.
10. Woodside J.M., Augustine F.K. Jr., Giberson W. Blockchain technology adoption status and strategies. *Journal of International Technology and Information Management*. 2017;26(2). URL: http://scholarworks.lib.csusb.edu/cgi/viewcontent.cgi?article=1300&context=jitim (accessed on 10.10.2019).
11. Stratopoulos T.C., Wang V.X. Blockchain technology adoption. *SSRN Electronic Journal*. 2018. DOI: 10.2139/ssrn.3188470
12. Ahuja G., Lampert C.M. Entrepreneurship in the large corporation: A longitudinal study of how established firms create breakthrough invention. *Strategic Management Journal*. 2001;22(6–7):521–543. DOI: 10.1002/smj.176
13. Lamport L., Shostak R., Pease M. The Byzantine generals problem. *ACM Transactions on Programming Languages and Systems*. 1982;4(3):382–401. DOI: 10.1145/357172.357176
14. Fischer M., Lynch N., Paterson M. Impossibility of distributed consensus with one faulty process. *Journal of the ACM*. 1985;32(2):374–382. DOI: 10.1145/3149.214121
15. Ben-Or M., Hassidim A. Fast quantum Byzantine agreement. In: STOC'05. Proc. 37th Annu. ACM symp. on theory of computing (Baltimore, MD, May 22–24, 2005). New York: ACM; 2005:481–485. DOI: 10.1145/1060590.1060662
16. Krawisz D. The proof-of-work concept. Satoshi Nakamoto Institute. 2013. URL: https://nakamotoinstitute.org/mempool/the-proof-of-work-concept/ (accessed on 10.10.2019).
17. Bissias G., Levine B.N., Ozisik A.P., Andresen G. An analysis of attacks on Blockchain consensus. URL: https://arxiv.org/pdf/1610.07985.pdf (accessed on 10.10.2019).
18. Zhang S., Lee J.-H. Double-spending with a Sybil attack in the Bitcoin decentralized network. *IEEE Transactions on Industrial Informatics*. 2019;15(10):5715–5722. DOI: 10.1109/TII.2019.2921566
19. Demeester T. Critique of Buterin's "A proof of stake design philosophy". Medium. 2017. URL: https://medium.com/@tuurdemeester/critique-of-buterins-a-proof-of-stakedesign-philosophy-49fc9ebb36c6 (accessed on 10.10.2019).
20. Zhang S., Lee J.-H. Analysis of the main consensus protocols of Blockchain. *ICT Express*. 2019;5(3). DOI: 10.1016/j.icte.2019.08.001
21. Wahab A., Memood W. Survey of consensus protocols. 2018. URL: https://arxiv.org/ftp/arxiv/papers/1810/1810.03357.pdf (accessed on 10.10.2019).
22. Grewal-Carr V., Marshall S. Blockchain: Enigma. Paradox. Opportunity. Deloitte. 2016. URL: https://www2.deloitte.com/content/dam/Deloitte/uk/Documents/Innovation/deloitte-uk-blockchain-full-report.pdf (accessed on 10.10.2019).
23. Stolfi J. Letter to the Editor, NIST Reports. Ref: NISTIR 8202 (DRAFT): Blockchain Technology Overview. 2018. URL: https://www.ic.unicamp.br/~stolfi/temp/nist-report-review.pdf (accessed on 10.10.2019).
24. Radoccia S. What's holding Blockchain back from large-scale adoption? Forbes. Sept. 21, 2017. URL: https://www.forbes.com/sites/quora/2017/09/21/whats-holding-blockchain-back-from-large-scale-adoption (accessed on 10.10.2019).
25. Castillo M. The DAO attacked: Code issue leads to $ 60 million ether theft. Coindesk. June 18, 2016. URL: https://www.coindesk.com/dao-attacked-code-issue-leads-60-million-ether-theft (accessed on 10.10.2019).
26. Karlstrøm H. Do libertarians dream of electric coins? The material embeddedness of Bitcoin. *Distinktion: Scandinavian Journal of Social Theory*. 2016;15(1):23–36. DOI: 10.1080/1600910x.2013.870083

27. Krylov G.O., Lisitsyn A.Y., Polyakov L.I. Comparative analysis of volatility of cryptocurrencies and fiat money. *Finansy: teoriya i praktika = Finance: Theory and Practice.* 2018; 22(2):66–89. (In Russ.). DOI: 10.26794/2587–5671–2018–22–2–66–89
28. Goswami S. Scalability analysis of Blockchains through Blockchain simulation. UNLV Theses, Dissertations, Professional Papers, and Capstones. 2017;(2976). URL: https://pdfs.semanticscholar.org/108f/9d7493fecd7cdb1a2a123d89a4db16b79679.pdf?_ga=2.210275989.1023187009.1572354254–1709531060.1571930732 (accessed on 10.10.2019).
29. Truby J. Decarbonizing Bitcoin: Law and policy choices for reducing the energy consumption of Blockchain technologies and digital currencies. *Energy Research & Social Science.* 2018;44:399–410. DOI: 10.1016/j.erss.2018.06.009
30. Bloomberg J. Don't let Blockchain cost savings hype fool you. Forbes. Feb. 24, 2018. URL: https://www.forbes.com/sites/jasonbloomberg/2018/02/24/dont-let-blockchain-cost-savings-hype-fool-you/#3b47f4f45811 (accessed on 10.10.2019).
31. Davis S. Likens S. Blockchain is here. What's your next move? Pw C. 2018. URL: https://www.pwc.com/gx/en/issues/blockchain/blockchain-in-business.html (accessed on 10.10.2019).
32. Bohannon J. Why criminals can't hide behind Bitcoin. Science. March 09, 2016. DOI: 10.1126/science.aaf4167
33. Halaburda H. Blockchain revolution without the Blockchain? *Communications of the ACM*. 2018;61(7):27–29. DOI: 10.1145/3225619
34. Stinchcombe K. Blockchain is not only crappy technology but a bad vision for the future. Medium. Apr. 5, 2018. URL: https://medium.com/@kaistinchcombe/decentralized-and-trustless-crypto-paradise-is-actually-amedieval-hellhole-c1ca122efdec (accessed on 10.10.2019).
35. Albrecht S., Lutz B., Neumann D. How sentiment impacts the success of Blockchain startups. An analysis of social media data and initial coin offerings. In: Proc. 52nd Hawaii int. conf. on system sciences. 2019:4545–4554. URL: https://scholarspace.manoa.hawaii.edu/bitstream/10125/59892/ 0452.pdf (accessed on 10.10.2019).
36. Lee C.C., Kriscenski J.C., Lim H.S. An empirical study of behavioral intention to use Blockchain technology. *Journal of International Business Disciplines.* 2019;14(1):1–21. URL: https://faculty.utrgv.edu/louis.falk/jibd/JIBDmay19.pdf (accessed on 10.10.2019).

## ABOUT THE AUTHORS

***Grigorii O. Krylov*** — Dr. Sci. (Phys.-Math.), Cand. Sci. (Engin.), Cand. Sci. (Juris.), Professor, Department of Information Security, Financial University, Moscow, Russia;
Professor at National Research Nuclear University MEPhI, Honorary Figure of Russian Higher Education, Moscow, Russia
nik155@yandex.ru

***Vladimir M. Seleznev*** — Cand. Sci. (Engin.), MBM, Member of the Board, JSC LatCard (Electronic money financial institution), Riga, Latvia
v_seleznev@pisem.net

*The article was submitted on 02.09.2019; revised on 11.09.2019 and accepted for publication on 20.10.2019. The authors read and approved the final version of the manuscript.*

ORIGINAL PAPER



DOI: 10.26794/2587-5671-2019-23-6-36-49
UDC 336.012.23,336.018,336.711.2,336.741.2(045)
JEL A10, B53, E40, E42, E44

# The Essence of Cryptocurrencies: Descriptive and Comparative Analysis

**E.V. Sinel'nikova-Muryleva**[a], **K.D. Shilov**[b], **A.V. Zubarev**[c]
Institute of Applied Economic Research, RANEPA, Moscow, Russia
[a] https://orcid.org/0000-0001-7494-2728; [b] https://orcid.org/0000-0002-2149-3946;
[c] https://orcid.org/0000-0003-2945-5271

## ABSTRACT

The aim of the article is to systematize the views on the concept of cryptocurrency from the literature and among international and national organizations and regulators, to analyze its economic essence and the place in the modern monetary and financial system. The definition and the functions of cryptocurrency are discussed in the framework of descriptive and theoretical analysis. The paper systematized the existing approaches to the concept analysis of cryptocurrency; the place of cryptocurrency in modern economic theory is shown.The article concludes that cryptocurrencies are often determined through the set of basic characteristics. Cryptocurrencies are not money, though they can perform the main function of money — to be a means of payment; they can be a means of making settlements, assets, platforms for concluding smart contracts, a means for crowdfunding. They are not private money in Hayek's interpretation. Cryptocurrencies can be described in the framework of the models of new monetarism (payment economics).

***Keywords:*** cryptocurrencies; crypto assets; payment systems; private money; economics of payments; blockchain

***For citation:*** **Sinel'nikova-Muryleva E.V., Shilov K.D., Zubarev A.V. The essence of cryptocurrencies: descriptive and comparative analysis. *Finance: Theory and Practice.* 2019;23(6):36-49. DOI: 10.26794/2587-5671-2019-23-6-36-49**

## INTRODUCTION

Amid its rapidly increasing and immense professional and public interest the subject of cryptocurrencies has raised the number of studies. The analysis of the economic nature of cryptocurrencies and their functions are widely discussed.

Cryptocurrencies and distributed ledger technology are two key concepts related to cryptoeconomics. The distributed ledger technology (blockchain) is often considered separately from cryptocurrencies, since it is only a certain type of database, the basis for cryptocurrencies. During the cryptocurrency boom, many large enterprises and even states were experimenting with distributed ledgers and were trying to apply them in various sectors of the economy. However, a significant part of these projects remained ink on paper or their implementation was limited to pilot launches and tests. At the same time, some experiments were successful, and today blockchain is used in information systems of government, medicine, and logistics. Nevertheless, experience has shown that blockchain without cryptocurrencies is a rather specific product that can show all its benefits compared to classical databases only under certain conditions.

As for cryptocurrencies, Bitcoin is mostly discussed in the academic community, although by now, the popularity of other cryptocurrencies has also grown significantly. Modern cryptocurrencies differ from each other not only by the features of the cryptographic algorithms, by the mechanisms of consensus, by the issuance and the degree of (de)centralization, but also by their target functions. Besides, many cryptocurrencies are considered as a potential investment tool. This work follows the previous research and aims to systematize the views on cryptocurrencies and their essence that exist in the literature.

## BLOCKCHAIN AS THE BASE FO CRYPTOCURRENCIES

Most cryptocurrencies run on blockchain technology, which is a type of a distributed ledger, i.e. represents a certain type of database. Each block in blockchain contains a set of transactions completed during a certain period of time.

There are several classifications of blockchain by various criteria. In the light of the discussion about cryptocurrencies, the method of forming a blockchain (adding new blocks) is of interest. It is determined by the type of consensus, i.e. the mechanism, which decides on the degree of information security and how new blocks of information are formed.

There are three main types of consensus mechanism algorithms: "proof-of-work", "proof-of-stake" and "proof-of-authority", the algorithm based on solving the Byzantine Generals' Problem (it has not proved its effectiveness).

Before we speak more specifically about the types of consensus, it is necessary to define another term important for blockchain — "a node".

A node is a device in a blockchain network, i.e. any electronic device, such as a computer or telephone that has an Internet connection and an IP address. Nodes maintain the network by saving a copy of blockchain and, in some cases, processing transactions. Owners of nodes provide their computing resources to store and verify transactions, so they may get a transaction fee (commission). This is called mining (mining for PoW algorithms) or forging (forging for PoS algorithms).

There are two types of nodes:

1. A full node downloads the entire data of a specific blockchain and validates any new transaction, thus confirming and conducting transactions, placing them in blocks.

2. A partial (or lightweight) node does not store complete ledger. Thus, blockchain size is not a problem for this type of nodes, since there is no need to store a huge amount of data. Lightweight nodes only download the part of the blockchain which they require using SPV (Simplified Payment Verification) mode. They will connect to full nodes clients and use bloom filters to ensure that they only receive transactions, which are necessary and relevant to their operations.

The proof-of-work (PoW) is a common consensus algorithm used by the most popular cryptocurrency network Bitcoin. The idea is that the nodes of the blockchain compete to start the generation of each new block, which is called mining. The competition consists in solving a cryptographic problem (select a particular hash[1] of a certain complexity, which will serve as the header of a new block). This is what determines the competitive nature of mining: the more computing power is added to the network, the higher average number of calculations needed to create a new block. This method also increases the cost of the block creation, increasing the efficiency of the system. As a reward for its work, the victorious miner gets some new Bitcoin. This reward for recording a new block (solving a cryptographic problem) represents the currency issue. The Bitcoin protocol, as well as many other cryptocurrencies, is designed in such a way that issuance occurs at approximately equal intervals of time, and the value of each issuance is known in advance and is defined in the protocol properties; therefore, the trajectory of all future issuances, and therefore the cryptocurrency supply path, is known in advance.

The PoW enables any Bitcoin user to make secure transactions without the intervention of third parties. However, the main blockchain's weaknesses that form the very essence of currencies such as Bitcoin are well known. They consist in low transaction speed, fluctuating, and sometimes, high transaction costs. In addition, mining operations to verify blockchain process are associated with huge energy consumption.

The "proof-of-stake" consensus algorithm determines the probability of a participant to

[1] A hash is the result of a hash function. Such functions help prevent rewriting any information, since in this case it will be necessary to rewrite all subsequent blocks, which is impossible (see [1] for more details).

create a new block by the number of cryptocurrencies / tokens on their balance. The main PoS advantage is that there is no need to spend a large amount of energy on cryptographic problems. At the same time, while a new block is created, no more cryptocurrency is produced — the only reward is the fee from the transactions included in the block.

It is also possible to combine PoW and PoS mechanisms when some of the blocks are mined (for example, every $n^{th}$ block, i.e. the place of such blocks in the chain is determined, the remaining blocks are added by validators).

The idea of the consensus mechanism based on solving the Byzantine Generals' Problem (byzantine fault tolerance algorithms, BFTA) is the constant exchange and reconciliation of ledger copies between the network participants resulting in consensus. Such systems are characterized by high transaction speed and lack of mining. The nodes participating in the consensus (depending on the cryptocurrency) can get some transaction fees from approved transactions. Such algorithms demonstrate high transaction speed with only a relatively small number of decision nodes and, therefore, are more often used in partially centralized ledgers.

Depending on the issuing mechanism, the vast majority of cryptocurrencies can be divided into those with limited offer, and the maximum amount is delayed, and those whose offer is fully issued at the moment when cryptocurrency is created.

Cryptocurrencies of the first type usually use PoW as a consensus mechanism, when the generation of new coins is a reward to miners, network participants, creating new blocks in the chain by using their computing power (Bitcoin, Etherium).

Cryptocurrencies of the second type use other consensus mechanisms, for example, PoS, where the likelihood of becoming a participant in creating a new block depends on the balance of coins in the account, the computational work is not so expensive, and the reward is only the fee from approved transactions (Nxt, BlackCoin).

Most common is using both consensus mechanisms[2], when most of the blocks are created by PoS, but some "holding" blocks are created by mining (EmerCoin, PeerCoin).

There are other methods of consensus and issuance. For example, in the Stellar decentralized platform for currency transactions, with its own lumen currency, the consensus mechanism is based on a particular solution to the Byzantine Generals' Problem (Federated Byzantine Agreement, FBA) [2]. Stellar had 100 billion lumens created at the genesis of the project, most of which are still not in free circulation (belong to the founders). Nevertheless, the following so-called inflationary mechanism was installed in the system, ensuring an increase of coins at a rate of 1% per year. Stellar charges a fee for each transaction. The fee pool is the lot of lumens collected from transaction fees. The pool plus the number of coins in circulation, multiplied by the coefficient of weekly inflation, is distributed to a certain number of network participants. They are chosen by other participants' votes — everyone can vote once for someone else; the vote is weighted by the number of lumens on the balance. Anyone who gains more than 0.05% of the total number of votes (i.e., from the total number of coins) is rewarded from the weekly fee pool.

Again, three main consensus mechanisms used to create cryptocurrencies today are proof-of-work, proof-of-stake and proof-of-authority (the algorithm based on solving the Byzantine Generals' Problem). Each of them has its flaws and weaknesses. For example, a not-so-popular cryptocurrency based on PoW can be attacked by temporary rental of huge computing power (which has been done several times and is called "51% attack").

Cryptocurrencies based on PoS are potentially vulnerable to other types of attacks, such as "deep attacks". If someone gains control over wallets containing already spent coins, s/he will be able to "roll back" the time until the mo-

[2] Note, that two most common and well-known cryptocurrencies — Bitcoin and Ether — use the non-hybrid consensus mechanism.

ment when these wallets contained coins, and, having thus obtained 51% of the coins, build an alternative blockchain. If this new alternative blockchain is longer than the main one, the attacker will change the contents of the blockchain backdated. Additional mechanisms, for example, dynamic checkpoints, are used to protect against such attacks. Overall, PoS turned out to be more stable than Po W. Nevertheless, it is now quite common to use both consensus mechanisms for issuing cryptocurrencies, since it reduces the overall risk of cyber-attacks.

## DEFINITIONS OF CRYPTOCURRENCY AND ITS FUNCTIONS

There is no single definition of cryptocurrency. For example, the Bank for International Settlements (BIS) equates the concepts of "virtual currency"[3], "digital currency" and "cryptocurrency"[4] and defines "digital currency" based on the following key characteristics:

- issued only electronically;
- is not issued in national currencies and is not related to them;
- is no one's obligation (unlike traditional money);
- has zero intrinsic value, i.e. does not generate a stream of payments;
- is used for peer-to-peer exchange, i.e. direct (decentralized) exchange between the parties in the system using distributed ledger technology;
- is an asset with some characteristics of money (in particular, it is a means of payment).

Thus, the BIS interprets cryptocurrency as an asset with a number of unique characteristics. It is noteworthy that the BIS calls digital currencies potential substitutes for electronic money. Traditionally, the concept of money is defined through its functions[5]. In particular, according to the ECB report[6], "money is anything that is used widely to exchange value in transactions. It functions as a medium of exchange, storage of value and unit of account". Banknotes and coins are usually just a small part of the country's total money supply. According to the UK Financial Conduct Authority[7], electronic money (e-money) is electronically (including magnetically) stored monetary value, represented by a claim on the issuer, which is issued on receipt of funds for the purpose of making payment transactions. It must be accepted as a means of payment by a person other than the electronic money issuer. Types of e-money include pre-paid cards and electronic pre-paid accounts for online use

The ECB defines electronic money (e-money) as "an electronic store of monetary value on a technical device that may be widely used for making payments to entities other than the e-money issuer. The device acts as a prepaid bearer instrument which does not necessarily involve bank accounts in transactions"[8]. As a rule, electronic money is stored in the same account as the fiat money used to create electronic money. It is different for cryptocurrencies.

The ECB refers to cryptocurrencies as to "decentralized, bi-directional virtual currency schemes"[9]. The term "virtual currency" is defined as a digital representation of value, not issued by a central bank, credit institution or e-money institution, which in some circumstances can be used as an alternative to money. The term "virtual currency scheme(s)" is used

[3] Definition in ECB report (see European Central Bank. Virtual currency schemes. ECB Report. 1–55, October 2012): "A virtual currency is a type of unregulated, digital money, which is issued and usually controlled by its developers, and used and accepted among the members of a specific virtual community".

[4] See Bank of international settlements, CPMI. *Digital currencies.* 2015; Bank of international settlements, CPMI. *Central bank digital currencies.* 2018.

[5] Note, that in work [3], one of the earliest studies of the theoretical direction of the new monetarism and the economics of payments, money is identified with "memory" about the good behavior of an economic agent in the past: if "today" a person has money, it means "yesterday" they made their goods delivery commitments to the counterparty.

[6] European Central Bank. *Virtual currency schemes — a further analysis.* ECB Report; February 2015:1–37.

[7] URL: https://www.fca.org.uk/firms/payment-services-regulations-e-money-regulations (accessed on 23.09.2019).

[8] URL: https://www.ecb.europa.eu/stats/money_credit_banking/electronic_money/html/index.en.html (accessed on 23.09.2019).

[9] European Central Bank. *Virtual currency schemes — a further analysis.* ECB Report; February 2015:1–37.

to describe both the aspect of value and that of the inherent or in-built mechanisms ensuring that value can be transferred.

The International Monetary Fund (IMF) also does not provide a strict definition of cryptocurrency. However, according to the IMF, cryptocurrencies are generally not currencies but rather assets and high-risk investments[10].

In accordance with Article 2 of the Draft Federal Law of 25.01.2018 "On digital financial assets" of the Ministry of Finance of the Russian Federation, "cryptocurrency is a type of digital financial asset created and recorded in a distributed ledger of digital transactions by participants of this ledger in accordance with the rules for maintaining a digital transaction ledger" [11].

The question comes up: which of the above properties of money do cryptocurrencies perform?

Today, cryptocurrencies partially fulfill the function of a means of payment, since certain groups of economic agents are ready to accept them as payment for goods and services. According to the BIS report[12], "money is an indispensable social convention backed by an accountable institution within the State that enjoys public trust". However, to use a certain instrument as a means of payment, it is more important that there is an analogue of the "social convention" between agents than the validity of such a means of payment[13].

Today, cryptocurrencies are not secure savings or a unit of account due to the high volatility of the main cryptocurrencies. The exchange rate of cryptocurrency is based on supply and demand. In this regard, two aspects influence the high volatility of exchange rates: first, the high speculative component in demand and, second, the limited cryptocurrency supply, i.e. the complexity of elastic expansion of its supply in response to market demand. For this reason, cryptocurrencies today cannot be a reliable means of preserving purchasing power. The cryptocurrency volatility is also explained by the fact that cryptocurrencies are an inconvenient unit of account due to frequent price revisions expressed in units of cryptocurrencies. Besides, the high volatility of the exchange rate (coupled with the fact that cryptocurrencies are no one's obligation[14]) discredits cryptocurrencies, which also does not contribute to their distribution as "good money"[15].

Unlike "money", cryptocurrencies perform a unique function of transferring and storing information. First, cryptocurrency blockchains store all secure and immutable transaction information. In this regard, this data source can always be addressed to resolve any issues. Second, many cryptocurrencies are specifically designed so that writing smart-contracts easy. This allows not only to get rid of intermediaries and reduce time and money costs for many types of transactions, but also record information about these transactions in blockchain, which cannot be changed by unscrupulous counterparties.

The BIS defined cryptocurrency as an asset, calling a more detailed consideration of the characteristics that formally satisfy assets in general and financial assets in particular. According to the Organization for Economic Co-

[10] International Monetary Fund. *Money, transformed. The future of currency in a digital world.* Finance and development. 2018;55(2).

[11] Ministry of Finance of Russia. Draft Federal Law of 05.22.2018 "On Digital and Financial Assets". January 2018. URL: https://www.minfin.ru/ru/document/%3Fid_4%3D 121810 (accessed on 23.09.2019).

[12] Bank of international settlements, CPMI. *Central bank digital currencies.* 2018.

[13] In certain periods, e.g., hyperinflation, the money issued by the central bank may lose the trust of economic agents due to a significant and continuing decline in purchasing power. In such cases, agents may switch to more reliable instruments that in terms of preserving the purchasing power (not fixed by law as a means of payment) for transactions or barter.

[14] There are two ways to issue cryptocurrencies: decentralized — by a network of users, and centralized — by one or a group of agents. Regardless of the method of issue, "traditional" cryptocurrencies are not an obligation of any economic agent, unlike the money of the central bank.

[15] Individual national currencies show high fluctuations in prices (exchange rates) of one currency regarding another in relatively short intervals. In fact, any good or durable asset that can be saved for future use is a potential store of value, and in this regard, some of them are more reliable than money.

*Table 1*

**Comparative analysis of cryptocurrencies as money and asset**

| Features | Money | Assets | Financial assets | Cryptocurrencies |
|---|---|---|---|---|
| Store of value | Yes | Yes | Yes | No |
| Means of payment | Yes | No | No | Partially |
| Unit of account | Yes | No | No | No |
| Granting ownership | No | Yes | Yes | Yes |
| Providing the owner with economic benefits through storage or use | Possible* | Yes | Yes | Possible |
| Is the obligation of the other party | Yes | No | Yes | No |
| Information transfer and storage function | No ** | No | No | Yes |

*Source:* compiled by the authors.

* Assuming that this is the narrowest monetary aggregate (M0), the benefit may occur during deflation. The benefit of storing components of wider monetary aggregates is due to the presence of interest income.

** Except for considering the concept "money is memory", according to which possessing money by an economic agent is the evidence that s/he had conscientiously fulfilled his obligations to the counterparty.

operation and Development (OECD)[16], assets are entities functioning as stores of value and from which economic benefits may be derived by their owners by holding them, or using them, over a period of time. As mentioned earlier, cryptocurrency is not a secure saving, in other words, it does not have stable purchasing power over a long period of time. At the same time, the issue of property rights in the context of cryptocurrency is controversial and depends on the legislative regulation in each country.

Cryptocurrencies often do not provide the owner with a stream of payments, unlike land, real estate, or stocks and bonds[17]. The argument that is usually used to explain the lack of intrinsic (fundamental) value in cryptocurrencies, which is confirmed in some econometric studies, in particular by work [4].

At the same time, the demand for cryptocurrency is largely related to the expectations of agents regarding the increase in its exchange rate, and in this context, cryptocurrencies can provide their owners with the economic benefits of storage. Financial assets, as defined by the OECD[18], in addition to the above characteristics, are someone else's obligation; this condition is not satisfied for cryptocurrencies in their classical sense. Thus, cryptocurrencies satisfy individual properties of assets in their broad interpretation. Today, verifying how "standard" pricing models for financial assets can describe cryptocurrencies is a popular area of research in applied finance [5–9]. In particular, the works test the capabilities of the CAPM, APT or multifactor models to adequately describe the dynamics of cryptocurrency prices. The literature also raises the question of risk diversification of an investment portfolio with cryptocurrencies [10, 11].

*Table 1* illustrates a comparison of cryptocurrencies with money and assets.

Howmuch.net data[19] also proves the negligible share of cryptocurrencies compared to other types of assets. Nevertheless, cryptocurrencies

[16] OECD. Glossary of Statistical Terms (Assets). URL: https://stats.oecd.org/glossary/detail.asp? ID=2974 (accessed on 23.09.2019).

[17] Note, that the stellar cryptocurrency implies an increase in coins on the account at a rate of 1% per year.

[18] OECD. Glossary of Statistical Terms (Financial Assets). URL: https://stats.oecd.org/glossary/detail.asp? ID=961 (accessed on 23.09.2019).

[19] URL: https://howmuch.net/articles/worlds-money-in-perspective-2018 (accessed on 23.09.2019).

have become a very important topic discussed in recent years in the literature, and their development prospects are an open question.

## CRYPTOCURRENCIES VS TRADITIONAL PAYMENT SYSTEMS

Our analysis shows that cryptocurrencies can be used as a means of payment, but they cannot serve as a reliable unit of account or a means of saving.

In addition to the fundamental problem of trust in cryptocurrencies, which are no one's obligations, and inelasticity or insufficient flexibility of the offer by some cryptocurrencies, other limitations of cryptocurrency payment systems are also highlighted [12–14].

The first problem is associated with the low transaction speed in blockchain of most cryptocurrencies. For example, according to the BIS[20] and howmuch.net, Bitcoin is able to conduct only 7 transactions per second, while the traditional Visa and Paypal payment systems — 24,000 and 193, respectively. On the other hand, such projects as Ripple, EOS and Futurepia are capable of carrying out 1,700.3 thousand and even 300 thousand transactions per second, respectively, which indicates their high potential in this area.

The next limitation of cryptocurrency systems is associated with insignificant volumes of transactions compared to payments made through retail and wholesale payment systems around the world. In addition, there is a fee volatility due to hardware restrictions on the amount of information per one block: increasing demand for transfers in the system leads to increasing fees.

The composition of market participants who are ready to use cryptocurrency systems is limited[21], and the energy footprint required for cryptocurrency mining is high. The increase in computing power is accompanied by an equivalent increase in electricity consumption. According to the results by O'Dwyer and Malone [15], the entire mining network is on par with Ireland for electricity consumption in 2009–2014. In fact, the authors concluded that the monetary cost of the energy and equipment should be compared to the reward for miners. According to digiconomist.net estimates, in 2017, 32.7 TWh were spent on Bitcoin mining, which is comparable to the annual energy consumption of Serbia, Denmark or Belarus, and 11.1 TWh — on Ethereum mining, which is approximately equal to the energy consumption of Zambia or Lithuania. As a comparison, in 2017, Moscow spent 105 TWh. Currently, the annual electricity consumption for Bitcoin mining is 73.12 TWh, which is comparable to Austria's energy consumption[22].

It is also important that traditional payment systems consume much less electricity than the Bitcoin payment system or any other blockchain payment system based on PoW, which implies mining. For example, the cost of energy consumption per transaction for Bitcoin is equal to that of almost 600 thousand Visa transactions[23].

Information should be stored if payments will be made using blockchain. According to the BIS estimates[24], starting from 1 July 2018, all electronic non-cash retail transactions[25] are processed via a cryptocurrency, hypothetical ledger size for nationwide retail cryptocurrency in the Euro area, China and the United States will be more than 45, 80 and 105 TB by 2021, respectively. A problem will arise if this information needs to be stored in all blockchain nodes.

[20] Bank of international settlements. BIS *Annual Economic Report*. 2018.

[21] At the same time, the largest banks, in particular Barclays and HSBC, declare their interest in the new technology and participate in the project to create an international payment system based on blockchain.

[22] URL: https://digiconomist.net/bitcoin-energy-consumption (accessed on 23.09.2019).

[23] URL: https://www.statista.com/statistics/881541/bitcoin-energy-consumption-transaction-comparison-visa/ (accessed on 23.09.2019).

[24] Bank of international settlements. BIS *Annual Economic Report*. 2018.

[25] The calculations were made not for all countries of the Euro area, but only for France, Belgium, the Netherlands, Germany and Italy.

Another serious issue is whether use and storage of cryptocurrencies is reliable and safe regarding no-failure operation of the technology? People should be sure of the low vulnerability of cryptocurrencies to fraud and malfunctions. So far, the technical security of distributed ledger technology has not been tested on a large scale. At the same time, changing the ledger with a large number of nodes will be more difficult, since a huge number of copies will have to be manipulated at the same time. On the other hand, the consensus protocol can be manipulated by a malicious participant (group of participants) who controls the majority of votes or computing power ("consensus capture"). Moreover, cryptographic methods that are secure today may be hacked in the future if computing power continues to increase. Bruno Huttner [16] also noted anticipated threats to blockchain technology and digital currencies from quantum computers. The advent of quantum computing over the next 10–15 years current cryptography might not be so secure anymore. In other words, as a result, quantum computers may well bypass the existing security system that underlies blockchain and digital currencies.

The anonymity of cryptocurrencies (or pseudonymity) carries the risk of potential money laundering or terrorist financing. If the law does not require this, user information can be protected from disclosure to third parties and governments, while criminals can be held back by the risk of investigation and prosecution. Banks whose business will be associated with cryptocurrencies will have to comply with the Know Your Customer rule and the requirements for combating money laundering and terrorist financing when conducting their operations with cryptocurrencies.

Nevertheless, it is possible to list benefits of blockchain based payment systems vs traditional payment systems, mentioned in the literature[26]. The first benefit is the lack of need for a central authority. In traditional payment systems, there is an authority like a bank that is able to control all customer's actions through their system. Banks have all the information about customer payments and other personal information. There is a potential risk that banks may share this information with third parties. Blockchain-based payment system is more secure and transparent for customers in terms of data protection. However, state bodies are able to identify people in case of suspicions or evidence of their involvement in illegal activities.

The second benefit is the lack of need for a high budget for security. Traditional systems, including banks and payment system operators (like Visa or Mastercard) spend vast sums of money in order to protect the customer data (they build servers, security teams and control teams that have a high effect in their budget management). Blockchain system carries the risks of a "51% attack" or a "deep attack", but such a hack for criminals is also associated with high costs. Therefore, if the cryptocurrency system is large enough and there are many users in the blockchain payment system, it can be considered safe at the current time.

The third benefit of blockchain payment systems is instant cash-out. This argument is controversial. Banks require a settlement time to cash-out company's revenue, while blockchain payment systems provide an easier and faster cash-out process without any settlement rate. Of course, this does not apply to the customer's cash-out from their payment card linked to the bank account. A wide network of ATMs around the world makes it possible to receive cash 24/7 at minimal cost.

The fourth benefit is the fact that fees in cryptocurrency systems are acceptable and reasonable. However, this argument is also controversial. On the one hand, traditional payment systems include various payment intermediaries: a payment system operator, a customer's bank and a seller's bank, and all of them require a commission and transaction fees. In a decentralized system, i.e. in blockchain payment sys-

[26] URL: https://medium.com/menapay/traditional-payment-systems-vs-blockchain-payment-systems-1fbccff56b87 (accessed on 23.09.2019).

tems, transaction fees are determined by the participants — supply and demand in the market. It is expected that this method should lead to a reduction in commission fees compared to traditional payment systems. On the other hand, one of the main problems of cryptocurrency markets is the high volatility of commissions. Moreover, during periods of abnormally high prices for cryptocurrencies, commission fees also increase sharply. For example, transaction fees in the Bitcoin system reached $ 55 as of December 22, 2017 — the peak cryptocurrency price period[27].

The fifth benefit is the ability to make fast international transfers. Especially in cross-border transactions, traditional payment systems fail in giving a fast service. Blockchain helps its customers to make a lot faster transactions between peers in international payments.

There are also several developed international payment models based on central bank digital currencies (CBCD)[28]. In wholesale payment systems of central bank digital currencies, like in traditional wholesale payment systems using reserves for settlement transactions, there are credit, settlement, operational and liquidity risks. The relationship of these risks in payment systems based on central bank digital currencies is currently unknown and may significantly differ from the distribution of risks in traditional payment systems. Mitigation or optimization (compromise) of risks will largely depend on the technical solutions chosen to make payments (issuing "protocols", an intraday liquidity policy, interest payments on central bank digital currencies, etc.). It is assumed that technical solutions can reduce credit, settlement, operational and liquidity risks in the wholesale payment systems of central bank digital currencies. According to Project Ubin[29], distributed ledger technology is a potential opportunity to improve domestic securities transactions by offering the calculations of Delivery-vs-Payment (DvP) in cases of significant improvements in cross-border payments (payment versus payment) and securities transactions (DvP).

Thus, the infrastructure of traditional and cryptocurrency-based payment systems reveals the main differences between them, as well as advantages and disadvantages.

In the literature, as well as among economists and market participants, the comparative advantages and disadvantages of various cryptocurrency payment systems are discussed. Cryptocurrencies Bitcoin, Ripple, and Ethereum are the most interesting to compare. Ripple is the one that most corresponds to the payment system in the traditional sense. The latter dominates both Bitcoin and Ethereum in terms of transaction speed (analogue of RTGS, real-time gross settlement system, payment system with currency exchange) and coin scalability. Ethereum is a decentralized platform that launches smart contracts, so its scope is not limited to payments. As for Bitcoin, it is still the main cryptocurrency for payments and investment.

The following sections are devoted to the view of economic theory on the concept of cryptocurrency.

## TRADITIONAL MONETARY-FINANCIAL MODELS AND CRYPTOCURRENCIES

Attempts to define cryptocurrencies in terms of usual established economic and financial categories led to a discussion to what extent cryptocurrencies are private money. First of all, it is about comparing them with historical examples of means of payment, as well as with Hayek private bank money [17] in the context of

[27] URL: https://bitinfocharts.com/comparison/bitcoin-transactionfees.html (accessed on 23.09.2019).

[28] See Bank of Canada, Bank of England. *Cross-border Interbank payments and Settlement. Emerging opportunities for digital transformation.* November 2018. A detailed discussion of central banks digital currencies is beyond the scope of this paper.

[29] Bank of America, Merrill Lynch, BCS Information Systems, Credit Suisse, DBS Bank, HSBC, J.P. Morgan, Mitsubishi UFJ Financial Group, OCBC Bank, R 3, Singapore Exchange, and UOB Bank. *The future is here. Project Ubin: SGD on Distributed Ledger*. 2017.

*Table 2*

**Comparative analysis of Hayek money and cryptocurrencies**

| | Hayek money | Cryptocurrencies |
|---|---|---|
| Currency issuance | Centralized | Decentralized |
| Is it anyone's obligation? | Commercial issuing bank's | No |
| Currency deissuance | Possible | Depends on protocol |
| Interest rate | Yes | Not at the moment, since the relevant credit and deposit operations were not distributed |

*Source:* compiled by the authors.

the potential crowding out of state money with "private" ones[30].

Hayek wrote this work when reducing inflation was an acute problem and, according to Hayek, could not be solved due to the seigniorage the authorities resorted to. The author believed that the regulation of monetary issuance leads to loss of efficiency of the monetary system, and that currency should be considered an ordinary commercial product and produced in a competitive (market) way. In the result of the competition, there will remain only the currencies that will best fulfill the functions of money, i.e. serve as a means of payment and store their value in time. *Table 2* compares Hayek money and cryptocurrencies. It is clear that they formally represent different economic phenomena, mainly due to the fact that most cryptocurrencies are no one's obligation, unlike the money of private commercial banks.

According to formal definitions of cryptocurrencies, as well as to what we see in practice, cryptocurrency is no one's obligation. Nevertheless, some private digital currencies have appeared on the market (also called cryptocurrencies by their issuers), and their exchange rate is fixed in some national currencies. In other words, there are exceptions when a digital currency issuer declares its obligation to exchange digital coins for another asset, e.g. the US dollar. Cryptocurrencies that have some kind of guarantee regarding the price volatility are called stablecoins. Centralized stablecoins are cryptocurrencies with a central issuer that is involved in the production of crypto tools and the storage of their security in their accounts. These currencies can be divided into two groups:

1. Guaranteed by fiat currency.
2. Guaranteed by any traded goods or asset (meaning exchange goods).

There are also so-called decentralized stablecoins. These are cryptocurrencies guaranteed by another cryptocurrency (non-fiat currency or an asset, as discussed above).

## NEW MONETARISM, ECONOMICS OF PAYMENTS AND CRYPTOCURRENCY

We reviewed the discussion regarding the economic nature of cryptocurrencies and crypto assets. The question comes up whether there are any formal models explaining potential benefits and consequences of using cryptocurrency? Today, there are only a few theoretical works and formal models describing the behavior of cryptocurrency and the cryptocurrency market. The reason for this is that traditional

[30] Speaking of historical examples of private money, we mean, for example, debt receipts in China of the X–XII centuries, money secured by silver in Japan of the XV–XVI centuries, banknotes in the form of receipts confirming the deposit of metal money in Europe (Venice, Holland) XVII century. Crowding out central bank money by private money is based on the idea that inflation, due to coin corruption or seigniorage, reduces the purchasing power of state money and discredits it. One of the most striking examples of mass corruption of coins and high inflation is the XVII century coin crisis in central European countries located on the territory of modern Germany, called "Kipper- und Wipperzeit" (literally "Tipper and See-saw time"). For more information on the origin of paper money and central banks, see work [18].

economic theory does not have the tools necessary to work with cryptocurrencies. The only theoretical exception that analyzes cryptocurrencies within strict models is the new monetarist approach, and specifically one of its sectors, the economics of payments[31].

In his work [23], Waknis built a dual currency version of Lagos & Wright money search model [24]. His goal was to answer the fundamental question of monetary theory: whether currency can be efficiently provided by private competitive money suppliers[32] and whether competitive money supply is more efficient than a monopoly? This is an important issue both theoretically and practically due to the recent emergence of various financial instruments and cryptocurrencies, which can serve as a means of payment and to some extent savings, i.e. potentially act as money. The competition between these instruments raises the question of an effective way to conduct transactions and the best monetary policy in the world with a competitive money supply. Waknis presented a model with a centralized market as an infinitely repeating game between a long-lived player (suppliers of money) and a short-lived player (continuum of agents).

There are two sub-periods:

1. A day sub-period where special goods are traded in a decentralized market. The decentralized market is characterized by trading frictions and hence money gets valued for the liquidity services it provides.

2. A night sub-period where a general good is traded in a centralized Walrasian market. The night trading is anonymous and is used by agents to trade in the general good and rebalance their portfolios.

The economy is characterized by imperfect memory and record keeping to rule out credit transactions[33]. To describe the equilibrium we begin by describing the value functions, taking as given the terms of trade and distribution of monies. The state variables for the individual include his real money balances and a vector of aggregate states and the growth rates of currency $R$ and $B$ respectively; $\phi^R$ and $\phi^B$ are the value of money in currency R and B respectively, in the centralized market[34]. The value functions of agents depend on their entry into two existing markets: centralized and decentralized. Value functions also depend on standard "search and coincidence" parameters: a probability of a meeting, a single coincidence meeting, and and that of a barter exchange.

There are two monetary authorities, BankR and BankB issuing R and B currency respectively. New money is issued by the money suppliers in the centralized market to consume the general good[35]. The author models the choice of monetary growth rate under no commitment as an infinitely repeated game. Because the short lived player optimizes myopically i.e., is concerned only with optimizing current period consumption and the money that it carries out of the centralized market — it always plays Nash response and hence the equilibrium outcomes lie on its best response function. As the money suppliers' are long run players, utility maximization amounts to choosing the money growth rate to maximize the average discounted payoff.

In the centralized market, the game is modelled as dynamic with two money suppliers, maximizing their utility, and a continuum of economic agents. The author showed that the Nash equilibrium in a static game gives the highest inflation tax, similar to the case with one issuer of money in the work by Waknis [27]. In the general case of infinitely repeated games, there are multiple equilibria. The competition between money suppliers and the fact that agents play only Nash responses transforms the centralized market game to a dilemma between the two money suppliers.

[31] For more details, see works by Williamson S. and Wright R. [19, 20], and by Nosal E. and Rocheteau G. [21, 22].

[32] In this case, private competitive money supplier include cryptocurrency suppliers.

[33] For more details, see Kocherlakota [3] and Wallace [25].

[34] It represents the units of general good that be bought by one unit of the respective currency in the centralized market.

[35] A privilege derived from access to record keeping technology [26].

If both the money suppliers are patient enough, then the equilibrium with lowest inflation tax (cooperative equilibrium) is weakly renegotiation proof, implying that currency competition is likely to generate a low inflationary outcome. This means that there are conditions under which competition between monies is preferable because it can lead to low inflation, which is in line with Hayek's ideas discussed earlier.

## CONCLUSIONS

The aim of this work was to write both a comprehensive and an exhaustive review disclosing the essence of cryptocurrencies, their functions, as well as the problems and benefits associated with their use. Special attention was paid to the technological basis of cryptocurrency issuance, since the features of issuance protocols are the starting point for discussing substantive issues related to the functioning of cryptocurrencies.

Despite the lack of a single definition and understanding of the essence of cryptocurrencies in the literature, the analysis allows us to make the following conclusions. First, cryptocurrencies do not satisfy all the characteristics of money and assets. Second, cryptocurrencies today are speculative assets that partially fulfill the function of a means of payment. Third, cryptocurrencies can have significant development prospects in terms of making payments, storing and transmitting information, primarily due to the innovative technology on which they operate.

Despite their limitations (some cryptocurrencies currently do not have technical solutions) and "internal" reliability of the cryptocurrency payment system, cryptocurrencies are of significant interest not only to investors, the public, but also to monetary policy authorities. The reason is that making payments by distributed ledger technology can reduce transaction costs and has an inbuilt function of transmitting and storing information. The growth in demand for crypto payments led to a situation where not only commercial, but also central banks consider issuing their own digital money.

The main condition for trust in any currency, including cryptocurrency, and its widespread use by agents is the stability of its purchasing power (for more details see [28]). Although the analysis based on formal models shows that under certain conditions suppliers of private money adhere to issuing methods leading to low inflation, the very nature of cryptocurrencies contradicts the idea of centralized responsibility for the financial system. Thus, cryptocurrencies cannot be regarded as a replacement for the existing monetary system, at least for now.

## ACKNOWLEDGMENT

The authors are grateful to the referee for valuable comments and suggestions.

## REFERENCES

1. Preneel B. The first 30 years of cryptographic hash functions and the NIST SHA-3 competition. In: Pieprzyk J., ed. Topics in cryptology — CT-RSA 2010. The 10th Cryptographers' track at the RSA conference (San Francisco, CA, 1–5 March, 2010). Berlin, Heidelberg: Springer-Verlag; 2010:1–14.
2. Mazières D. The stellar consensus protocol: A federated model for internet-level consensus. Stellar Development Foundation. 2015. URL: https://www.stellar.org/papers/stellar-consensus-protocol.pdf
3. Kocherlakota N. Money is memory. *Journal of Economic Theory*. 1998;81(2):232–251. DOI: 10.1006/jeth.1997.2357
4. Cheah E.-T., Fry J. Speculative bubbles in Bitcoin markets? An empirical investigation into the fundamental value of Bitcoin. *Economics Letters.* 2015;130:32–36. DOI: 10.1016/j.econlet.2015.02.029
5. Ciaian P., Rajcaniova M., Kancs A. The digital agenda of virtual currencies. Can BitCoin become a global currency? *Information Systems e-Business Management*. 2016;14(4):883–919. DOI: 10.1007/s10257–016–0304–0

6. Hayes A. The decision to produce Altcoins: Miners' arbitrage in cryptocurrency markets. *SSRN Electronic Journal*. 2015. DOI: 10.2139/ssrn.2579448
7. Hayes A. Cryptocurrency value formation: An empirical study leading to a cost of production model for valuing Bitcoin. *Telematics and Informatics*. 2017;34(7):1308–1321. DOI: 10.1016/j.tele.2016.05.005
8. Sovbetov Y. Factors influencing cryptocurrency prices: Evidence from Bitcoin, Ethereum, Dash, Litcoin, and Monero. *Journal of Economics and Financial Analysis*. 2018;2(2):1–27. DOI: 10.1991/jefa.v2i2.a16
9. Liu Y., Tsyvinski A. Risks and returns of cryptocurrency. *SSRN Electronic Journal*. 2018. DOI: 10.2139/ssrn.3226952
10. Dyhrberg A. H. Bitcoin, gold and the dollar — A GARCH volatility analysis. *Finance Research Letters*. 2016;16:85–92. DOI: 10.1016/j.frl.2015.10.008
11. Carpenter A. Portfolio diversification with Bitcoin. *Journal of Undergraduate Research in Finance*. 2016;6(1):1–27. URL: https://jurf.org/wp-content/uploads/2017/01/carpenter-andrew-2016.pdf
12. Huberman G., Leshno J., Moallemi C. Monopoly without a monopolist: An economic analysis of the bitcoin payment system. Bank of Finland Research Discussion Paper. 2017;(27). URL: http://ipl.econ.duke.edu/seminars/system/files/seminars/1874.pdf
13. Easley D., O'Hara M., Basu S. From mining to markets: The evolution of bitcoin transaction fees. *Journal of Financial Economics*. 2019;134(1):91–109. DOI: 10.1016/j.jfineco.2019.03.004
14. Abadi J., Brunnermeier M. Blockchain economics. Centre for Economic Policy Research. CEPR Discussion Papers. 2018;(13420). URL: https://scholar.princeton.edu/sites/default/files/markus/files/blockchain_paper_v3g.pdf
15. O'Dwyer K., Malone D. Bitcoin mining and its energy footprint. In: 25th IET Irish signals & systems conf. 2014 and 2014 China-Ireland int. conf. on information and communications technologies (ISSC 2014/CIICT 2014). (Limerick, Ireland, 26–27 June 2014). Limerick: University of Limerick; 2014:262–268. URL: http://karlodwyer.com/publications/pdf/bitcoin_KJOD_2014.pdf
16. Huttner B. Quantum threats and possible solutions for blockchains and digital currencies. In: World Summit on the Information Society Forum (WSIS Forum). Session 304: Central Bank issued digital currency: Challenges for security and interoperability. (Geneva, 19–23 March, 2018). 2018:19–23.
17. Hayek F. Denationalization of money — The argument refined: An analysis of the theory and practice of concurrent currencies. London: The Institute of Economic Affairs; 1976. 146 p.
18. Moiseev S. History of central banks and paper money. Moscow: Veche; 2015. 536 p. (In Russ.).
19. Williamson S., Wright R. New monetarist economics: Models. In: Friedman B. M., Woodford M., eds. Handbook of monetary economics. Amsterdam: North Holland; 2010;3A:25–96.
20. Williamson S., Wright R. New monetarist economics: Methods. Federal Reserve Bank of Minneapolis. Research Department Staff Report. 2010;(442). URL: https://www.minneapolisfed.org/research/sr/sr442.pdf
21. Nosal E., Rocheteau G. The economics of payments. Federal Reserve Band of Cleveland. Policy Discussion Paper. 2006;(14). URL: https://www.clevelandfed.org/en/newsroom-and-events/publications/discontinued-publications/policy-discussion-papers/pdp-0614-the-economics-of-payments.aspx
22. Nosal E., Rocheteau G. Money, payments, and liquidity. Cambridge, MA: The MIT Press; 2011. 504 p.
23. Waknis P. Competitive supply of money in a new monetarist model. Munich Personal RePEc Archive. MPRA Paper. 2017;(75401). URL: https://mpra.ub.uni-muenchen.de/75401/1/MPRA_paper_75401.pdf
24. Lagos R., Wright R. A unified framework for monetary theory and policy analysis. *Journal of Political Economy*. 2005;113(3):463–484. DOI: 10.1086/429804
25. Wallace N. Whither monetary economics? *International Economic Review*. 2001;42(4):847–869. DOI: 10.1111/1468–2354.00137
26. Fernández-Villaverde J., Sanches D. Can currency competition work? NBER Working Paper. 2016;(22157). URL: https://www.nber.org/papers/w22157.pdf

27. Waknis P. A Leviathan central bank: Modeling Seigniorage in a money search model. *Economics Letters*. 2014;125(3):386–391. DOI: 10.1016/j.econlet.2014.10.027
28. Schnabel I., Shin H. Money and trust: Lessons from the 1620s for money in the digital age. BIS Working Papers. 2018;(698). URL: https://www.bis.org/publ/work698.pdf

## ABOUT THE AUTHORS

***Elena V. Sinel'nikova-Muryleva*** — Can. Sci. (Econ.), Senior Researcher, Institute of Applied Economic Research, Russian Presidential Academy of National Economy and Public Administration (RANEPA), Moscow, Russia
el.sinelnikova@gmail.com

***Kirill D. Shilov*** — Researcher, Institute of Applied Economic Research, Russian Presidential Academy of National Economy and Public Administration (RANEPA), Moscow, Russia
shilovkd@gmail.com

***Andrei V. Zubarev*** — Can. Sci. (Econ.), Senior Researcher, Institute of Applied Economic Research, Russian Presidential Academy of National Economy and Public Administration (RANEPA), Moscow, Russia
texxik@gmail.com

***Authors' declared contribution***:
Sinel'nikova-Muryleva E.V.— articulation of the issue, development of the concept of the article, critical analysis of the literature, logical structuring of the material, drawing conclusions.
Shilov K.D.— collection of statistical data, tabular and graphical presentation of the results, drawing research conclusions.
Zubarev A.V.— research concept development, drawing research conclusions.

*The article was submitted on 08.10.2019; revised on 22.10.2019 and accepted for publication on 28.10.2019. The authors read and approved the final version of the manuscript.*

ORIGINAL PAPER



DOI: 10.26794/2587-5671-2019-23-6-50-62
UDC 330+338(045)
JEL B410, E110, E660, F200, O100, O200

# Digital Property and New Economic Relations

**O.N. Grabova**[a], **A.E. Suglobov**[b]
[a] Kostroma State University, Kostroma, Russia;
[b] Financial University, Moscow, Russia
[a] https://orcid.org/0000-0003-3542-1764; [b] https://orcid.org/0000-0003-1860-6783

## ABSTRACT

Modern economic relations are developing under the influence of digital property that creates conditions for unprecedented socialization of production and new realities in the relations of appropriation and alienation. This requires both theoretical interpretation and practical research. The aim of the article is to identify current trends in the development of digital property and the new economic relations that it forms in the world, to systematize the conditions for digital property in Russia. The authors used the findings of institutional and evolutionary economic theories, political economy, as well as the principles and methods of SWOT-analysis in order to systematize the issue. The paradigm of the development of Russia should be changed from consumption to production of innovative products and technologies of the digital economy. The paper presents the essential characteristics of digital property and a model of the influence of the digital economy and global integration on modern economic relations. Potential opportunities for the economic development in the system of new economic relations were identified due to the SWOT-analysis of the conditions for the development of digital property in Russia. At the same time, endogenous institutional and target restrictions on the development of the digital economy in Russia (as weaknesses), as well as exogenous restrictions in the form of threats were specified. The authors found the strategic modeling of systems engineering education as a long-term basis for the development of the digital economy necessary. The research results can be used in developing national programs.

***Keywords:*** property; economic relations; institutes; digital economy; economic structure; national economy; global economy

***For citation:*** **Grabova O.N., Suglobov A.E. Digital Property and New Economic Relations. *Finance: Theory and Practice.* 2019;23(6):50-62. DOI: 10.26794/2587-5671-2019-23-6-50-62**

## INTRODUCTION

Developing digital economy and new technologies of the fourth industrial revolution is rapidly creating a qualitatively new environment in almost every area of life. According to the laws of dialectics, quantitative changes — mainly in software, computer technology and Internet communications — quickly switched to qualitative changes predetermining innovative products in the real sector (material and information, including through the active integration of these sectors), and also developing new business technologies and new technologies in the public sector. This leads to the realization that the humanity has found itself in a new era where countries are enormously integrated and connected and, at the same time, they are divided, not for technical reasons, but because of deep economic contradictions.

## RESEARCH THEORY AND METHODOLOGY

The digital economy itself is still being comprehended [1, 2]; its main development indicators[1] are identified, the resource of digitalization in the real, financial and public sectors, as well as the management of the digital future are under study [3]. Rigorous research have been made to check if Russia is ready for the challenges of the digital revolution [4] and

[1] Abdrakhmanova G.I., Gokhberg L.M., Dem'yanenko A.V., D'yachenko E.L., Kovaleva G.G., Kotsemir M.N., Kuznetsova I A., Ratai T.V., Ryzhikova Z.A., Strel'tsova E.A., Fridlyanova S. Yu., Fursov K.S. Digital economy: a brief statistical digest. M.: HSE; 2018. 96 p.

negative externalities [5, p. 38–40]. The works by I.G. Salim'yanova and A.S. Pogorel'tseva [6, 7] presented the detailed analysis of the digital economy from the perspective of institutional theories.

The main primary aim of developing innovative technologies is accelerated economic growth. It requires rethinking of Keynesian and neoclassical models of economic growth from the perspective of a new wave of "industrial" revolution. In this regard, the research by some outstanding scientists should be noted: J.R. Hicks suggested that innovations (technical changes) can be interpreted as shifts in the production function; R. Solow believed that the main factor in dynamics and long-term economic growth is technological progress; J. Schumpeter gave pride of place to innovations, but behind the innovations he saw entrepreneurs whose actions cause economic growth influenced by new combinations of factors of production; P. Romer considered growth in R&D investment and investment in human capital as the main factor in economic growth. Prognostic development models are based on these theories, confirming the importance of innovative factors [8].

Analyzing the discussions and the economy digitalization, we have revealed the dominance of a technocratic approach (everybody speaks about technology, artificial intelligence, neural networks, distributed ledger systems, blockchain, Internet commerce, etc.), while the significance and essence of economic relations are leveled out. Nowadays, a balance and integration of various approaches in solving the problems of the digital economy is needed more than ever: economic, managerial, engineering ("technocratic") and legal [9]. (The significance of these approaches is not determined by this listing order).

At the same time, revealing the essential characteristics of modern phenomena and processes based on economic theory, primarily political economy and evolutionary and institutional synthesis, is very significant, but often refused. Namely, the development of new economic relations is not observed for all digitalization processes. The non-mythic nature of economic relations and their asymmetric development regarding institutions is proved by a vivid example of the cryptocurrency market not institutionalized (by law) in Russia. Noting endogenous institutional changes as a reflection of social dynamics is not enough [10]. It is important to consider the interaction of institutions and economic relations, whose core are property relations. As an ever-increasing part of the real economy, the digital economy transforms its internal ties and relationships and will have an impact on applied economic sciences. For example, those related to the analysis of big data, accounting, taxation, moving information technology finance, new management models due to changes in transaction models, etc. However, studying the impact of the digital economy (as part of the real economy) on economic theory, or rather, their dialectical relationship is important for us. We see the potential in evolutionary and institutional theory and political economy that explores economic relations. At the same time, we do not neglect the study of economic behavior, individual phenomena, and the phenomena as the basis of a positive analysis demanded by the positive economy. However, by isolating individual phenomena, this approach tears the problem apart and sometimes leads away from the systemic vision. Sometimes the article will present the subject to the detriment of a positive detailed analysis; sometimes there will be an expert opinion, based on a comprehension of real facts, trends and the methodology provided by political economy. The methodology is about developing productive forces aided by economic (production) relations. The evolutionary and institutional theory also speaks of the significance in the systemic vision of the essence of economic phenomena — institutions of different levels and temporary effects.

## RESULTS AND DISCUSSION

In general, the digital economy is the economy of technical innovations that become the driver for development in all areas of the economy. At the same time, they embrace new innovative resources and become accelerators in the economies of countries with these resources. This does not contradict official approaches. The program "Digital Economy of the Russian Federation" (approved by the Government of the Russian Federation in its resolution No. 1632-r dated July 28, 2017) suggests that the digital economy is markets and industries, platforms and technologies, and the environment (normative regulation, information infrastructure and personnel) where economic agents carry out economic activities. Its key factor of production is digital data. We emphasize that behind all the technologies in the digital sphere, one should recognize the owners of new digital resources who build new economic relations by their means. An essential study of these relations will provide a synthesis of evolutionary and institutional theories (*Fig. 1*) [11].

Economic relations formed under the influence of economic interest [12] are reflected in institutions, and the viability of the ideas [13] is refracted through economic relations.

Unfortunately, Russia's role here is not significant, since it is neither a dominant owner, nor a manufacturer of modern digital products, programs or technologies. Due to digital technologies and paralleling various sanctions, Russia is imposing the role of a raw materials appendage: we are increasingly absorbing imported digital products (of various origin, Chinese or American-Chinese production) in exchange for non-renewable (or restored over a period longer than human life) resources: oil, gas, forest, etc. It must be admitted that Russia is trying, but cannot change the paradigm of raw materials development to the paradigm of the producer of new innovative (and, above all, digital) products. Russia still consumes innovative products (in exchange for natural resources), but practically does not create new ones. Institutions (formal and informal) fail to change the development paradigm of Russia.

A new production socialization level and new factors creating profit predetermine the need to reveal the essential characteristics of modern phenomena and the processes, based on building new economic relations under the influence of new digital property. At the same time, digital property is a new asset that creates value based on innovative IT products. They include integrated products combining the developments in IT and other real sectors, and corresponding to the new technological structure. Active digital property in innovative industries is presented by ownership of the means of production, technology, IT products (programs, databases, information media), and passively — as registered (patented) intellectual property. This property is involved primarily in economic relations in the production process, and as a consequence, in the processes of exchange, consumption and distribution. It is the production of innovative products of the digital economy that determines the legal owner, having all main authorities: ownership, use and disposal, and which is the main beneficiary — profit. At the same time, these authorities may undergo significant transformations. In this regard, the idea of "economic relations between machines" and "relations" with artificial intelligence comes up inadvertently (or nevertheless intentionally) [5, p. 132, 145]. The question arises: is it so not to see the owners behind machines and technologies? New digital technological ways are building new global value chains, whose management is theoretically justified now [14].

The study relies on the SWOT analysis, since the SWOT analysis emphasizes the tough competitive environment for developing digital property. We did not place this approach in the theory and methodology section, as it is only a way of structuring the problem, possibly controversial. However, striving for normative analysis, we believe that the SWOT

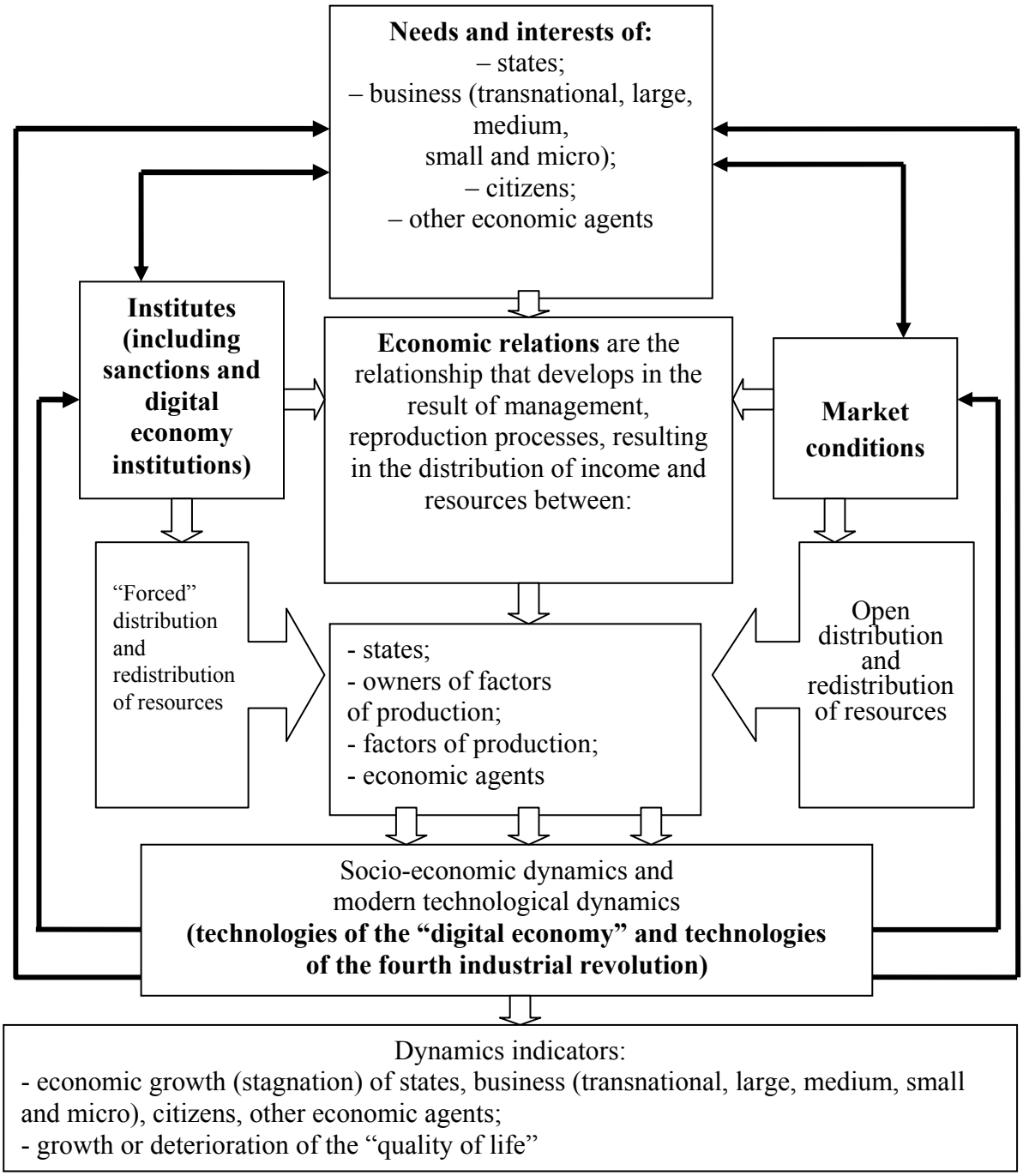



*Fig. 1.* **Influence of the digital economy and global integration on modern economic relations**

*Source:* developed by the authors.

analysis allows revealing possible ways of development and overcoming negative trends (see *Table*).

## WEAKNESSES

— The digital economy development paradigm in Russia is consuming, rather than producing; the main software products, technological and material resources are not of Russian origin. The consuming paradigm can bring a short-term effect, in theory regarded as a "middle-income trap" [15–17].

— In formal institutions, this paradigm is settled (indirectly) as a normative regulation of the digital economy development of Russia. The programs are more focused on developing

*Table*

**Analysis of the conditions for the development of digital property in Russia**

| Weaknesses | Threats |
|---|---|
| 1. Inadequate digital economy development paradigm | 1. Overconcentration of digital property in certain countries and its "self-growth" |
| 2. Regulatory documents for the digital economy development oriented to resource development | 2. Well-established partnerships between the main players in the digital market |
| 3. Informal institutions: "career growth, and not the realization of a person's creative potential" | 3. "Part dependence" effect |
| 4. Emasculation of a scientific systemic approach in the educational process | 4. Profit growth due to after-sales service of software (and other innovative) products |
| 5. Minimum amount of digital property | 5. Intellectual property protection institute, in-house privacy policy |
| 6. Inefficiency of state innovation projects in the real sector and institutions of responsibility | 6. "Brain drain" |
| Strengths | Opportunities |
| 1. Consolidating leader and political will | 1. Development of educational potential and building an "engineer of the future" model |
| 2. Institutional framework for the development of the producing digital economy | 2. Prestige of an engineer in society |
| 3. Initial consuming phase as potential | 3. Active state support for effective domestic companies that have realized themselves in the digital economy market |
| 4. Examples of successful implementation of digital technologies in government agencies | 4. "Innovation responsibility centers" and the "institute of responsibility" of state managers |
| 5. "Innovation growth points" of the producing digital economy | 5. Prioritizing the development of the producing digital economy |
| 6. Domestic education system, priorities in financing science and grant support for scientists | 6. Recruiting leading engineers |

*Source:* developed by the authors.

resources, rather than achieving breakthrough results in the form of innovative products and technologies. The expert group of the Financial University concluded that these forecast indicators of the socio-economic development of the Russian Federation do not correspond to the implementation of breakthrough scientific, technological and socio-economic development of the Russian Federation, including the priorities, potential and tools for the digitalization development in the real sector [18].

— Informal institutions and real economic relations develop youth guidelines not to realize themselves as a creator, especially in high tech, but to build a career, mainly in management; the contemporary ideals of a successful life are the career of a top manager as a Russian dream.

New educational standards FSES 3 ++ in engineering for postgraduates, the normative documents, reinforce the position that managerial competencies are of a higher level than the technical ones. Here come prioritizing of education and constructing a model of a future economy that has no future. There are strong incentives for engineers to leave the profession. They are preserved after the university. Leadership and building a manager's career are an imposed (or not imposed?) ideology, which should be opposed by the idea of professional development and self-realization (not only in the engineering, but also at this stage of world development; this is especially sensitive for this sphere).

— Introducing the competency-based approach in Russian education system used to be and is now based on emasculating the knowledge-based approach; the ultimate goal as a competence — is a form, not the essence, of the educational process. Ultimately, this adversely affects the development of the real sector and advanced technologies. The new economy (postindustrial, informational) was initially presented as a knowledge economy (rather than a competency economy), and this was a more accurate definition that reflected the importance and priority of intellectual capital at the present stage of world development. Science itself is a certain system of knowledge that cannot be replaced by a set of competencies. Integrating a competency-based and knowledge-based approach in the education system will allow Russia to overcome the trend of Western digital technology consumption and move to the economic development paradigm of Russia as a producer and, possibly, eliminating prohibitive barriers and sanctions — as an exporter of these technologies. This is especially significant in educating engineers (including IT engineers).

— Contemporary institutions and economic relations insufficiently promote investments in digital property in the form of intellectual property (regulated by patent law), implemented technological projects, software products, high-tech products and other components that characterize and are a condition for the development of technologies of the fourth industrial revolution (as well as subsequent "waves"). As a result, the minimum size of "producing digital property" does not contribute to its concentration. Therefore, Russia does not have a large sector or integrated "digital clusters" in the economy ("producing digital clusters") with a stable financial, material and human potential that would determine the innovative digital area of the development of the domestic economy.

— In Russia, we are witnessing the inefficiency and sincerity of corporations and structures funded by the state, called to be drivers for the development of digital technologies. (Although in this case, efficiency could be interpreted not only from the perspective of traditional economic indicators, but as dominance, capturing of the market (for the medium term). All these projects demonstrate the development of resources, and not the creation of innovative products and technologies that correspond to the new technological structure. In addition, these corporations are focused not on research-based effective projects, but on a management class formation, the main recipient (consum-

er) of the resources. Moreover, the inefficient management is relayed to higher education as the "best practice".

## THREATS

— The concentration of digital property in companies with a specific country affiliation is increasing in the world. If the large property of the banking sector, pharmaceutical, energy companies is scattered around the world [for example, in the automotive industry — these are Ford (USA), Toyota (Japan), Volkswagen (Germany), Hyundai (South Korea), Volvo (Sweden), etc.], digital property demonstrates the implementation of a successful strategy to capture the market between the two countries. The annual report by former Morgan Stanley analyst and well-known venture investor Mary Meeker shows the largest technology digital companies in the world and their level of capitalization: all the 20 leaders from the USA and China, their total capitalization is $ 5.9 trillion. [To compare, the revenue part of the Russian budget in 2018 was 15.26 trillion rubles, including oil and gas revenues — 5.48 trillion rubles, not dollars. Accordingly, based on the weighted average dollar exchange rate for 2018 (62.7078) — 0.243 trillion dollars and 0.087 trillion dollars]. At the same time, 75% of the cost is US digital property, and 25% is the property of Chinese companies. The leading six companies (out of 20) account for 81% of the total market capitalization of the rating (incredible concentration of property!). These are American companies Apple, Alfabet, Amazon, Microsoft and Chinese companies Tencent and Alibaba 2. Microsoft demonstrates the following financial indicators: capitalization — exceeded $ 1 trillion; the revenue and the net profit for 2018 were 125.8 and $ 39.24 billion (110.4 and 16.57 — for the previous period) 3. Interfax also reports that Microsoft's activity (property) is developing due to the revenue from the sale of software products (including for servers), the sale of cloud services; the revenue from professional networks and advertising in search engines is growing.

— Leading companies in the digital market rely in their development on well-established partnerships allowing them to maintain monopoly in the long term; moreover, the connections and the cooperation have an economic effect.

— There is a "part dependence" effect (dependence on the previous development path) in any technology, including digital technologies. It happens if this technology is built-in and acts in the way that the rest resources and the whole system can no longer work without it, since these resources had been mutually tuned before. Removing or replacing a high-tech product is almost impossible, only improving based on compatibility with the elements of the entire system is possible. That is, the creation of an innovative product involves either embedding it in an existing system, or requires building a new system for the product, which implies direct investment, as well as investments in setting up the entire system, including staff training. Therefore, the technology, the system and the high-tech product are parts of the property predetermining economic relations in already established markets and the behavior of the main owners of this digital property. The dominance and monopolization of these markets (as well as associated markets) will be supported due to this effect.

— Most digital products sold require after-sales service. Any software product, unlike a non-digital product, has a unique property — improvement, updating, and therefore, after it is sold, its service will be sold for a long time. Due to this, the digital content producer has constant resources for its own development. In the real sector (mainly the oil and gas), when transiting to market relations, foreign ERP software (production enterprise resource management system) was introduced. Its an-

[2] URL: https://bcs-express.ru/novosti-i-analitika/top-20-krupneishikh-tekhnologicheskikh-kompanii-mira) (accessed on 25.11.2019).

[3] URL: https://www.interfax.ru/business/669682 (accessed on 25.11.2019).

nual maintenance amounts to 20% per year of the initial product cost. It demonstrates the economic growth of digital property due to this resource.

— The intellectual property protection institute, an in-house privacy policy — all this will work against Russia in the long term if Russia does not become the legal owner of intellectual and digital property, at least in certain breakthrough directions.

— Moreover, there remains the threat of a "brain drain", as part of the youth do not see prospects for realizing their own potential.

Strengths and opportunities are the support and the prospects possessed by Russia to take its rightful place in the global economy, where it will have competitive advantages in the new economic structures.

## STRENGTHS

— For Russia, it is important to have a consolidating leader when developing a producing digital economy. There is a political will towards the priority development of the latest technologies.

— Institutional framework for the digital economy development has been created. The basic regulatory documents are: the state program "Information Society for 2011–2020" 4, the program "Digital Economy of the Russian Federation" 5, the strategy of the information society development in the Russian Federation for 2017–20306. It is important that intellectual property protection institutions have been built.

— The initial consuming stage of digital achievements in various fields (including in the real sector, which constitutes the previous technological order, in the nascent and developing companies of the new fourth industrial revolution, in the public sector, in the banking sector and in education) is a necessary potential and condition for the emergence of a new manufacturing digital property;

— There are good examples of successful introduction of digital technologies in government agencies — in the Federal Tax Service, as well as the Central Bank of the Russian Federation and Sberbank of Russia — but these are not producing sectors and not the real sector of the economy.

— The so-called "producing" digital property in Russia is the active and powerful development of domestic companies in the field of software development, primarily for the domestic market): for automation of management, accounting and tax accounting and control (this property is developed mainly within national borders).

— The system of domestic education retains its potential. However, this strength has its flaws, which can transform it into a weakness. In addition, a system of grant support for scientists (including young ones) in priority areas has been built. The educational potential of Russia and Russians is the long-term basis for economic development, stability and overcoming crises. This is the intellectual capital enclosed in each person allowing them to adapt and improve in the rapidly changing conditions of the digital economy.

## OPPORTUNITIES

— The education system should be paid special attention so that it does not lose its accumulated potential because of permanent reforms, and indeed, is a strength and source of opportunities for the development of the digital economy. Based on the earlier economic and mathematical analysis (according to the statistics from the regions of the Central Federal District), in particular, we examined the relationship between gross regional product per capita and such an indica-

[4] The state program "Information Society for 2011–2020" was approved by Decree of the Government of the Russian Federation dated 04.15.2014 No. 33 (as amended on 12.30.2018). URL: http://www.consultant.ru (accessed on 06.01.2019).

[5] The program "Digital Economy of the Russian Federation" was approved by order of the Government of the Russian Federation of July 28, 2017 No. 1632-r. URL: http://www.consultant.ru (accessed on 06.01.2019).

[6] The strategy of the information society development in the Russian Federation for 2017–2030 was approved by Decree of the President of the Russian Federation dated 09.05.2017 No. 203. URL: http://www.consultant.ru (accessed on 01.06.2019).

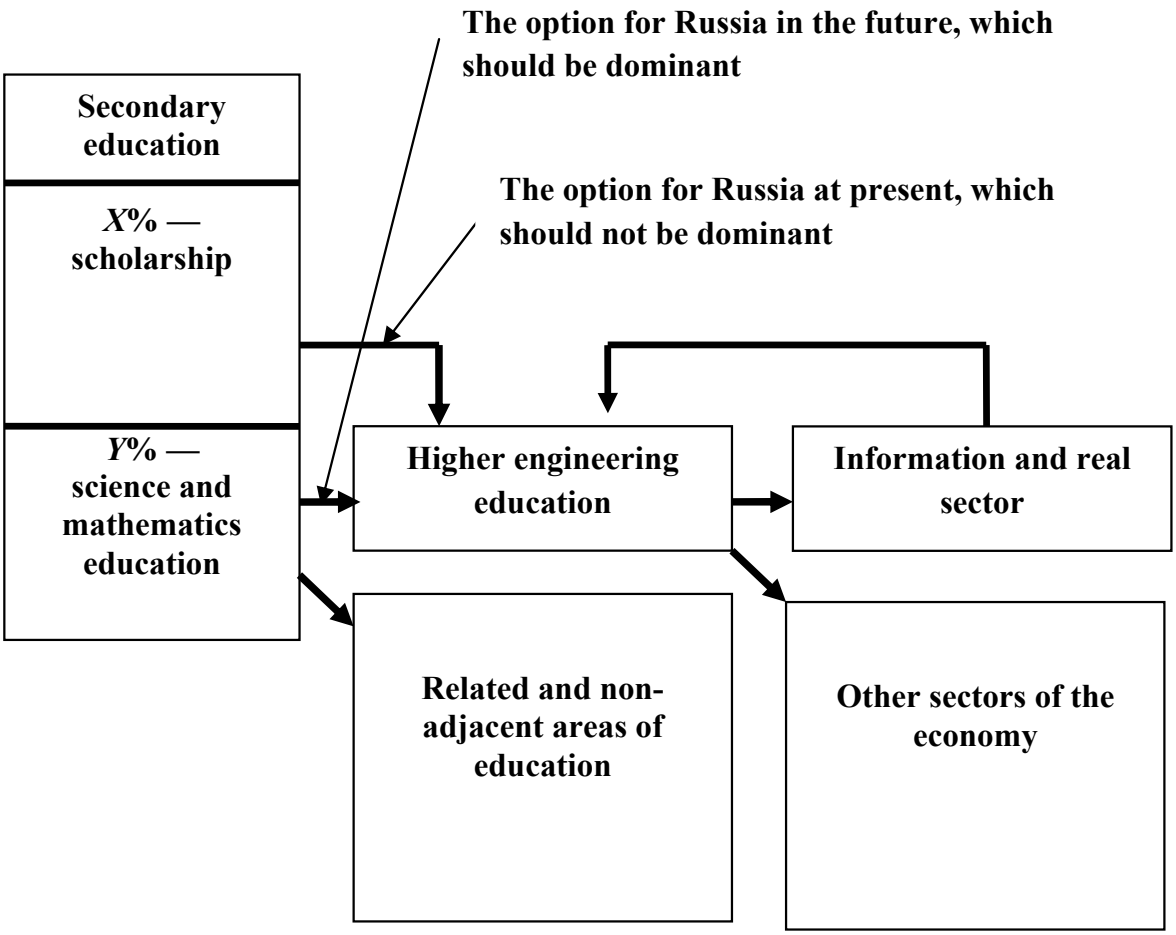



*Fig. 2.* **The model of formation of the "engineer of the future"**

*Source:* developed by the authors.

tor as the proportion of personnel engaged in research and development in the number of economically active population. We revealed an increase in the influence of this factor on gross regional product [9]. In this regard, it is necessary to model the priority for the technical or engineering education system and "nurturing the engineer of the future" at the state level (*Fig. 2*).

In this model (see *Fig. 2*), the focus is on the following main points. First, in the secondary education system, students show different abilities or tendencies in the humanities or exact sciences. However, it is also necessary to create the environment for the future scientific and technical education already in school, due to a very distant ambitious aim to obtain (the education or even training) an "engineer of the future". Developing this environment is that as many students as possible gain real knowledge (the knowledge, not the notorious competencies) in mathematics, physics, chemistry. It is even necessary to determine the percentage of students who should increase their intellectual potential in these scientific fields. Such an environment requires financial resources.

Second, all students with a penchant for exact sciences should definitely get a qualitative higher technical (engineering) education. It is only they who can become the "engineer of the future", an engineer with good school knowledge in the exact sciences, and after the graduation — with mathematical and technical thinking. This type of thinking is demanded by the digital economy (for building, not for managing!). It is formed by small increments; it matures in the result

of qualitative continuous education. Today, for various reasons, individual disciplines in schools are taught at a very low level (for example, physics), so that almost no one passes the exams. As a result, in universities, even state-financed openings in departments that train staff for the digital economy do not have enough applicants.

The nexus between secondary education and higher specialized engineering education is probably the most important. Unfortunately, the prestige of engineering education in Russia (which was in Soviet times!) was lost and the real sector was destructed during the reforms of the 90s and then recovered painfully. Therefore, many students with substantial potential in mathematics, physics, chemistry, are choosing the related fields of education, as well as those completely unrelated to the exact sciences.

Moreover, engineering openings are filled as a residual. First, applicants fill prestigious economic and legal state-financed openings, and the rest apply for engineering openings. These schoolchildren do not have basic solid knowledge in the exact sciences, nor a specific way of thinking. Even the most remarkable teachers are unable to increase their potential to the required level (an individual approach is also impossible due to the limited funding of higher education). Therefore, such scholars will not become "engineers of the future". These are opportunity costs of the digital economy.

Third, we are talking about the digital economy, when Russia should not become a consumer of innovative products and technologies, but a producer. Therefore, we should answer the following questions: what is needed and what knowledge is needed to prepare a "producer" of goods and technologies of the digital economy (big data, neurotechnologies and artificial intelligence, distributed ledger systems, quantum technologies, new manufacturing technologies, industrial Internet, robotics and sensor components, wireless technologies, virtual technologies and augmented reality[7]) technology or the fourth industrial revolution. (According to the classification by C. Schwab [5], digital technologies are: new computing technologies, blockchain and distributed registry technologies, the Internet of things. Transformation of the physical world: artificial intelligence and robots, advanced materials, additive manufacturing and multidimensional printing. Human "transformation": biotechnology, neurotechnology, virtual and augmented reality. Integration of the environment: receiving, accumulating and transmitting energy, geoengineering, space technology). Each technology needs a rigid system of knowledge in higher mathematics, physics, and software technology (based mainly on mathematical thinking).

— Due to certain personnel demands, an appropriate state policy is required, aiming at increasing the prestige of an engineer in society. The importance of social prestige (as informal institutions) should be supplemented by economic factors [19]. Today, the prestige of professions in Russia is determined by the "Russian dream of becoming a top manager", since they suggest the highest salaries. Their extra-profits could somehow be justified if Russian top managers were not involved in large monopolies pumping out natural rents, but, in fact, developed the real and information sector. In this regard, the vision of the digital economy is indicative: for young specialists under 35 years old it is "leadership, innovation", for mature specialists over 36 years old — it is "automation, production, technology, design, unified databases" [4, p. 15]. Mature specialists still see the essence of the digital economy, while young people (new-style managers) may not see anything behind the leadership slogan. Business models are just an add-on that cannot exist without a basis, real digital property.

— In the real sector, one should rely on the innovative companies (already operating

[7] The program "Digital Economy of the Russian Federation" was approved by order of the Government of the Russian Federation of July 28, 2017 No. 1632-r. URL: http://www.consultant.ru (accessed on 01.06.2019).

and producing in the digital economy) that proved their commercial effectiveness. It is necessary to provide them with active state support in the form of tax benefits (they exist, but should be expanded), lowered (minimum or zero) interest rates on loans (O. S. Sukharev provided the mathematical justification [20]), grants, etc.

— A simple financial investment in "innovative" state-owned corporations is inefficient. Therefore, we do not need just innovative centers, but "innovative responsibility centers", with a specific manager responsible for the result in the form of a ready-made and popular, mass innovative (high-tech or software) product on the market. Responsibility centers are one of the elements of the responsibility institution for state managers that should be built. Behind every project and corporation, both unsuccessful and successful, are specific public sector managers who failed or coped with the national aims and objectives.

— Since the digital property of leading manufacturers is large, Russia should prioritize the construction of a producing digital economy that will achieve global leadership in selected areas. An analysis of the critical points of bifurcations, an analysis of competitive advantages, considering the accumulated scientific human and technological potential, are required. After all, there is a turning point for Russia, when the leading countries, having received alternative energy production technologies, will abandon Russian oil and gas, so it makes sense to be the first to receive these technologies. However, we should intensify our efforts in working with leading scientists and engineers.

— "Dos moipu sto, kai tan gan kinaso (give me a foothold and I will turn the Earth): give us specialists and responsible managers and we will build a digital economy," — these words by Archimedes were rephrased to emphasize the importance of intellectual capital for the digital economy. Russia should solve the problem of attracting leading engineers as soon as possible — possibly as owners in new digital industries.

## CONCLUSIONS

The study offers the following main conclusions. The analysis of the new integrated environment for the development of economic relations is predetermined by many factors of socio-economic dynamics and the development of institutions, but the technology of the digital economy and the fourth wave (and new waves) of the industrial revolution become the driver. This problem must be solved at the national and global levels, as well as at the micro level. Unfortunately, Russia does not act as a manufacturer of high information technologies, but only as a consumer. Therefore, at the level of world exchange, Russia has to give up its natural resources in exchange for high-tech products, based on the most important factor in the development of the economy — human capital (in the new waves of the industrial revolution — intellectual capital). A vicious circle may appear if the human intellect of Russia is depleted due to the fact that it was removed from high-tech reproductive processes (these reproductive processes affect not only the economy, but also the education). Leading countries will strive to maintain systemic leadership in the new waves of industrial revolutions. Despite the negative externalities of the digital economy, the importance of this new factor of production can hardly be overestimated, and Russia should undoubtedly increase its participation in this process to improve the competitiveness, the quality of life of citizens (including the quality of educational and intellectual capital), and economic growth and ensuring national sovereignty. In this regard, we justified the need in Russia to move from the paradigm of consumption of products and technologies of the digital economy that have foreign jurisdiction to the paradigm of production of our own innovative products that meet new technological patterns and are able to compete or stay ahead of the competition on the world market.

## REFERENCES


1. Zubarev A.E. Digital economy as a form of patterns manifestation of the development of a new economy. *Vestnik Tikhookeanskogo gosudarstvennogo universiteta = Bulletin of PNU.* 2017;(4):177–184. (In Russ.).
2. Apatova N.V. Digital economy: Main directions of development. Simferopol: Zueva T.V.; 2018. 216 p. (In Russ.).
3. Ageev A.I. Managing the digital future. *Mir novoi ekonomiki = The World of New Economy.* 2018;12(3):6–23. (In Russ.). DOI: 10.26794/2220–6469–2018–12–3–6–23
4. Ageev A.I., Asanova E.A., Glibenko O.V., Remizov M.V., Smirnova V.A. Ready for a digit? Assessing the adaptability of the high-tech complex of Russia to the realities of the digital economy. Final report. Moscow: RAS Institute for Economic Strategies; 2018. 61 p. URL: http://spkurdyumov.ru/uploads/2018/05/To_the_figure_is_ready_Estimation_of_the_adaptability_of_the_Russian_ITC_to_the_realities_of_the_digital_economy.pdf (In Russ.).
5. Schwab K., Davis N. Shaping the fourth industrial revolution. Transl. from Eng. Moscow: Eksmo; 2018. 320 p. (In Russ.).
6. Salim'yanova I.G., Pogorel'tsev A.S. Digital transformation of the economy: An analysis of trends in the context of institutional economic theories (Part 1). *Izvestiya Sankt-Peterburgskogo gosudarstvennogo ekonomicheskogo universiteta.* 2018;(6):7–14. (In Russ.).
7. Salim'yanova I.G., Pogorel'tsev A.S. Digital transformation of the economy: An analysis of trends in the context of institutional economic theories (Part 2). *Izvestiya Sankt-Peterburgskogo gosudarstvennogo ekonomicheskogo universiteta.* 2019;(1):11–17. (In Russ.).
8. Grabova O.N., Sviridov N.N., Kozlova M.A. Factor analysis of the socio-economic development of the regions of the Central Federal District. *Voprosy regional'noi ekonomiki = Problems of Regional Economy.* 2016;(3):22–32. (In Russ.).
9. Su H.-N., Moaniba I.M. Investigating the dynamics of interdisciplinary evolution in technology developments. *Technological Forecasting and Social Change*. 2017;(122):12–23. DOI: 10.1016/j.techfore.2017.04.024
10. DellaPosta D., Nee V., Opper S. Endogenous dynamics of institutional change. *Rationality and Society*.2017;29(1):5–48. DOI: 10.1177/1043463116633147
11. Grabova O.N., Suglobov A.E., Karpovich O.G. Evolutionary institutional analysis and prospects of developing tax systems. *Revista Espacios*. 2018;39(16):40. URL: https://pdfs.semanticscholar.org/851a/5992157c335ad26789039d65056e90446570.pdf.
12. Brezis E.S. Legal conflicts of interest of the revolving door. *Journal of Macroeconomics*. 2017;52:175–188. DOI: 10.1016/j.jmacro.2017.04.006
13. Markey-Towler B. The competition and evolution of ideas in the public sphere: A new foundation institutional theory. *Journal of Institutional Economics*. 2019;15(1):27–48. DOI: 10.1017/S 1744137418000061
14. Erznkyan B.A. Systemic-institutional paradigm of managing organizations of a new technological structure. *Vestnik Kemerovskogo gosudarstvennogo universiteta. Seriya: Politicheskie, sotsiologicheskie i ekonomicheskie nauki = Bulletin of Kemerovo State University. Series: Political, Sociological and Economic Sciences*. 2019;4(1):63–69. (In Russ.). DOI: 10.21603/2500–3372–2019–4–1–63–69
15. Agénor P.-R. Caught in the middle? The economics of middle-income traps. *Journal of Economic Surveys*. 2017;31(3):771–791. DOI: 10.1111/joes.12175
16. Lee J.-D., Baek C., Maliphol S., Yeon J.-I. Middle innovation trap. *Forsait = Foresight and STI Governance*. 2019;13(1):6–18. (In Russ.). DOI: 10.17323/2500–2597.2019.1.6.18
17. Vivarelli M. The middle income trap: A way out based on technological and structural change. *Economic Change and Restructuring*. 2016;49(2–3):159–193. DOI: 10.1007/s10644–015–9166–6
18. Assessment of the forecast of socio-economic development of the Russian Federation for the period 2019–2024. *Finansy: teoriya i praktika = Finance: Theory and Practice.* 2018;22(6):153–156. (In Russ.). DOI: 10.26794/2587–5671–2018–22–6–153–156

19. Taffesse A., Tadesse F. Pathways less explored — Locus of control and technology adoption. *Journal of African Economies*. 2017;26(1 Suppl.): i36-i72. DOI: 10.1093/jae/ejx013
20. Sukharev O. S. Managing the structure of technological development: Risk and "interest portfolio". *Upravlenets = The Manager*. 2019;10(1):2–15. (In Russ.). DOI: 10.29141/2218–5003–2019–10–1–1

## ABOUT THE AUTHORS

***Olga N. Grabova*** — Dr. Sci. (Econ.), Associate Professor, Professor of Department of Economics and Economic Security, Kostroma State University, Kostroma, Russia
graon07@mail.ru

***Aleksandr E. Suglobov*** — Dr. Sci. (Econ.), Professor, Department of Accounting, Analysis and Audit, Financial University, Moscow, Russia
a_suglobov@mail.ru

***Authors' declared contribution*:**
Grabova O. N. — theoretical and methodological justification of the dynamics of digital property, general conclusions and recommendations on the development of the digital economy in the Russian Federation.
Suglobov A. E. — theoretical justification of threats and risks of the digital economy in the strategic system of ensuring economic security of the Russian Federation.

*The article was submitted on 30.09.2019; revised on 14.10.2019 and accepted for publication on 20.10.2019. The authors read and approved the final version of the manuscript.*

ORIGINAL PAPER



DOI: 10.26794/2587-5671-2019-23-6-63-75
UDC 330.322:338.241:001.895(045)
JEL M11

# Financial Management of Innovative Activity

**V.P. Shestak**[a], **E.L. Moreva**[b], **I.G. Tyutyunnik**[c]
[a] National Research Nuclear University MEPhI, Moscow, Russia; [b, c] Financial University, Moscow, Russia
[a] https://orcid.org/ 0000-0003-1358-9486; [b] https://orcid.org/ 0000-0001-6355-7808; [c] https://orcid.org/ 0000-0003-0992-0666

## ABSTRACT

Increasing investment activity is a key problem for Russia. Despite many state's efforts, investment activity is low. The aim of the article is to propose an innovation management method based on a systems approach. The main objective of the research is to find an effective approach to optimizing state efforts to enhance financial management of innovative activity. The research methodology is based on the analysis of the enterprise closed innovation system. Economic and mathematical methods are used to represent the management function as an operator equation of the first kind. This allows to create a control algorithm to maximize the effectiveness. The methods of computational diagnostics and tomographic economics are used for the element-by-element analysis of the subsystems of the innovation system. The information base for the study was publications concerning the theory of management and business management. The possibility of applying computational diagnostic methods to optimize the financial management of innovation activity was proved by separating the controlling and controlled subsystems of the enterprise innovation system and observing all laws of production. A form of control functional was obtained on the sets of observable characteristics of the controlling and controlled subsystems while optimizing the results of innovative activity due to the feedback channel. The results of the study may be of practical interest for innovative projects in order to transfer the enterprise to innovative development, in particular, in relation to the restructuring of organizational structures and institutional support in the digital economy format.

***Keywords:*** financial management; financial flows; innovation system; innovative activity; management function; tomographic economics; management and development of the enterprise; digital economy

***For citation:*** **Shestak V.P., Moreva E.L., Tyutyunnik I.G. Financial management of innovative activity.** ***Finansy: teoriya i praktika* = *Finance: Theory and Practice*. 2019;23(6):63-75. DOI: 10.26794/2587-5671-2019-23-6-63-75**

## INTRODUCTION

Digital transformation provides an increasing intellectualization of production. Strengthening innovative activity requires changes in enterprise management. Developing new areas of management, primarily innovation, raises the question of its effective and sustainable integration with other areas of management. Financial management belongs to the most important of these.

An impact focus on the innovative activity of an organization (enterprise) from the perspective of financial flows — financial management — can both significantly strengthen innovations and make them difficult in case of inadequately selected aims and measures in relation to the production and implementation of innovations.

Getting acquainted with modern developments on resolving this issue, as well as the prospects for their development and the practical conclusions that follow from this, can help Russian enterprises optimize their efforts to find and maintain a balance between the innovative and financial components of their operations.

## FINANCIAL AND LEGAL SUPPORT OF INNOVATION MANAGEMENT

American experience in the legal support of renovations of manufacturing and innovation is of interest. In particular, American Manufacturing and Innovation Act of 2013 includes the following targets:

- to continue renovation of equipment;
- to improve the quality of work with data and information, to develop computer technology, including new paradigms such as quantum computers, simulation technology;
- to develop advanced software to achieve a better fit between modeling of complex systems and their implementation;
- to accelerate the creation of an infrastructure of advanced technologies (to improve coordination of the federal technology transfer system);
- to prepare the industry for future advanced computing technologies;
- to increase the manufacturing competitiveness in the United States and domestic production;
- to support the digital economy by developing next-generation communication systems;
- to stimulate US leadership in advanced manufacturing research, innovation and technology; to accelerate the development of advanced manufacturing personnel.

To achieve these targets, it is necessary to create a network of innovation centers in the manufacturing industry and provide financial assistance for their creation and support.

To solve the above problem is extremely important for modern Russia, where enterprises still do not show much interest in innovations. Their level of innovative activity is significantly inferior to the indicators of the countries leading in this field.

Various adverse circumstances of a conjunctural, cyclical and structural nature contribute to this passivity.

According to the Strategy for Russia's Innovative Development 2020 (approved by the order of the Government of the Russian Federation of December 8, 2011 No. 2227-r), the 2008–2009 global economic crisis led to a reduction in private business spending on innovation and slowed Russia's innovative development.

At the meeting of the Presidium of the Presidential Council for economic modernisation and innovative development of Russia on July 18, 2017, the Prime Minister of the Russian Federation D.A. Medvedev focused on the barriers impeding innovation in Russia, in particular, the implementation of the National Technological Initiative (NTI), conceived as a "driver of Russia's innovation system."

The first barrier was called "the current legal regulation, conservative by nature". This thesis should be read as the recognition that certain norms block the effective implementation of new technologies by excessive re-

quirements at all stages of their development and commercialization. The task set by the Presidium of the Council is to create a normative space, "as nnovation-friendly as possible".

The second barrier is the excessive diversity of federal normative legal acts (hereinafter referred to as the NLA) in the field of innovation. However, there is no algorithmic combination of the norms of various branches of law (in particular, civil, labor, tax, budget, administrative). There is a discrepancy between the needs of scientific, technical and innovative activities and the limits for state educational and scientific organizations to use budget funds.

Fiscal measures in relation to innovation are also unsuccessful. Attempts to activate them by reforming the administration of VAT have little effect on financial flows for manufacturing and implementing innovations. Practical difficulties in reimbursing and (or) deducting the "input" VAT both during the implementation of the investment program (which is formally provided for by the current legislation, but faces a number of difficulties in practice), and after the launch the problem remains. As a result, significant funds with VAT are "frozen" for up to several years.

Besides, financing innovation is hindered by the overly complex administration of obtaining financial resources. For example, obtaining the right to an innovative tax credit (hereinafter — ITC) for federal taxes includes:

- proceedings in the application of the interested parties (organization) by one department of the authorized body;
- multi-stage approval of the decision by other departments of the authorized body;
- legal examination of the submitted documents and further approval, etc.

The list of documents for the ITC includes 12 items. If the ITC is provided with tax credited to various budgets (for example, to the federal and regional budgets), the procedure for obtaining the credit should be followed twice.

These unfavorable factors for innovations often explain the low demand in the Russian economy, its inefficient structure in the form of purchasing off the shelf equipment abroad to the detriment of own new developments. However, despite these factors, innovative activity is growing in many countries of the world. It is no accident that the country's leadership issues a challenge not only to create favorable conditions for the effective development of innovative activity in Russia, to join the efforts of the state, business and civil society for the rapid growth of the national economy, but also to achieve the "Russian economic miracle" through a qualitative change in the structure and management system of economic assets[1].

This message urges a critical review of the impossibility to activate domestic innovations without changing their fiscal environment and mobilizing additional state financial resources. Modern research help identify other, including financial, efforts of organizations to increase innovation activity, and raise the question of the special management of this process by domestic economic entities. At the same time, the regulatory legal framework and the previously mentioned incentive measures will help them shape the direction of innovative development. A systems approach allows an effective solution to this problem faced by domestic business.

## SYSTEMS APPROACH AS A THEORETICAL BASIS FOR SOLVING THE PROBLEM OF FINANCIAL INNOVATION MANAGEMENT

As the management paradigm prevailing in the XXI century, the systems approach dictates a holistic view of the reality studied by the social, humanitarian and natural sciences. It involves the use of various combinations of approaches, methodologies, models

[1] The Programme for the Development of the Digital Economy of the Russian Federation until 2035. URL: http://spkurdyumov.ru/uploads/2017/05/strategy.pdf (accessed on 21.05.2019).

and methods to study diverse topics through systems thinking, including a convergent approach. The study of managerial, economic and other problems based on this paradigm requires an appeal to the theories of complex systems, chaos, computational complexity and the concept of self-learning [1].

The application of the systems approach to the management of an economic organization is closely connected with the Penrose's concept, whose foundations are formulated in her work "The theory of the growth of the firm", 1959 [2]. The author considered the enterprise as an indivisible fund of physical and human resources, which can only be used effectively together. Applying them separately and/or outside the enterprise would not bring the same profit and would not create competitive advantages.

The theory by E. Penrose gained wide popularity and received further development, considering other laws and patterns of reproduction of the enterprise, the orderliness of their organization, awareness, proportionality, composition and others.

However, applying just the systems approach was not sufficient to study the management of innovative activities due to its experimental nature. Experts emphasized this feature of innovation activity. Jeff Bezos[2], the richest man on the planet, compared (2017) producing and developing innovations with an experiment, whose result cannot be predicted. Experiments are prone to failures [3][3].

However, this fact does not deny the legitimacy of questioning innovation management in an economic organization. The above contradiction might be removed by managing the commercialization of research and development results, as well as other scientific and technical achievements in through a new or improved product (process, including its organizational or marketing form) used in practice, as a separate element of economic activity[4]. (Formation laws of such an element through the general management of organizations are analyzed in works by domestic and foreign researchers [4–7]).

Innovation management can provide the enterprise with various strategic competitive advantages in various functional areas. An important niche in the market, establishment, good relations with the state and other stakeholders, high social effects, a favorable impact on macroeconomic parameters and others are among them[5]. In the financial sector, such advantages include optimizing the costs of innovative activities, breaking even, profitability, ensuring excess profit, increasing the value of the company, strengthening its financial stability, and others.

Besides various functional aspects, when managing innovations, it is important to consider time differences to achieve and keep the effects, as well as their relative nature. The effects of innovation are especially significant when comparing the enterprise with its competitors in a given market segment.

Thus, innovation management can be regarded as a conceptual activity for developing and targeting implementation of production forms (labor organization and others) where qualitatively new types of equipment and technologies, means of production, intellectual property are invented, designed, created and brought to market (patents, licenses, etc.), as well as other products of intellectual en-

[2] Jeff Bezos (one of the most influential high-tech entrepreneurs, the founder and CEO of the largest online store Amazon.com, the founder and owner of the space exploration company Blue Origin, the owner of *The Washington Post* publishing house) surpassed Bill Gates in 2017 and became the richest person in the world. On January 9, 2018 his net worth was valued at 105 billion dollars.

[3] In the scientific method, an experiment is an investigation of a certain phenomenon under conditions controlled by an observer. It differs from an observation by active interaction with the studied object. Usually, an experiment serves to test a hypothesis, to establish causal relationships between phenomena.

[4] GOST R 54147–2010: Strategic and innovation management. Terms and definitions. URL: http://docs.cntd.ru/document/1200086161 (accessed on 10.02.2019).

[5] Top Trends in the Gartner Hype Cycle for Emerging Technologies, 2017. URL: https://www.gartner.com/smarterwithgartner/top-trends-in-the-gartner-hype-cycle-for-emerging-technologies-2017/ (accessed on 10.01.2018).

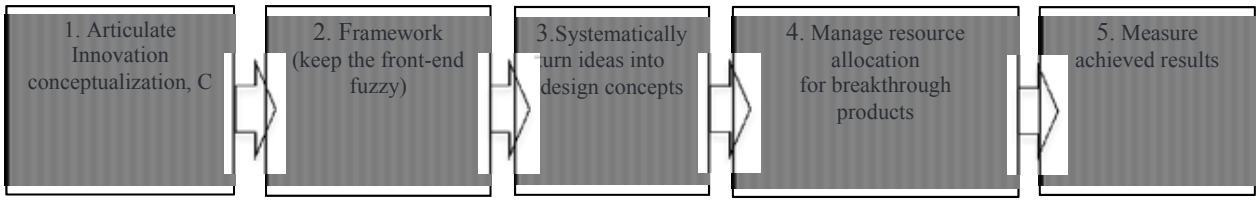



*Fig. 1.* **Process of innovative activity in the aspect of its conceptualization**

*Source:* compiled by the authors based on the research by M. Broekhof, V. Godillot [8].

deavor. (The enterprise development concept is represented by various analytical databases, in particular, by the "Gartner Hype Cycle")6.

In this case, the scheme of innovative activity as a controlled process, with the measure achieved results (MAR) being the market effect of commercialization, looks similar to the one shown in *Fig. 1*.

Moreover, in the financial aspect, conceptualization can be represented, first of all, by target values, such as sum of profits (*target profit*), indicators of long-term financial stability (*in the long run financial stability*) and/or others.

## ECONOMIC AND MATHEMATICAL APPARATUS FOR INNOVATION MANAGEMENT. COMPUTATIONAL DIAGNOSTICS

The economic and mathematical apparatus helps managing innovation in financial terms. In particular, it includes means of computational diagnostics. developed in the 60s of the XX century for the first time [9], they are now widely used in various fields of scientific knowledge to solve inverse problems like [10]:

$$Ax = Y, \qquad (1)$$

where

$X$ — is the control action,

$Y$ — is the product of impact by X,

$A$ — is an integral operator that "turns" the impact by X into a measured controlled variable $Y$.

Equation (1) relates to operator equations of the first kind. Solving these equations is considered incorrect, since in the end, the recorded value of $Y$ is determined by an a priori unknown operator $A$. Y acts as an adjustable value with the measured value indicated by *MAR* (...), and $A$ is determined by the properties of the object.

The specifics of the task suggests that to solve this type of equations, one should use algorithms (regularization methods) that allow obtaining an approximate solution. This, in turn, requires developed mathematical tools for measurements and a large amount of a priori information about their object.

The development of the apparatus of computational diagnostics and its application to solve economic problems in the last decades of the XX — beginning of the XXI centuries contributed to these conditions in many respects.

For example, A.A. Kuklin et al. (2015) used economic diagnostics, creating a new area of research — economic tomography [11]. At the same time, the authors developed and substantiated the theoretical and methodological tools to recognize emerging threats at the early stages, which allowed businesses to survive the crisis with less loss. For that, the researchers classified the past socio-economic crises, developed a system of computational experiments and mathematically processed the trajectories of changes in the main indicators in relation to element-by-element scanning considering the influence of various factors.

Thus, the authors determined the kind and form of the equation operator (1), which allowed to comprehensively assess the "crisis"

[6] Top Trends in the Gartner Hype Cycle for Emerging Technologies, 2017. URL: https://www.gartner.com/smarterwithgartner/top-trends-in-the-gartner-hype-cycle-for-emerging-technologies-2017/ (accessed on 10.01.2018).

state of Russian regions and to justify opportunities to manage them.

Later, already in this century, having analyzed the practice of using economic and mathematical methods and models to increase the efficiency of innovation management, domestic researchers S. N. Larin and E. V. Zhilyakova (2013) [12] compiled a generalized economic and mathematical model of innovative activity of the enterprise. They considered various parameters of the impact by the internal and external environment of the enterprise, the market, competitors and state regulation. At the same time, they considered innovative activity both as an economic resource and as an object of management. The question of managing this facility remained open.

Using the mathematical apparatus, well known in management science for solving problems of financial and other types of innovation management, is possible if unstructured or poorly structured innovative activities are transferred to the level allowing to develop appropriate economic and mathematical models, including optimization models. At this level, it is convenient to consider that the input control signal x is determined only by an idea or a strategy (articulate an innovation conceptualization / strategy, see 1 in *Fig. 1*). The proposed application of computational diagnostics methods to optimize the innovation management by separating the controlling and controlled subsystems of the enterprise's innovation system and observing all laws of organization of production may be of practical interest in preparing enterprises for advanced computing technologies and supporting the digital economy, in particular, regarding organizational restructuring and institutional support.

## ENTERPRISE INNOVATION MANAGEMENT AS A SYSTEM

Working with innovations at the enterprise mentioned above, including its financial component, are of particular importance for both theory and practice. In the first case, we are talking about innovation management as a special object of research, which can be represented as a holistic closed-loop system. A closed control system is a system where the control action x is formed based on the enterprise development concept. During its transformation, the system is based on a comparison of the expected and the actual results of innovative activity [13].

*Fig. 2* presents a general structural diagram of the innovation management system.

In *Fig. 2*, the properties of operator *A* are defined by the characteristics of two innovation management subsystems of the enterprise (controlling and controlled) operating within the framework of the general system for managing its economic (including financial) activity. In such a system, the feedback signal (Δx) is determined by comparing the output value *Y* with the setting (set value) $Y_0$.

A special monitoring mechanism (device, system) is needed to receive the signal. It will help to determine the difference between the set and measured values of the controlled variable (MAR) to generate a feedback signal Δx.

However, this mechanism is not default, but requires special efforts to be developed and implemented. This is especially important in highly dynamic, and sometimes fundamentally changing conditions in the modern era of digital transformation. The question how to get value $Y_0$, quickly compare it with the actual one and adjust to innovation management, becomes vital, and therefore, the priority for the functioning and strengthening of modern business. Thus, the innovation management subsystems of the enterprise require a special analysis.

## INNOVATION MANAGEMENT SUBSYSTEMS OF THE ENTERPRISE

The innovation management subsystems of the enterprise are an organic component of the entire management system that regulates the reproduction and development of the en-

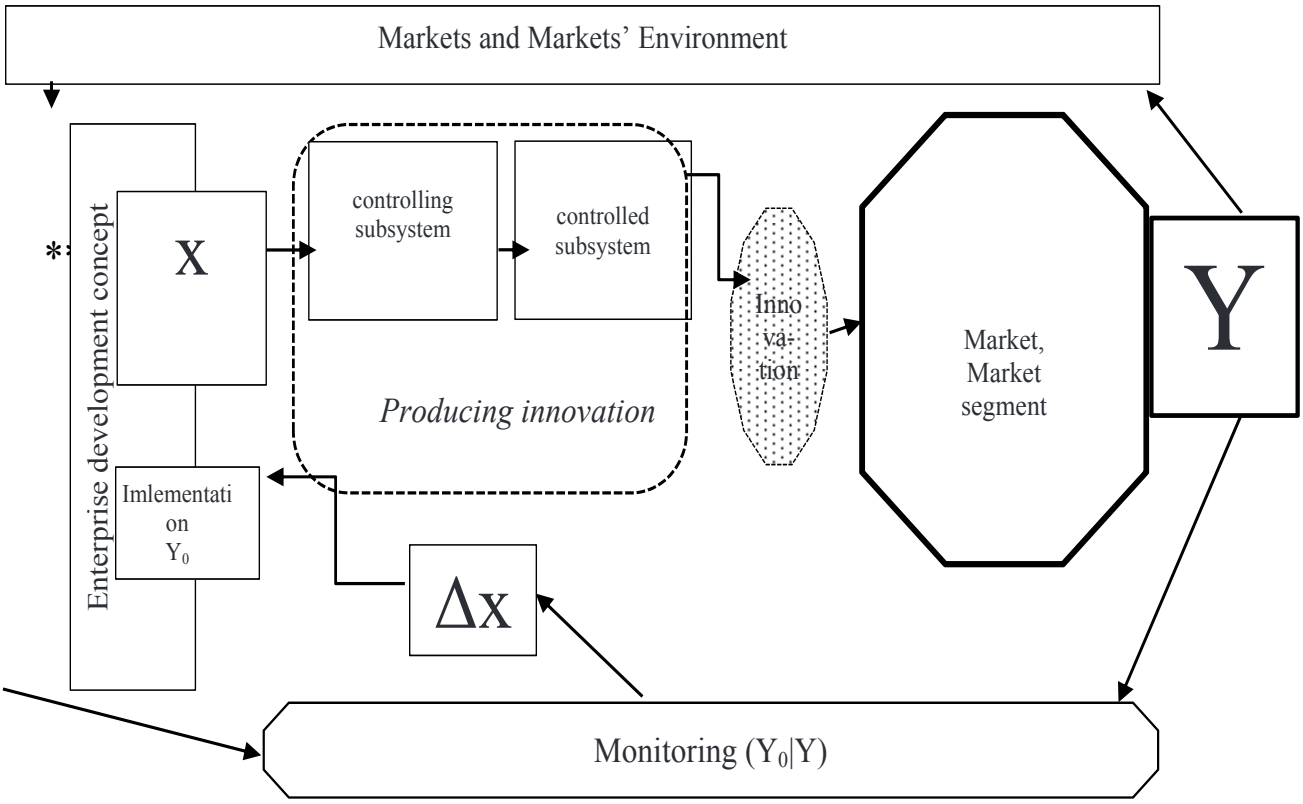



*Fig. 2.* **Block diagram of the enterprise innovation activity management system**

*Source:* developed by the authors.

| Controlling subsystem functions | Controlled subsystem functions |
|---|---|
| Enterprise development | Corporate targets |
| Self protection | Organization structure |
| Profitability | Motivation system |
| Regulatory support of the internal structure of the enterprise | Labor productivity |
| Resource support of the enterprise (material, financial, intellectual) | Intellectual and professional development |
| Professionalism — self-certification | Socio-psychological climate |
| Positioning in the external environment — PR | Relationship with the external environment |
| Social Responsibility Concept | Technical and technological support, work with sources |
| Organization of production | Synergistic effects |

*Fig. 3.* **Functional diagram of organizational management**

*Source:* developed by the authors.

terprise as a whole. This system is subdivided into the controlling and controlled subsystems, whose functionality is represented below (*Fig. 3*).

Thus, the functional scheme of the enterprise innovation management system can be presented in a similar format and includes two modules: a controlling subsystem with a set of $f_i$ functions and a controlled subsystem with a set of $\xi_j$ functions. Based on this, an equation for managing innovation activity is as follows:

$$Y = F\,[(f_1, f_2 \ldots f_{i)}(\xi_1, \xi_{2\ldots}\ \xi_j)], \qquad (2)$$

where:

$Y$ — is the management result;

$f$ and $\xi$ are the values of the functions describing the controlling actions and the response of the controlled subsystem, respectively, for the values of the time necessary to consider the results i and j = 1, 2 ...;

$F$ is the additive functional — a function defined by the set of $f$ and $\xi$ functions (whose values are usually represented by real numbers).

Then the equation of target $Y_0$ will be as follows:

$$Y_0 = F_0\,[(f_1^0, f_2^0 \ldots f_{i)}^0(\xi_1^0, \xi_2^0{}_{\ldots}\ \xi_j^0)], \qquad (3)$$

Comparing $Y$ with $Y_0$, including in the context of their functional components in the form of elements of equations (2) and (3), allows to analyze the causes of discrepancies in the actual and expected control results, to clarify the state of operator A and to improve the control action (feedback signal) for better $Y$ result.

Functional $f$ and $\xi$ can change both in a substantive way and in time. The target setting can change, as well as its effects of a long, medium, and short-term nature. Formally, this can complicate the calculations, but it will not change their essence.

Such attempts are widely undertaken in modern literature. For example, to improve the innovation process at the enterprise, Zak Goldberg (2017) [14] proposed considering the "support triangle" with the following parties:

1) *payroll system*, included in the enterprise's HR system and implying that the employees are paid on time and in full;

2) *Customer Relationship Management Software* (CRM) — information base of the customer status (reflection);

3) *outsourcing application* — the so-called "concept of outside assistance", according to which outsourcing should be widely used during the start of the innovation process until hiring freelancers.

To confirm the effectiveness parameters of innovation management (the number and nature of the functions of equation (2)), C. Juma [15] suggested considering the so-called "enemies to innovation", i.e. the conflict between innovators and defenders of the status quo at the enterprise. Their action was fraught with industrial conflicts, inhibition of innovation, emasculating the content of the latter and/or reducing their effectiveness.

In the era of digital transformation and the ever closer integration of various fields of activity and public life in increasing innovative activity of business, the role of public institutions increased noteworthily. Their prompt response to the successes of the commercial sector in the field of innovation, the dissemination of more complete information among them about the state and dynamics of the needs of citizens, as well as the development of public demand for innovations, turned out to be very significant today. This affects the improvement of resource exploitation by enterprises, their concentration in the most promising areas of activity and increasing the effectiveness of operations.

The use of the above tools is also advisable when referring to special functional areas of innovation management and, above all, financial. Focusing on the impact of financial flow management on innovative activity helps specify the above equations (1) and (2), and,

accordingly, improve the setting parameters (Y 0), optimizing the organization's efforts to achieve the maximum effect.

In this case, one should consider the specifics of the ratio of financial and innovative activities, as well as the organization of their management. They root back to the survival imperatives and expanded reproduction in these areas, as well as the response. The differences between them determine the formation of a complex system of relationships between these areas. This system concerns the relationship between target setting in financial and innovative management, the efforts undertaken in two areas to achieve the objectives and conditions that are formed in them for this purpose.

A special treatment to the problems of financial management of innovative activity allows addressing the financial sector on ensuring the innovative effect ($Y^{Fin}$) and focus:

$$Y^{Fin} = F^{Fin}\,[(f_1^{Fin}, f_2^{Fin} \ldots f_i^{Fin})(\xi_1^{Fin}, \xi_2^{Fin}{}_{\ldots}\ \xi_j^{Fin})], \quad (4)$$

and

$$Y^{Fin}{}_0 = F^{Fin}{}_0\,[(f^{Fin}{}_1{}^0, f^{Fin}{}_2{}^0 \ldots f^{Fin}{}_i{}^0)\ (\xi^{Fin}{}_1{}^0, \xi^{Fin}{}_2{}^0{}_{\ldots}\ \xi^{Fin}{}_j{}^0)], \quad (5)$$

where the index ($^{Fin}$) is used to indicate the impact of financial management on innovation and its reactions to it.

(Considering equation (1), the definition of this contribution also helps clarify the state of operator A and provides possibilities for optimizing control action X).

On the practical level, the solution to this problem is not trivial due to the variability of the managerial efforts of the financial and innovative components, intensified in conditions of high uncertainty of the innovative context and the inability to interpret it accurately [16].

This does not allow us to unambiguously evaluate their interaction, which allows both its harmonization and mismatch [17]. The ability to calculate positive or negative results helps correlate them with the efforts to prevent (or overcome) in case of conflict interaction and evaluate them in terms of the overall management of the organization.

Judging by international experience, this issue is becoming increasingly relevant today and finds its solution in ways to identify potential conflicts between financial and innovative entities regarding the mutual obligations and competencies (tension-based framework) that arise between them [18].

This, in turn, presupposes the correct definition of the roles and competencies of their participants, their ability to coordinate their actions with each other, as well as full consideration of the impact of innovations on the position of different stakeholders of innovation activity.

From the position of financial management, the definition and target setting for innovators to achieve certain financial targets requires special analysis and careful criteria selection for their adequate financial assessment in terms of meeting the project budget, innovation costs, pricing for a new product / process / ..., the profitability of the corresponding project and/or other indicators.

When developing the financial content of innovations, there is a need to promptly provide innovators with the necessary information about the state of the financial environment for their activities, to determine the state of sources of such information and the mechanisms for its receipt, and, if necessary, to determine measures to improve it; to model the interaction between financiers and innovators, in particular, to assess possible discrepancies between the formal procedures for financial evaluation of innovative activity and its actual state; and so on [19].

In terms of financial management tools, more and more attention today is paid to the importance of mobilizing new funds for subjects of innovative activity and diversification of the portfolio they form.

In the case of venture financing, for example, project activities, depending on its sector affiliation, it is advisable to turn to various crowdfunding or other funding, mobilizing quasi-currency sources based on digital technologies, and their combination within the framework of the innovative capital model [20].

Today, the mobilization of new, non-financial in nature means of influencing innovative activity is very promising. For example, through 2022, 75% of organizations with frontline decision-making teams reflecting a diverse and inclusive culture will exceed their financial targets[7]. [21]

However, the development of this toolkit implies its balanced application, considering the insufficient knowledge of the behavior of the subject. In this regard, it seems appropriate to begin its implementation with testing and/or experimentation. In the latter case, when analyzing the additional financing of innovations (with investment value E), it is possible to build various models for determining the probability of commercialization p (f, ξ, E) in this financial content (i.e., to clarify and improve the properties of operator A).

## CONCLUSIONS

Based on the facts above, we can conclude that modern theory and practice of innovation management have sufficient material to systematically evaluate it as a whole, and individual functional areas, in particular.

In a qualitative aspect, these estimates go back to the concepts of the company (resource, strategic, and some others) formulated in the second half of the XX century and widely developed at the beginning of the XXI century. Their development and integration with the mathematical apparatus, in particular, in computational diagnostics, offers an opportunity of a quantitative assessment of managerial efforts.

In terms of practice, the approach based on computational diagnostics offers great opportunities for managing innovations in individual functional areas. Among them the financial sector is of particular importance, where innovation is oriented towards achieving certain value targets and therefore, the use of various monetary instruments. An important step to solve this problem is to analyze financial management from the perspective of identifying the controlling and controlled subsystems, building an appropriate model to verify them in the context of individual enterprises, their groups and larger associations. The latter is of particular interest for managing innovations at the meso- and macrolevels and serves as an independent direction for subsequent research in the framework of the studied problems.

## FUTURE DEVELOPMENT PROSPECTS

The importance and relevance of this research is also evidenced by the modern experience of regulating innovation activity abroad (USA, Germany, Canada, East Asia, China and the Baltic countries). It shows that the directions of the state's influence on the innovative activity of business entities are quite uniform: the system of organizational, financial, legal, information and other mechanisms is traditionally used. At the same time, their combinations and results differ significantly. In fact, each country implements its own innovation policy, in which, in particular, the place and role of financial instruments is considered differently. Given the differences in the national characteristics of the subjects of innovative activity, this ultimately leads to building many national innovation systems that differ from each other in key parameters for the development of scientific, technical and other types of environment, and the

[7] Strategic Predictions for 2019 and Beyond. URL: https://www.gartner.com/smarterwithgartner/gartner-top-strategic-predictions-for-2019-and-beyond/ (accessed on 15.05.2019).

corresponding sectors, countries and regions [22–23]8. Thus, the approach proposed in this article also allows us to optimize government efforts to enhance innovation and can be used in Russia and other countries. The latter also offers great opportunities for international comparisons, which help better understand the national/sectoral features of the controlled and controlling subsystems (operator A), improve the conceptualization of the management impact and increase the efficiency of financial innovation management.

[8] Foreign experience in supporting innovation. Review of current literature. URL: http://www.spsl.nsc.ru/FullText/dor/2015–48.pdf (accessed on 10.01.2018).

## ACKNOWLEDGEMENTS

The article is based on the results of budgetary-supported research according to the state task carried out by the Financial University in 2017 as part of the research work "Improving the mechanisms of state regulation of industrial development to increase competitiveness of domestic products". Financial University, Moscow, Russia.

## REFERENCES

1. Jackson M.C. Systems approaches to management. New York: Kluwer Academic/Plenum Publ.; 2000. 465 p.
2. Penrose E. The theory of the growth of the firm. Oxford: OUP Publ.; 1995. 272 p.
3. Kusterer D.J., Schmitz P.W. The management of innovation: Experimental evidence. *Games and Economic Behavior*. 2017;104:706–725. DOI: 10.1016/j.geb.2017.06.011
4. Moreva E.L. Management and productivity: Foreign conceptions and verification problem. *Upravlencheskie nauki = Management Science*. 2016;6(3):55–66. (In Russ.).
5. Martinsuo M., Korhonen T., Laine T. Identifying, framing and managing uncertainties in project portfolios. *International Journal of Project Management*. 2014;32(5):732–746. DOI: 10.1016/j.ijproman.2014.01.014
6. Korhonen T., Laine T., Lyly-Yrjänäinen J., Suomala P. Innovation for multiproject management: The case of component commonality. *Project Management Journal*. 2016;47(2):130–143. DOI: 10.1002/pmj.21586
7. Laine T.J., Korhonen T.A., Martinsuo M.M. Managing program impacts in new product development: An exploratory case study on overcoming uncertainties. *International Journal of Project Management*. 2016;34(4):717–733. DOI: 10.1016/j.ijproman.2016.02.011
8. Babkin A.V., ed. Industrial innovation management methodology. St. Petersburg: SPbPU Publ.; 2013. 285 p. (In Russ.).
9. Broekhof M., Godillot B. How to manage innovation as a business: Understanding the best approaches and tools to manage the complexity of innovation. 2015. URL: https://www.oracle.com/assets/how-to-manage-innovation-2295966.pdf (accessed on 10.01.2018).
10. Cormack A.M. Early two-dimensional reconstruction and recent topics stemming from it. In: Lindsten J., ed. Nobel lectures in physiology or medicine 1971–1980. Singapore: World Scientific Publ. Co.; 1992:551–563.
11. Vasin V. Irregular nonlinear operator equations: Tikhonov's regularization and iterative approximation. *Journal of Inverse and Ill-Posed Problems*. 2013;21(1):109–123. DOI: 10.1515/jip-2012–0084
12. Kuklin A.A., Bystroi G.P., Okhotnikov S.A., Vasil'eva E.V. Economic tomography: Opportunity to foresee and respond to socio-economic crises. *Ekonomika regiona = Economy of Region*. 2015;(4):40–53. DOI: 10.17059/2015–4–4 (In Russ.).
13. Larin S.N., Zhilyakova E.V. Modeling the interaction of participants in innovation. *Ekonomicheskii analiz: teoriya i praktika = Economic Analysis: Theory and Practice*. 2013;(11):52–58. (In Russ).

14. Fried A., Götze U., Möller K., Pecas P. Innovation and management control. *Journal of Management Control*. 2017;28(1):1–4. DOI: 10.1007/s00187–017–0246–9
15. Goldberg Z. The little things to make running your innovation smoother. Online Learning and Resource Center. 2017. URL: http://www.innovationmanagement.se/2017/12/01/the-little-things-to-make-running-your-innovation-smoother/ (accessed on 10.01.2018).
16. Juma C. Innovation and its enemies: Why people resist new technologies. New York: Oxford University Press; 2016. 416 p.
17. Davila T., Wouters M. Management accounting in the manufacturing sector: Managing costs at the design and production stages. In: Chapman C. S., Hopwood A. G., Shields M. D., eds. Handbook of management accounting research. Vol. 2. Amsterdam: Elsevier Science Publ.; 2007:831–858. DOI: 10.1016/S 1751–3243(06)02015–3
18. Jorgensen B., Messner M. Accounting and strategizing: A case study from new product development. *Accounting, Organizations and Society*. 2010;35(2):184–204. DOI: 10.1016/j.aos.2009.04.001
19. Alvesson M., Willmott H. Making sense of management: A critical introduction. London, Thousand Oaks, CA: SAGE Publ.; 2012. 320 p.
20. Hall M. Accounting information and managerial work. *Accounting, Organizations and Society*. 2010;35(3):301–315. DOI: 10.1016/j.aos.2009.09.003
21. Moreva E. L. Ventrue capital in Russia and the global evolution of venture capital. *Journal of Reviews on Global Economics*. 2018;(7):843–850. DOI: 10.6000/1929–7092.2018.07.82
22. Shumaev V. A. Innovation management: State, theory, practice. Moscow: Moscow Witte Univ. Publ.; 2015. (In Russ.).
23. Campanella E. No small change: How to manage the costs of innovation. Foreign Affairs. May 15, 2017. URL: https://www.foreignaffairs.com/reviews/review-essay/2017–05–15/no-small-change (accessed on 10.01.2018).

## ABOUT THE AUTHORS

***Valerii P. Shestak*** — Dr. Sci. (Eng.), Professor, National Research Nuclear University MEPhI, Moscow, Russia
VPShestak@fa.ru

***Evgeniya L. Moreva*** — Cand. Sci. (Econ.), Associate Professor, Deputy Director, Institute for Industrial Policy and Institutional Development, Financial University, Moscow
eu7711460@mail.ru

***Igor' G. Tyutyunnik*** — Researcher, Institute for Industrial Policy and Institutional Development, Financial University, Moscow, Russia
tytynnik.igor@rambler.ru

***Authors' declared contribution*:**
Shestak V. P. — abstract; keywords; management of innovative activity of the enterprise as a system; subsystem management of innovative activity of the enterprise.
Moreva E. L. — introduction, financial and legal support of management of innovative activity; management of innovative activity of the enterprise as a system; subsystem management of innovative activity of the enterprise; conclusions
Tyutyunnik I. G. — financial and legal support of management of innovative activity, system approach as a theoretical basis for solving the problem of financial management of innovative activity.

*The article was submitted on 29.08.2019; revised on 14.09.2019 and accepted for publication on 20.10.2019.*
*The authors read and approved the final version of the manuscript.*

ORIGINAL PAPER

DOI: 10.26794/2587-5671-2019-23-6-76-90
UDC 338.001.36(045)
JEL G34



# Assessment and Analysis of the Cost of Debt Changes after Domestic Russian Mergers and Acquisitions

**V.B. Mikhal'chuk**
National Research University Higher School of Economics,
Moscow, Russia
http://orcid.org/0000-0002-1899-685X

## ABSTRACT

The study analyzes the impact of domestic Russian mergers and acquisitions on the cost of debt for companies involved in deals. The author systematized the existing findings in this area in developed and emerging markets. The methodology developed by the author for analyzing the impact of mergers and acquisitions on the cost of debt considers the specifics of the Russian market and can be used in conditions of limited information about non-public companies. The estimation of the cost of debt is based on synthetic credit ratings of the companies involved in the deal and the corresponding yield spreads between corporate and government bonds. The methodology was tested on a sample of 73 domestic deals completed in 2014–2016. Random effects model with robust standard errors was used to test the significance of factors affecting the cost of debt. This research makes several practical contributions. First, in the studied sample, deals lead to an increase of the cost of debt by 3,1% within a year after the deal. Second, significant factors affecting the change in the cost of debt after domestic Russian mergers and acquisitions were identified. The cost of debt is reduced by the purchase of large companies during the period of economic growth. There is a significant impact of the deal value on the increase of the cost of debt. Company management, academic researchers and experts can use research results to assess potential deals of mergers and acquisitions on emerging markets. The developed methodology can be applied to mergers and acquisitions in other countries to analyze the features of these markets.

***Keywords:*** mergers and acquisitions; synergy; credit rating; risk premium; corporate bonds; risk-free interest rate; cost of debt; strategy

***For citation*: Mikhal'chuk V.B. Assessment and analysis of the cost of debt changes after domestic Russian mergers and acquisitions**. ***Finance: Theory and Practice*. 2019;23(6):76-90. DOI: 10.26794/2587-5671-2019-23-6-76-90**

## INTRODUCTION

Mergers and acquisitions are important strategic decisions for companies. A large number of assets is involved in deals annually: in 2018, the global M&A market reached $ 4.1 trillion1.

In 2015–2018, the Russian M&A market was characterized by stagnation. Adopted in March 2014, the economic sanctions against Russia led to a decrease in deals initiated from abroad and to a decrease in domestic activity in the market due to the limited access to capital for many Russian companies. Low oil prices and ruble devaluation at the end of 2014 further limited activity in this market.

The value of 652 M&A deals recorded in 2018 in Russia stood at $ 51.7 billion, down 3 times on the figure for 2012 in value terms. The market has traditionally been dominated by domestic deals, which accounted for 65% of the market

[1] Morgan J.P. 2019 Global M&A Outlook. URL: https://www.jpmorgan.com/jpmpdf/1320746694177.pdf (accessed on 02.04.2019).

in value terms in 2018[2]. Many M&A initiatives were postponed due to uncertainty about the future development of the economy.

In this context, the analysis of the prospects of potential transactions and, when possible, a more accurate assessment of possible synergy became very important in the Russian market. Today, there are virtually no studies analyzing domestic Russian mergers and acquisitions involving non-public companies to identify synergies.

Therefore, the issue of developing tools for empirical analysis of domestic Russian transactions, considering the specifics of the national M&A market and applicable in conditions of limited information about companies is of interest.

This study is focused on developing such tools and testing them on a sample of 73 domestic deals completed in 2014–2016 to assess the factors affecting the synergy through lower costs of debt.

## DEFINITIONS

Definitions of mergers and acquisitions are widely represented in the literature. Contrary to Anglo-Saxon law and foreign scientific literature, this concept has different meanings in Russian law.

According to foreign authors, the merger is when one of the companies involved in the transaction ceases to exist, and the acquisition is when the target company can continue as a subsidiary [1, p. 23–28; 2, p. 5–7; 3, p. 924, 925].

In Russian law, a merger is one of the five forms of reorganization under the Civil Code, and there is no such a term as "acquisition"[3]. Here, a merger corresponds to what is called "consolidation" in foreign literature, when a new company is the result of a deal[4].

This study determines mergers and acquisitions based on control over the investee. Control refers to the right, received as a result of a transaction, to determine the financial and operational policies of a company in order to derive benefits from its activities[5].

Owning more than 50% of the target company's shares after the transaction was sufficient for control. The analysis of control in a buyout was conducted according to the Guide to the International Financial Reporting Standard (IFRS) 10 "Consolidated Financial Statements".

In general, it was assumed that owning 40–50% the target company's shares was sufficient for control with high diversification of the shares of the remaining shareholders, but insufficient for control with two or three other large shareholders with a total share larger than the considered block of shares. The transaction was excluded from further analysis if there was no information on the share capital structure.

The target company can be liquidated as a result of a transaction with the consolidation of assets and liabilities or saved as a subsidiary of the acquirer.

Most authors generally define synergy as an additional cost created as a result of a business consolidation and inaccessible to companies separately [1, p. 44; 2, p. 25].

For the purposes of this study, synergy was defined as the reduction in the cost of debt of the consolidated company after the transaction compared to the consolidated indicators of the companies separately before the transaction.

This approach to determine M&As and synergies allows analyzing transactions involving non-public companies that prevail in the Russian market in quantitative and value terms.

## PREVIOUS STUDY

M&As may be motivated by seek to reduce the cost of capital and to increase the value of a consolidated company.

The cost of debt is a source to reduce the weighted average cost of capital. The reduction

[2] KPMG. M&A market in Russia in 2018. URL: https://assets.kpmg/content/dam/kpmg/ru/pdf/2019/02/ru-ru-ma-survey-feb-2018.pdf (accessed on 02.04.2019).

[3] Civil Code of the Russian Federation (Part 1) No. 51-FZ as of November 30, 1994 (updated on December 29, 2017). P. 57.

[4] Federal Law N 208-FZ of December 26, 1995 on Joint-stock companies (updated on 07.03.2018). P. 16.

[5] International Financial Reporting Standards (IFRS) 10 "Consolidated Financial Statements" (enacted in the Russian Federation by Order No. 217n) (updated on 27.06.2016). P. 7.

in the cost of debt in the result of the transaction may happen for several reasons: access to new, cheaper sources of debt financing, consolidation of the company, improved financial stability of the company, etc.

The cost of debt generally depends on three variables:

- Risk-free rate as the lower bound of the cost of debt for all companies. If the risk-free rate increases, the cost of debt for all companies increases.
- Company default risk. For high-risk companies, the cost of debt is higher.
- Tax benefits due to the need to pay interest on taxable profits. Tax benefits increase with increasing tax rates.

The literature uses several methods to assess the cost of debt, depending on the characteristics of debt financing companies.

For companies issuing long-term and liquid bonds in the debt market, the estimated yield to maturity of such bonds can be used as the company's cost of debt.

Companies with illiquid bonds in circulation are usually subject to rating. For such companies, the cost of debt can be estimated by the default spreads associated with credit ratings.

For companies with no credit rating, there are two ways to estimate the cost of debt. First, if the information is available, one can use the history and parameters of the company's bank (and other financial institutions) debt. Second, one can assign a synthetic rating according to the financial data of the company, evaluate the default spread and calculate the cost of debt.

*Table 1* shows the methods to estimate the cost of debt in a number of recent empirical studies. Depending on the databases, research objects and countries, the authors apply all of the methods to estimate the cost of debt described above.

In the literature on synergies in M&As, authors usually distinguish three main groups of factors for creating and destructing synergies: macroeconomic factors, characteristics of the deal and characteristics of the companies involved in the deal.

Macroeconomic factors include the dynamics of real gross domestic product (GDP) in the country of the deal, the state of the main sectors at the national and global levels, inflation, the national currency, interest rate changes and other variables.

Improving macroeconomic conditions may lead to an increase in the M&A market. For example, work [10] showed a positive correlation between the country's GDP growth rate and the volume of international M&As three years before and after the 2008 global economic crisis. Most of the selected 26 countries observed correlation, including developing countries such as Brazil, India, Malaysia and Russia.

In some studies, macroeconomic factors may be insignificant for the success of transactions. Study [11] analyzed 132 mergers and acquisitions involving banks in Asia and Latin America between 1998 and 2009. It demonstrated that the influence of inflation and the GDP growth rate in the country of the acquiring company is insignificant for the accumulated excess return on its shares.

The characteristics of the transaction include the attitude of companies to the transaction, the nature of integration, nationality, size of the transaction and other parameters.

The attitude of companies to the transaction can be hostile or friendly. Usually hostile transactions involve an additional premium to the market price of the target company compared to friendly transactions, which reduces the synergy of the transaction. On the other hand, hostile transactions are meant to reach significant goals, from which management expects high synergy.

The second factor in synergy creation may be the nature of integration. Horizontal transactions can create synergies by gaining greater market share (strengthening market power) and economies of scale. Vertical transactions are aimed at strengthening control over the value chain, and synergy arises from the reduction in the cost of products or services.

Studies show that both types of transactions can lead to synergies. Work [12] studied a sample of 259 horizontal and vertical transactions in

*Table 1*

**Recent empirical studies on debt valuation**

| Study | Valuation method | Country | Industry | Year |
|---|---|---|---|---|
| [4] | Information on bank debt | USA | All industries except banks | 1990–2004 |
| [5] | Credit rating and corresponding default spread | All countries | All industries | 1973–1998 |
| [6] | Yield to maturity of traded bonds | EU | Companies with state participation in all sectors | 2001–2009 |
| [7] | Yield to maturity of traded bonds | USA | All industries except banks and regulated industries | 2002–2007 |
| [8] | Yield to maturity of traded bonds | All countries | All industries except banks | 1988–2006 |
| [9] | Information on bank debt | 28 countries in the world | All industries, except banks and state companies | 2005–2012 |

*Source:* author's analysis based on the referenced studies.

the US mining and manufacturing industries in 1963–1978. After antitrust authorities reviewed the horizontal transactions6, the excess return accumulated over the month on the shares of the acquiring company was 2.45%. At the same time, there is no statistically significant difference between excess returns in horizontal and vertical transactions left unattended by antitrust authorities.

The impact of the transaction nationality on synergy attracts much attention of academic and practice-oriented research. Transactions can be national (domestic) and international (cross-border). International transactions can occur in companies in developed or developing countries. There are mixed transactions when one company is located in a developed country, and the other — in a developing one. Work [13] reviews the recent studies of this issue.

In most studies, increasing size of the transaction is associated with synergy destruction. For example, work [14] noted a negative correlation between the size of the transaction and the company's operational efficiency after the transaction. This may be due to systematic overpayment when acquiring large companies.

The characteristics of the companies participating in the transaction include transaction cost, size of the acquiring company (asset value), financial results, business legal structure, ownership concentration, type of ownership and other parameters.

The academic literature offers different opinions about the impact of the company size on synergy creation. According to one hypothesis, acquiring a large company can create conditions for economies of scale and other types of synergies. On the other hand, large deals can destroy synergies due to complex integration of a large company into a common business system.

In empirical studies, the size of the companies participating in a transaction is often presented as the relative transaction cost or the ratio of the transaction cost to the market value of the acquiring company (or the book value of its assets for non-public companies). Exemplified by 271 acquisitions of more than $ 100 million

[6] The United States Federal Trade Commission or the United States Department of Justice Antitrust Division.

in 1971–1982, study [15] described a positive correlation between the relative transaction cost and the share of subsequent downsizing transactions. The risk of unsuccessful integration and a subsequent sale of the asset rises if the transaction cost increases relatively to the value of the acquiring company.

Asymmetric information between the parties has a significant impact on the decision whether to conduct the transaction, as well as its results. Transactions can be successful for the acquirer when they have the most complete information about the target (public target company) and disclose a minimum of information about themselves (private acquiring company).

The high equity ownership concentration of the acquiring company has a positive effect on synergy creation due to the mitigation of agency conflict between managers and owners of widely held companies. Providing a sample of 228 M&As in India in 1995–2004, the authors of study [16] showed that a high ownership concentration in acquiring companies contributes to synergy creation after their transactions.

In developing countries, government participation in companies' equity can contribute to synergy creation through greater administrative influence on the market. On a sample of 1,148 transactions in China in 1998–2003, study [17] demonstrated that for the Chinese market, the share of state ownership in the capital of the target company is a significant factor in synergy creation.

## RESEARCH HYPOTHESES

The analysis of synergy in M&As resulted in five hypotheses below.

To test the influence of macroeconomic factors on the cost of debt in domestic Russian transactions, the study uses GDP growth in the Russian Federation in constant prices.

This variable was used to test *hypothesis 1 (GDP growth)*: *economic growth helps reduce the cost of debt in domestic Russian transactions.*

The data on the real GDP growth rate were received from the website of the Federal State Statistics Service of the Russian Federation.

To check the effect of transaction characteristics on the cost of debt in domestic transactions, the study used companies belonging to the same industry (dummy variable) and transaction size (natural logarithm of transaction cost in millions of dollars).

A dummy variable equals to 1 if the transaction is horizontal (both companies operate in the same industry) and to 0 for other industries. Belonging both companies to the same industry was determined by the two-digit OKVED code in the SPARK database in the section "Main activity type".

These variables are used to test two hypotheses about the influence of macroeconomic factors on the cost of debt:

*Hypothesis 2 (type of transaction): the cost of debt after a transaction between companies within one industry reduces more than after a transaction between companies from different industries.*

*Hypothesis 3 (transaction size): larger transactions lead to an increase in the cost of debt (hypothesis of overpayment compared to the fair cost of the target).*

The data on the transaction size were received from the Mergermarket database, the data on the revenue of the companies — from their financial statements or from the SPARK database.

Two variables are used to study the significance of the characteristics of companies on the cost of debt in domestic transactions: the target size (natural logarithm of the book value of the assets) and the share of the largest shareholder in the capital of the acquirer. These variables are used to test two hypotheses about the effect of company characteristics on the cost of debt:

*Hypothesis 4 (target size): acquisition of larger companies contributes to lower cost of debt.*

*Hypothesis 5 (acquirer's agency conflict): a high ownership concentration in the share capital of the acquiring company helps reduce the cost of debt.*

The data on the size of assets, publicity and state participation were received from the financial statements of the companies or from the SPARK database.

*Table 2*

**Research hypothesis**

| Hypothesis | Variable | Expected impact | Study |
|---|---|---|---|
| 1. Economic growth contributes to synergy creation | Real GDP growth in the Russian Federation | + | [11] |
| 2. Synergy in transactions between companies within one industry is higher than in transactions between companies from different industries | Dummy for transaction type | + | [12] |
| 3. Larger transactions lead to the destruction of synergy (hypothesis of overpayment for the target) | Natural logarithm of the transaction cost | – | [14] |
| 4. Acquiring larger companies contributes to synergy creation | Natural logarithm of the value of the target's assets | + | [15] |
| 5. High ownership concentration in the share capital of the acquiring company contributes to synergy creation | Share of the largest shareholder in the capital of the acquirer | + | [16] |

*Source:* author's analysis.

*Table 2* systematized the hypotheses for empirical research, proxy variables for an econometric model, anticipated impact, and the key studies for each hypothesis.

## SAMPLE

The information for the sample was collected from several commercial databases (Mergermarket, SPARK-Interfax, Bloomberg), open government data (Rosstat, the Central Bank of the Russian Federation), as well as unstructured information from the websites of the companies participating in the transaction, rating and information agencies.

The primary data on domestic Russian M&As completed from January 1, 2014 to December 31, 2016 were collected from Mergermarket.

The Mergermarket database contains information about the dates of the announcement and completion of the transaction, names and industries of the companies participating in the transaction, transaction characteristics (public or private, cross-border or domestic, mergers or acquisitions), payment method and transaction cost, a brief description of the transaction and links to primary sources of information.

The general population includes 309 completed domestic transactions in the reporting period. Transactions between companies in regulated sectors and the financial sector were excluded from the general population due to the peculiarities of reporting and profitability in these sectors.

Next, the data on the financial indicators of the companies participating in the transaction were collected from the SPARK-Interfax and Bloomberg databases. The financial data used in the analysis included: revenue, operating profit, general costs for ordinary activities and interest payable. The annual profit and loss statement of the companies were the primary source of financial information for the SPARK-Interfax and Bloomberg databases.

The sample included the financial indicators of the companies for seven years: three years before the transaction was completed, the year the transaction was completed and three years after its completion. If during the seven years one of

*Table 3*

**Excluded transactions and the final sample**

| Reasons for excluding transactions | Number of transactions |
|---|---|
| General population | 309 |
| No required financial statements | 59 |
| Transaction does not change the proprietary shareholder | 57 |
| Transaction between companies in the financial industries | 43 |
| Value of target assets less than 5% of acquirer's assets | 24 |
| Transaction between companies in regulated industries | 15 |
| Cross-border transaction | 14 |
| The acquirer ceased operations within a year after the transaction | 9 |
| Transaction is the acquisition of individual assets | 6 |
| Other reasons (duplicates, lack of information about the acquirer, etc.) | 9 |
| Final sample | 73 |
| Change in controlling shareholder | 50 |
| Consolidation | 23 |

*Source:* author's analysis.

the companies or both of them participated in another M&A transaction, ceased operations or did not publish the financial statement necessary for the analysis, the author reduced the period to obtain comparable data.

The considered period cannot be less than three years (a year before the transaction, the year of the transaction and the year after the transaction). Synergy was assumed to appear within no longer than three years after the transaction is completed.

The transactions were also excluded if the book value of the assets of the target company in the year the transaction was completed amounted to less than 5% of the acquirer's assets. Following studies [18] and [19], it was assumed that the transaction has a significant impact on the acquirer's financial statement only under this condition.

*Table 3* provides the details of all reasons for excluding transactions from the general population when collecting data.

In the final sample, the author separated the transactions that were a change in the controlling shareholder and did not imply the integration of activities of individual companies. This group includes transactions initiated by private individuals, investment companies and large diversified holdings.

The final sample contains 73 transactions that occurred in total for 3 to 7 years, as well as 446 individual observations. *Table 4* provides descriptive statistics on the main indicators of companies participating in the transactions included in the final sample, in the year of the transaction.

Assets, revenue and profitability of target companies and acquiring companies vary significantly. On average, acquiring companies are 16 times larger in assets and 8 times larger in revenues than target companies are.

## ASSESSING COST OF DEBT

The cost of debt assessment in the study is based on synthetic credit ratings of participating companies and the corresponding yield spreads between corporate and government bonds.

*Table 4*

**Descriptive statistics for companies in the final sample (in the year of the transaction)**

| Indicator (mln rubles) | Number | Average | Median | Min | Max | Standard deviation |
|---|---|---|---|---|---|---|
| Target companies | | | | | | |
| Assets | 73 | 28 173 | 6343 | 102 | 456 457 | 63 483 |
| Revenue | 73 | 24 507 | 4770 | 28 | 475 542 | 65 488 |
| Operating profit | 73 | 1472 | 246 | –9179 | 59 175 | 7878 |
| Percentage to be paid | 73 | 969 | 125 | 0 | 12 499 | 2122 |
| Operating cash flow | 68 | 979 | 221 | –29 252 | 50 735 | 8467 |
| Acquirers | | | | | | |
| Assets | 23 | 468 808 | 20 681 | 1480 | 9 953 401 | 2 067 987 |
| Revenue | 23 | 191 824 | 13 386 | 0 | 3 930 140 | 815 416 |
| Operating profit | 23 | 3212 | 1023 | –9678 | 34 481 | 7827 |
| Percentage to be paid | 23 | 16 385 | 319 | 0 | 358 112 | 74 502 |
| Operating cash flow | 22 | –4808 | 86 | –128 566 | 16 708 | 28 101 |

*Source:* author's analysis.

In the context of the depreciation of the ruble and sanctions against the Russian Federation, the tables of correspondence of debt coverage ratios and yield spreads, based on data from developed markets[7], may not be applicable to domestic Russian transactions, especially to the ones completed after 2014.

To solve this problem, the author compiled a similar table only for Russian public companies according to their financial statements for 2017, credit ratings, bond yields and default spreads (risk premiums) on February 20, 2019. A risk premium refers to the difference between yield to maturity of corporate bonds and zero coupon yield of government bonds of the Russian Federation with the same duration indicators.

Compiling the table and applying the obtained data to assess the cost of debt by non-public companies includes three stages.

The first stage determines the risk-free debt rate according to the yield on government bonds of the Russian Federation. The values of the yield curve on the last business day of each month were received from the website of the Central Bank of the Russian Federation[8] for the period from January 1, 2012 to February 20, 2019. The data on the website are based on the parametric model of the zero coupon yield curve of the Moscow Exchange[9]. *Table 5* presents the results.

The second stage forms a database linking the actual credit ratings of companies, interest coverage ratios and risk premiums. As in the sample of mergers and acquisitions, financial institutions and companies from regulated industries were not included in the database.

The yield to maturity and duration database is based on bond issues by companies with an ACRA national rating (Analytical Credit Rating Agency). The agency was established on Novem-

[7] For example, URL: http://pages.stern.nyu.edu/~adamodar/New_Home_Page/valquestions/syntrating.htm (accessed on 20.02.2019).

[8] The website of the Central Bank of the Russian Federation. URL: https://www.cbr.ru/hd_base/zcyc_params/ (accessed on 20.02.2019).

[9] The website of the Moscow Exchange. URL: https://www.moex.com/a3642 (accessed on 20.02.2019).

*Table 5*

**Government bond zero coupon yield curve (average per year), %**

| Years to maturity | 0.25 | 0.50 | 0.75 | 1.00 | 2.00 | 3.00 | 5.00 | 7.00 | 10.00 | 15.00 | 20.00 | 30.00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2012 | 6.0 | 6.2 | 6.3 | 6.4 | 6.8 | 7.1 | 7.5 | 7.8 | 8.0 | 8.3 | 8.5 | 8.7 |
| 2013 | 5.8 | 5.9 | 5.9 | 6.0 | 6.2 | 6.3 | 6.7 | 7.1 | 7.5 | 8.0 | 8.3 | 8.8 |
| 2014 | 8.0 | 8.3 | 8.5 | 8.6 | 9.2 | 9.5 | 9.6 | 9.6 | 9.6 | 9.5 | 9.5 | 9.4 |
| 2015 | 10.5 | 10.8 | 11.1 | 11.2 | 11.5 | 11.6 | 11.5 | 11.4 | 11.1 | 10.7 | 10.4 | 9.9 |
| 2016 | 9.5 | 9.5 | 9.4 | 9.4 | 9.2 | 9.1 | 8.9 | 8.8 | 8.8 | 8.8 | 8.8 | 8.9 |
| 2017 | 8.2 | 8.1 | 8.1 | 8.0 | 7.9 | 7.8 | 7.7 | 7.7 | 7.8 | 8.1 | 8.3 | 8.8 |
| 2018 | 6.8 | 6.8 | 6.9 | 7.0 | 7.2 | 7.4 | 7.6 | 7.8 | 8.0 | 8.2 | 8.3 | 8.6 |

*Source:* author's calculations based on the Central Bank of the Russian Federation data https://www.cbr.ru/hd_base/zcyc_params/ (accessed on 25.11.19).

ber 20, 2015. The list of its shareholders includes 27 major Russian companies and financial institutions each holding a share of 3.7% of its share capital, which totals over RUB 3 bln10.

The choice of a national rating agency instead of an international agency is due to the need to obtain ratings considering the specifics of the Russian market and the formation of a wider sample, especially among companies without an international investment rating.

The risk premium is estimated for each credit rating according to the yield curve of government bonds of the Russian Federation and corporate bond issues. To calculate the risk premium, they use the data on the yield of government bonds of the Russian Federation with the closest duration to the corresponding issue of corporate bonds. If there are several bond issues with the same rating, the risk premium for the credit rating is defined as a simple average value between all relevant bond issues.

The interest coverage ratio corresponding to the credit rating and default spread is calculated according to the consolidated annual financial statements of the company for 2017, compiled in accordance with international financial reporting standards.

$$\text{Interest coverage ratio} = \frac{\text{Operating profit}}{\text{Interest payable}}. \quad (1)$$

Formed at the second stage, the database includes 54 bond issues in circulation with market data on yield to maturity on February 20, 2019, organized by 13 companies with ACRA credit ratings and financial statement according to international standards for 2017. *Table 6* shows the relationship between credit ratings, interest coverage ratios and risk premiums.

The third stage assesses the cost of debt of the companies participating in the transaction. The interest coverage ratio before the transaction is calculated for companies considering the data of both companies separately and for the consolidated company after the transaction.

$$\text{Interest coverage ratio}_{i,t} = \\ = \frac{\text{Operating profit}_{iacquirer,t} + \text{Operating profit}_{i_{target},t}}{\text{Interest payable}_{i_{acquirer},t} + \text{Interest payable}_{i_{target},t}}. \quad (2)$$

The interest coverage ratio after the transaction is calculated according to the data of the consolidated company.

[10] The website of the Analytical Credit Rating Agency (ACRA). URL: https://www.acra-ratings.ru/about (accessed on 20.02.2019).

*Table 6*

**Relationship between corporate credit ratings, interest coverage ratios and risk premiums in Russia**

| ACRA credit rating | Companies in the sample | Outstanding bond issues | Average debt coverage ratio | Spread to risk-free return (risk premium) |
|---|---|---|---|---|
| AAA | PJSC Gazprom<br>JSC Russian Railways<br>PJSC Gazprom Neft<br>FSUE Russian Post | 18 | 4.56 | 0.72% |
| AA | JSC Federal Passenger Company<br>PJSC MegaFon<br>PJSC Rostelecom | 13 | 3.94 | 0.84% |
| A | LLC Tape<br>PJSC KAMAZ | 7 | 2.11 | 0.93% |
| BBB | JSC Garant-Invest Commercial Real Estate<br>PJSC PIK Group<br>JSC Avangard-Agro<br>JSC Samolet Group | 16 | 1.64 | 3.06% |

*Source:* author's analysis.

$$\text{Interest coverage ratio}_{i,t} = \\ = \frac{\text{operating profit}_{i_{consolidated\ company},t}}{\text{interest payable}_{i_{consolidated\ company},t}}, \quad (3)$$

where $i$ — is the transaction index; $t$ — is the index of the observation year. For the transactions where the acquiring company does not publish consolidated financial statements, consolidation was carried out according to the financial statements of both companies.

Each calculated interest coverage ratio was assigned a corresponding risk premium based on the actual data from the second stage of the assessment.

Risk premiums for companies with credit ratings below the investment level were extrapolated based on actual data by a polynomial trend line of the third degree (*Fig. 1*).

CCC credit rating and the corresponding risk premium of 14.0% was assigned to companies with interest coverage ratio of less than 0.5%. Companies with the interest coverage ratio of more than 4.56% got AAA credit rating and the risk premium of 0.7%. The risk premium for companies with the interest coverage ratio of 0.5%-4.56% was calculated according to the formula in *Fig. 1*.

The cost of debt of a company was calculated for each year as the total of the average yield of three-year government bonds of the Russian Federation for the corresponding year and the estimated risk premium of the company.

## HYPOTHESIS TESTING

The object of econometric analysis was an unbalanced data panel $\{y_{it}, x_{it}\}$, where $y$ is the cost of debt; $x$ — is possible factors of cost change; $i$ is the M&A index; $t$ — is the time index (years of monitoring companies before and after the transaction).

A random effects model was used to assess the significance of factors changing the cost of debt. The choice of this model is associated with the presence of time-invariant variables and was confirmed by the Breusch-Pagan and Hausman tests.

Due to the presence of heteroscedasticity, the model was evaluated with robust standard errors of the coefficients to obtain effective and consistent estimates of the coefficients. The Stata 15 program was used for the evaluation.

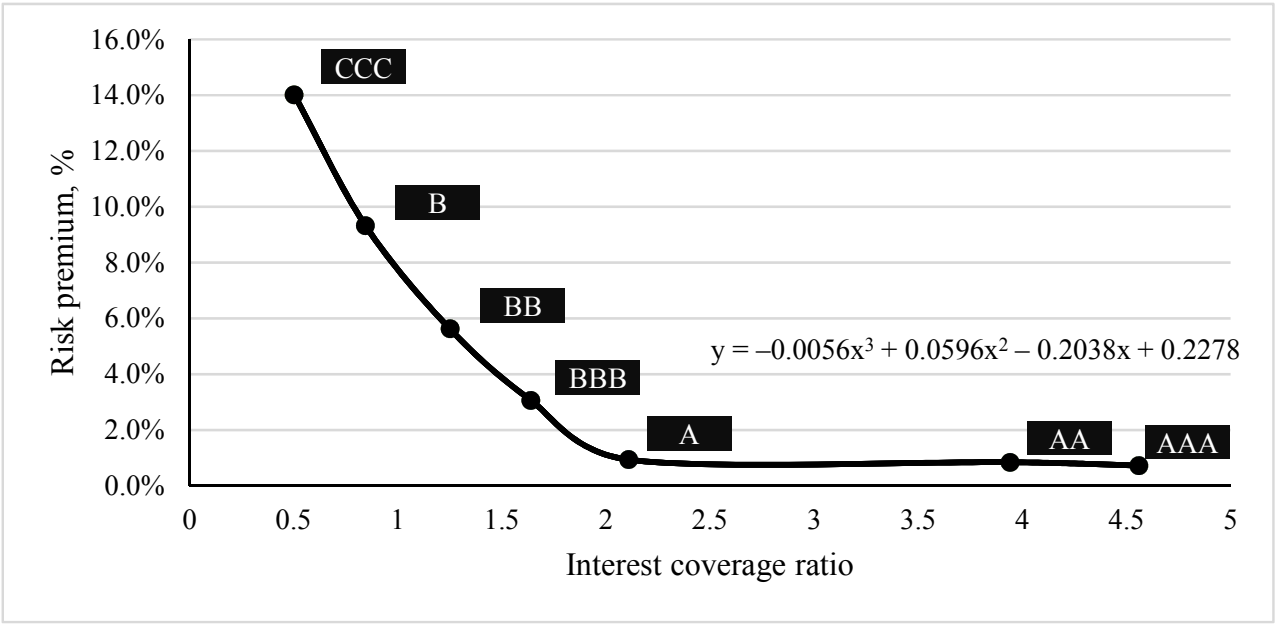



*Fig. 1.* **Dependence of risk premium on interest coverage ratio in Russia**

*Source:* author's analysis.

The general model equation is as follows:

$$cost\_of\_debt_{it} = \alpha + hypothesis_{it}\beta_1 + control_{it}\beta_2 + u_i + \varepsilon_{it}, \quad (4)$$

where *cost_of_debt* — is the estimation of the average cost of debt for the companies participating in the transaction; *hypothesis* — is a set of indicators to test hypotheses (factors changing the cost of debt); *control* — is a set of benchmarks.

The stability of the results was tested in two ways.

First, the basic model was evaluated separately with three groups of control variables: transaction characteristics, target and acquirer. The control characteristic of the transaction includes the equity share of the target after the transaction. The control characteristics of the target and the acquirer include operating cash flow, capital costs and the correlation of cash flows of companies. For the acquirer, the effect of the asset value, the presence of a foreign shareholder and the state in the equity capital was tested additionally.

Second, the basic model was evaluated separately, according to the observations only a year after the transaction was completed. The result helps determine the presence of a significant structural change in the data after the transaction, which affects the conclusions from the model evaluation for the entire observation period.

## RESULTS

*Fig. 2* shows the dynamics of the cost of debt over seven years of monitoring companies. *Table 7* presents average, median, minimum and maximum values of the cost of debt and the number of observations.

Almost all the companies in the sample have a low interest coverage ratio. In the transaction year, the average risk premium is 5.1%. According to the proposed methodology, it corresponds to the BB speculative credit rating. The estimated average cost of debt for the entire sample per transaction year is 15.9%.

Transactions lead to an increase in the cost of debt in the short term (in the year of the transaction and one year after), but after two years there is a tendency to a reduction in the cost of debt. Three years after the transaction, the cost of debt for the consolidated company returns to the level observed in the period prior to the transaction.

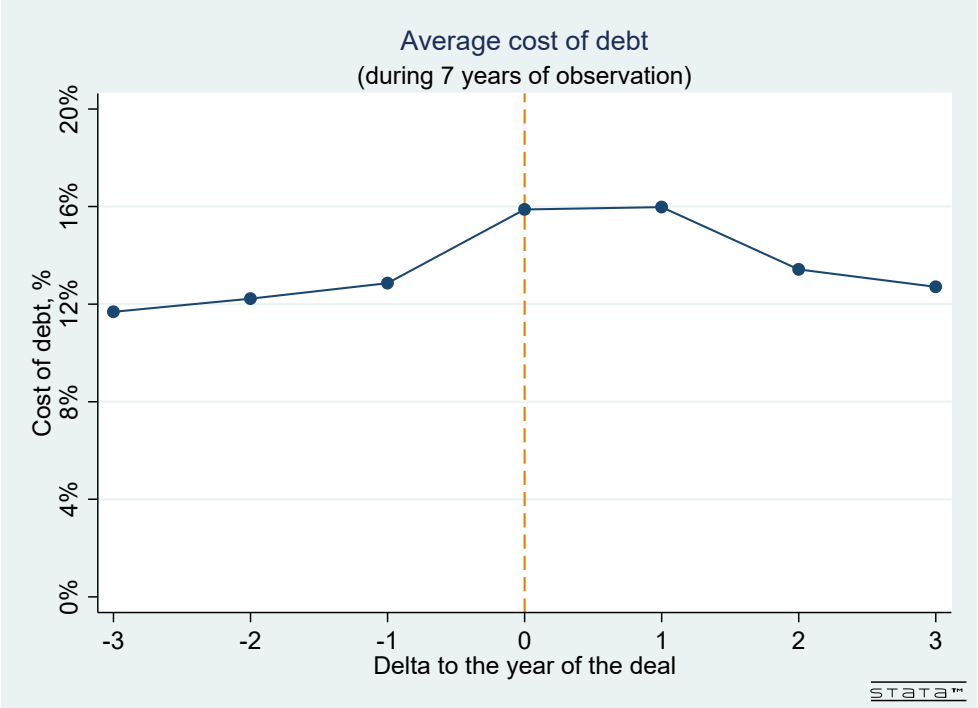



*Fig. 2.* **Average cost of debt for companies engaged in transactions during the entire research period**

*Source:* author's analysis.

*Table 7*

**Descriptive statistics for the cost of debt for every year**

| Delta to the year of the transaction, years | Number of observations | Average, % | Median, % | Min, % | Max, % |
|---|---|---|---|---|---|
| –3 | 62 | 11.7 | 8.2 | 6.9 | 21.1 |
| –2 | 68 | 12.2 | 9.6 | 6.6 | 23.5 |
| –1 | 73 | 12.9 | 10.2 | 6.5 | 25.6 |
| 0 | 73 | 15.9 | 12.3 | 9.4 | 25.6 |
| 1 | 73 | 16.0 | 12.4 | 8.5 | 25.6 |
| 2 | 62 | 13.4 | 9.8 | 8.1 | 23.1 |
| 3 | 35 | 12.7 | 8.6 | 8.0 | 21.8 |

*Source:* author's analysis.

Table 8 presents the results of econometric testing.

The results demonstrate that acquiring large companies during the period of economic growth contributes to lower cost of debt. A 1% increase in the value of the target's assets leads to a reduction in the cost of debt by 0.8% according to the basic model. A 1% increase in the real GDP growth rate leads to a reduction in the cost of debt by 1.2%.

Transaction cost is associated with the destruction of synergy. A 1% increase in transaction cost leads to a 2.7% increase in the cost of debt after the transaction. The negative effect from increasing the transaction cost by 1% is 3.4 times higher than the positive effect

*Table 8*

**Coefficient estimation results for the model**

| Variable | (1) Baseline model | (2) Baseline model after transaction | (3) First group of control variables | (4) Second group of control variables | (5) Third group of control variables |
|---|---|---|---|---|---|
| **Basic model parameters** | | | | | |
| GDP growth rate | −1.235*** (0.250) | −0.977*** (0.125) | −1.235*** (0.250) | −1.241*** (0.223) | −1.362*** (0.348) |
| Horizontal transaction | −0.005 (0.012) | −0.004 (0.015) | −0.003 (0.013) | −0.008 (0.011) | −0.015*** (0.004) |
| Natural logarithm of transaction cost | 0.027*** (0.004) | 0.036*** (0.006) | 0.028*** (0.003) | 0.028*** (0.003) | 0.027*** (0.002) |
| Natural logarithm of the target's asset value | −0.008* (0.004) | −0.012* (0.007) | −0.009** (0.004) | −0.007* (0.005) | −0.013*** (0.005) |
| Ownership concentration in the acquirer's capital | 0.053 (0.042) | 0.051 (0.043) | 0.051 (0.044) | 0.070* (0.039) | 0.129*** (0.017) |
| **Control characteristics of the transaction** | | | | | |
| Share in the capital of the target after the transaction | – | – | −0.020 (0.032) | – | – |
| **Control characteristics of the target** | | | | | |
| Natural logarithm of the operating cash flow of the target | – | – | – | −0.003 (0.003) | – |
| Natural logarithm of the capital costs of the target | – | – | – | 0.002 (0.002) | – |
| **Control characteristics of the acquirer** | | | | | |
| Natural logarithm of the acquirer's asset value | – | – | – | – | 0.021*** (0.007) |
| Natural logarithm of the acquirer's operating cash flow | – | – | – | – | −0.009* (0.005) |
| Natural logarithm of the acquirer's capital costs | – | – | – | – | −0.008*** (0.002) |
| The state in the acquirer's capital | – | – | – | – | −0.005 (0.005) |
| Foreign shareholder in the acquirer's capital | – | – | – | – | 0.012*** (0.003) |
| Cash flow correlation | – | – | – | – | −0.016** (0.006) |
| Control variables | Not included | Not included | Included | Included | Included |
| Constant | 0.027 (0.053) | 0.030 (0.061) | 0.053 (0.066) | 0.012 (0.052) | −0.092*** (0.024) |
| Number of observations | 446 | 243 | 446 | 446 | 446 |
| Number of transactions | 73 | 73 | 73 | 73 | 73 |
| Statistical significance test (chi-square) | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Coefficient of determination | 0.593 | 0.777 | 0.597 | 0.606 | 0.880 |

*Source:* author's analysis.

*Note:* Heteroscedasticity — robust standard errors are in brackets. The significance level of the regression parameters: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

from increasing the target's asset value by 1%, which may indicate that the acquirers overpay for the transaction in the context of lower cost of debt.

The ownership concentration in the acquirer's capital and the transaction type are not significant in the basic model.

To verify the stability of the results, the author additionally tested the basic model for observations after the transaction completion and three modifications of the model with control variables: with the transaction characteristics, with the characteristics of the target and with the characteristics of the acquirer.

Verification of the stability of the results confirms most of the estimates obtained in the basic model. In all control models, the GDP growth rate of the Russian Federation, the value of target assets and the transaction cost are significant with a level of at least 10% without changing the sign of the coefficient.

In the model modification with the transaction characteristics, the impact of the correlation of the free cash flows of the target and the acquirer on the cost of debt was also checked. This is due to the assumption that improved financial stability may occur after a transaction between companies with a negative correlation of cash flows. Testing confirms the presence of a significant inverse relationship between the correlation of cash flows and the cost of debt.

## CONCLUSIONS

The result of the study was the assessment of the significance of factors changing the cost of debt after domestic Russian M&As by the proposed method. The object of the study was Russian companies directly involved in M&As in Russia in 2014–2016.

The author generalized the previous study results regarding the M&A impact on the cost of debt.

Based on existing studies, the author proposed an approach to estimating the cost of debt considering the Russian specifics and estimated the cost of debt over seven years of monitoring the companies participating in the transaction. He developed an econometric random effects model and assessed the significance of factors changing the cost of debt.

Besides the scientific results, the study developed a number of practical recommendations. Acquiring large companies during a period of economic growth contributes to the reduction of the cost of debt. There is a significant effect of transaction cost on the increase in the cost of debt.

The developed methodology can be applied to M&As in other countries to analyze the specifics of these markets. Another direction for the study development may be to improve the model describing the relationship between the interest coverage ratio and the cost of debt for companies with speculative credit ratings.

## REFERENCES


1. Reed S., Lajoux A. The art of M&A: A merger acquisition buyout guide. Transl. from Eng. Moscow: Alpina Publisher; 2011. 960 p. (In Russ.).
2. DePamphilis D. Mergers, acquisitions, and other restructuring activities: An integrated approach to process, tools, cases, and solutions. Transl. from Eng. Moscow: Olymp-Business; 2007. 960 p. (In Russ.).
3. Damodaran A. Investment valuation: Tools and techniques for determining the value of any asset. 11th ed. Transl. from Eng. Moscow: Alpina Publisher; 2008. 1342 p. (In Russ.).
4. Chava S., Livdan D., Purnanandam A. Do shareholder rights affect the cost of bank loans? *The Review of Financial Studies*. 2008;22(8):2973–3004. DOI: 10.1093/rfs/hhn111
5. Elyasiani E., Jia J., Mao C. Institutional ownership stability and the cost of debt. *Journal of Financial Markets*. 2010;13(4):475–500. DOI: 10.1016/j.finmar.2010.05.001
6. Borisova G., Megginson W. Does government ownership affect the cost of debt? Evidence from privatization. *The Review of Financial Studies*. 2011;24(8):2693–2737. DOI: 10.1093/rfs/hhq154
7. Chen D. Classified boards, the cost of debt, and firm performance. *Journal of Banking & Finance*. 2012;36(12):3346–3365. DOI: 10.1016/j.jbankfin.2012.07.015

8. Hann R., Ogneva M., Ozbas O. Corporate diversification and the cost of capital. *The Journal of Finance*. 2013;68(5):1961–1999. DOI: 10.1111/jofi.12067
9. Hoepner A., Oikonomou I., Scholtens B., Schröder M. The effects of corporate and country sustainability characteristics on the cost of debt: An international investigation. *Journal of Business Finance & Accounting*. 2016;43(1–2):158–190. DOI: 10.1111/jbfa.12183
10. Reddy K., Nangia V., Agrawal R. The 2007–2008 global financial crisis, and cross-border mergers and acquisitions: A 26-nation exploratory study. *Global Journal of Emerging Market Economies*. 2014;6(3):16–29. DOI: 10.1177/0974910114540720
11. Goddard J., Molyneux P., Zhou T. Bank mergers and acquisitions in emerging markets: Evidence from Asia and Latin America. *The European Journal of Finance*. 2012;18(5):419–438. DOI: 10.1080/1351847X.2011.601668
12. Eckbo B. Horizontal mergers, collusion, and stockholder wealth. *Journal of Financial Economics*. 1983;11(1–4):241–273. DOI: 10.1016/0304–405X(83)90013–2
13. Lebedev S., Peng M., Xie E., Stevens C. Mergers and acquisitions in and out of emerging economies. *Journal of World Business*. 2015;50(4):651–662. DOI: 10.1016/j.jwb.2014.09.003
14. Grigoryeva S., Troitsky P. Impact of mergers and acquisitions on the operational efficiency of companies in emerging capital markets. *Korporativnye finansy = Journal of Corporate Finance Research*. 2012;6(3):31–43. (In Russ.). DOI: 10.17323/j.jcfr.2073–0438.6.3.2012.31–43
15. Kaplan S., Weisbach M. The success of acquisitions: Evidence from divestitures. *The Journal of Finance*. 1992;47(1):107–138. DOI: 10.1111/j.1540–6261.1992.tb03980.x
16. Bhaumik S., Selarka E. Does ownership concentration improve M&A outcomes in emerging markets? Evidence from India. *Journal of Corporate Finance*. 2012;18(4):717–726. DOI: 10.1016/j.jcorpfin.2012.04.001
17. Chi J., Sun Q., Young M. Performance and characteristics of acquiring firms in the Chinese stock markets. *Emerging Markets Review*. 2011;12(2):152–170. DOI: 10.1016/j.ememar.2010.12.003
18. Houston J., James C., Ryngaert M. Where do merger gains come from? Bank mergers from the perspective of insiders and outsiders. *Journal of Financial Economics*. 2001;60(2–3):285–331. DOI: 10.1016/S 0304–405X(01)00046–0
19. Penas M., Unal H. Gains in bank mergers: Evidence from the bond markets. *Journal of Financial Economics*. 2004;74(1):149–179. DOI: 10.1016/j.jfineco.2003.05.004

## ABOUT THE AUTHOR

***Vitalii B. Mikhal'chuk*** — Postgraduate Student, School of Finance, Faculty of Economic Sciences, NRU Higher School of Economics, Moscow, Russia
vitalymikhalchuk@gmail.com

*The article was submitted on 26.08.2019; revised on 10.09.2019 and accepted for publication on 20.10.2019. The author read and approved the final version of the manuscript.*

ORIGINAL PAPER



DOI: 10.26794/2587-5671-2019-23-6-91-116
UDC 336.7(045)
JEL G11, G12, G17, G32

# Model Risk Analysis of Multiplier Technology Applied at Stock Valuation of Russian Companies

**V.B. Minasyan**[a], **D.G. Ivko**[b]
Higher School of Finance and Management, Russian Presidential Academy of National Economy and Public Administration, Moscow, Russia
[a] https://orcid.org/000-0001-6393-145X; [b] https://orcid.org/0000-0001-7504-1390

## ABSTRACT

This work is a new direction in the authors' previous study on applying the market multipliers in assessing the value of oil and gas companies. The work is based on the findings of statistical studies of multipliers calculated for the industry, as well as their volatility over a 12-year period — from 2006 to 2017 inclusively, as exemplified by 46 companies from nine sectors of the economy of the Russian Federation. The analysis of the risk measures Value-at-Risk (hereinafter VaR) and Expected Shortfall (hereinafter ES) was conducted by means of volatility calculated in different ways. In particular, the multiplier volatility was introduced by V.B. Minasyan. It was established that for all nine sectors of the Russian economy, calculated with conventional stock volatility statistics (when possible), risk valuation measures VaR and ES led to lower calculated risk values compared to those calculated using multiplier volatility. The results of the study are of interest to evaluators, investors and other interested parties, as it allows to analyze the general behavior of the stock value in Russian companies and to compare the change in indicators of various economic sectors in terms of multiplier technology.

***Keywords:*** company valuation; multiplier P/E; multiplier P/B; stock value; stock volatility; multiplier volatility; risk measure VaR; risk measure ES

***For citation:*** **Minasyan V.B., Ivko D.G. Model risk analysis of multiplier technology applied at stock valuation of Russian companies. *Finance: Theory and Practice*. 2019;23(6):91-116. DOI: 10.26794/2587-5671-2019-23-6-91-116**

## INTRODUCTION

Speaking about company valuation, it is important to mention various approaches, models with their own advantages and disadvantages (see, for example, [1]). Today, experts note an increasing number of mergers and acquisitions1 [2], which emphasizes the additional interest in quick and efficient company valuation with minimum resources.

The data necessary for a qualitative company valuation, especially if they are not public, are not always available. Moreover, required indicators often change due to the high market volatility. What values should be used in a particular valuation model?

To evaluate stocks by the multiplier technology, the expected value estimated statistically often replaces their value.

Based on the example of 46 Russian companies, the results of multiplier behavior study by D.G. Ivko [3–5] show that multipliers have very high volatility both in industries and in specific companies. Therefore, the realized multiplier value will not necessarily be close to the expected value or to the value at the selected

[1] M&A market in Russia. Overview by KPMG. February 2019. URL: https://assets.kpmg/content/dam/kpmg/ru/pdf/2019/02/ru-ru-ma-survey-feb-2018.pdf (accessed on 27.09.2019).

moment. This may lead to a significant deviation of the real stock value from its valuation results when the multiplier method is applied.

Company valuation is mainly associated with decisions on purchase or sale of an asset, a merger and acquisition transaction. In such cases, incorrect valuation of a company or asset can affect the yield or contribute to loss of a deal for a potential investor.

The subject of this study is the risks associated with using multiplier technology in its various versions.

## MULTIPLIER TECHNOLOGY FOR STOCK VALUATION AND THE RELEVANT RISKS. DESCRIPTION OF THE SAMPLE OF COMPANIES

In the Russian Federation, a market (comparative) approach is widely used for company stock valuation. The approach is based on the market multiplier method. The valuation considers the information about the company compared to similar companies within the industry by other key performance indicators (see, for example, [1]), or compared to the industry indicators.

This approach suggests that these companies should be quoted at the same multiplier values.

There is a number of studies by European and American companies. However, the Russian stock market is relatively young and a series of minor shock news can increase the volatility of stock value indicators, etc. [6–9].

The "relative youth" of the mechanisms is an additional factor to be considered when using conclusions based on statistics from Western companies.

It is important that when applying the multiplier calculated for the industry, its real (fair) value for a particular company can deviate greatly from the corresponding estimate, since it is an average indicator for companies in the target industry. When using a multiplier of a public company, similar within the industry or in terms of operating activity, business structure or other key indicators, often they use either a statistical estimate of its expected value, or it is determined at a certain moment of time (for example, at the current moment of valuation). The result of applying the multiplier method described above depends on the choice of a similar company. In particular, the expected value of the multiplier of a similar company, as well as its value at a selected moment, can deviate greatly from the value at the time of the quote or deal. Obviously, the valuation quality is low.

The study examines how significant this deviation can be and how this will affect the valuation risk of companies from nine leading sectors of the Russian economy.

*Table 1* presents a list of the Russian economic sectors and the result of a sample of industry companies included in the MICEX index as of December 31, 2016.

Some works, for example, the one by V.A. Cherkasova [2], explore methods to select the so-called peer companies for valuation and describe the application of certain models to calculate corrective indicators. The approach using corrective indicators requires certain parameters and resources for the calculation. In practice, many evaluators use the multiplier technology due to its simplicity and speed of obtaining the stock valuation to make appropriate decisions.

A lot of research is devoted to this method and its application. A significant work by J. Liu, N. Doron and T. Jacob [10] is one of them. Other authors (S. Seghal, A. Pandey [11], C. Cheng and R. McNamara [6], E.F. Fama, and K.R. French [8]) have studied various aspects of the relationship of company multipliers with their profitability and value indicators.

R. Barnes [7] and D. Koutmos [9] have investigated the connection between the volatility of stock prices of companies and their individual indicators.

Following is the work by D.G. Ivko [4, 5], that studied the volatility of the multipliers P/E and P/B and their influence on the volatility of stock prices of Russian companies. We provide the volatility calculations for nine sectors of the Russian economy and the selected companies from the respective sectors for 2006–2017 inclusively.

*Table 1*

**Result of a sample of industry companies for research**

| No. | Name of industry / sector of the economy | Number of companies listed on the MICEX / RTS, pcs. | Number of companies selected for the portfolio* | Share of selected companies (coverage),% |
|---|---|---|---|---|
| 1 | Energy sector | | | |
| 2 | Metallurgy and mining | | | |
| 3 | Oil and gas | | | |
| 4 | Consumer sector | | | |
| 5 | Financial sector | | | |
| 6 | Chemical and petrochemical industry | | | |
| 7 | Telecommunications industry | | | |
| 8 | Engineering industry | | | |
| 9 | Transport | | | |
| | Total | 93 | 46 | – |

* Based on common stocks of Russian companies.

** In terms of capitalization, 7 companies cover 75% of all 24 listed companies in the industry.

*Source:* designed and compiled by the authors.

*Table 2* shows the data from the telecommunications industry and PJSC "ROSTELECOM". *Appendix 1* presents the results for the other sectors — the input data, on which only calculation results will be presented below.

*Table 2* shows the expected values and standard deviations of both absolute and relative values of the multipliers P/E and P/B at the industry and company level. The values of the multipliers and their volatility are quite high. Thus, using the multiplier calculated for the industry as part of valuation of the selected company at the moment, one can make a serious mistake due to the possible deviation of the multiplier calculated for the industry from the multiplier of the selected company and due to the significant volatility of the multiplier calculated for industry.

For example, replacing the multiplier P/B calculated for the industry with a multiplier of a similar company is even worse. Thus, ROSTELECOM, which is a public company, is the best similar company for itself. However, in this case, the significant volatility of its multiplier is obvious.

Therefore, the value of the company multiplier — both its expected value and the data at any particular moment (for example, during the valuation) — can significantly differ from the real value of the company multiplier at the time of a quote/deal. For non-public companies, there will also be a difference between the selected and the similar company. Obviously, there are significant risks in stock valuation of Russian companies as part of the multiplier method.

Following the study by D.G. Ivko on the presence and significance of the correlation of stock price volatility with the volatility of the considered multipliers [3, 4], the current study was

*Table 2*

**The results of calculations of indicators: the mathematical expectation and standard deviation based on data for 2006–2017**

| Indicator | Mathematical expectation of indicators | | Standard deviation of indicators (daily value) | |
|---|---|---|---|---|
| | Industry | PJSC "ROSTELEKOM" | Industry | PJSC "ROSTELEKOM" |
| For absolute values | | | | |
| Multiplier P/E | 16.14 | 34.48 | 40.79 | 16.14 |
| Multiplier P/B | 3.13 | 1.45 | 1.6 | 1.03 |
| Annual profit, rub. | 38 522 142 143 | 19 445 523 384 | 32 740 012 166 | 16 038 104 257 |
| Annual profit per 1 share, rub. | 20.69 | 8.91 | 13.97 | 6.37 |
| Book value, rub. | 434 978 343 567 | 156 013 716 041 | 224 183 681 052 | 98 070 503 443 |
| Book value per 1 share, rub. | 41.01 | 77.11 | 19.98 | 39.55 |
| Share price, rub. | 293.34 | 143.93 | 163.23 | 66.33 |
| For relative values | | | | |
| Return on multiplier P/E | –0.00064 | –0.00001 | 0.05399 | 0.0396 |
| Return on multiplier P/B | –0.00027 | –0.00007 | 0.09926 | 1.02606 |
| Share price, rub. | 0 | –0.00001 | 0.01625 | 0.0176 |

*Source:* designed and compiled by the authors.

conducted for nine industries for the periods of 2006–2011, 2012–2017 and 2006–2017.

*Table 3* presents the values of the correlation coefficients between the volatility of returns and the multipliers calculated for the industry. They show a periodically different, but significant statistical relationship between relative changes in the index calculated for the industry and the corresponding multipliers in seven out of nine industries.

The result makes us think about the quality of the valuations by the multiplier technology as applied to Russian companies.

In general, for the entire period from 2006 to 2017, for the telecommunications industry, the correlation coefficients between the volatility indicators of the portfolio index returns and the P/E portfolio volatility indicators and between the indicators of the portfolio index return volatility and the P/B portfolio volatility returns are

*Table 3*

**Results of the calculated values of correlation coefficients for the period from 2006 to 2017**

| Industry | Period | Results of correlation coefficients | |
|---|---|---|---|
| | | Between the volatility of returns on the portfolio's index and the volatility of returns on P/E portfolio | Between the volatility of returns on the portfolio's index and the volatility of returns on P/B portfolio |
| Oil and gas | 2006–2017 | –0.1068 | 0.7219 |
| | 2006–2011 | 0.6205 | 0.6048 |
| | 2012–2017 | –0.5374 | 0.5801 |
| Financial | 2006–2017 | 0.5924 | 0.1793 |
| | 2006–2011 | 0.5275 | 0.1056 |
| | 2012–2017 | 0.7652 | –0.0457 |
| Consumer sector | 2006–2017 | –0.239 | –0.2471 |
| | 2006–2011 | 0.7851 | –0.073 |
| | 2012–2017 | –0.6232 | –0.5877 |
| Transport | 2006–2017 | 0.2658 | 0 |
| | 2006–2011 | 0.6511 | 0 |
| | 2012–2017 | –0.2467 | 0 |
| Chemical | 2006–2017 | –0.1941 | 0.1886 |
| | 2006–2011 | 0.3649 | 0.3752 |
| | 2012–2017 | –0.4388 | –0.1612 |
| Engineering | 2006–2017 | 0.045 | –0.2972 |
| | 2006–2011 | 0.5555 | 0.8894 |
| | 2012–2017 | –0.2879 | 0.0687 |
| Metallurgical and mining | 2006–2017 | 0.4879 | 0.7029 |
| | 2006–2011 | 0.581 | 0.6476 |
| | 2012–2017 | 0.223 | 0.03 |
| Energy | 2006–2017 | 0.7007 | 0.7176 |
| | 2006–2011 | 0.8627 | 0.8681 |
| | 2012–2017 | 0.7523 | –0.0247 |
| Telecommunications | 2006–2017 | 0.0061 | 0.0255 |
| | 2006–2011 | 0.4062 | –0.104 |
| | 2012–2017 | –0.4108 | –0.0259 |

*Source:* designed and compiled by the authors.

*Table 4*

**Results of the calculated values of the correlation coefficients by years in the telecommunications industry for the period from 2006 to 2017**

| Correlation coefficient | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2006–2017 | 2006–2011 | 2012–2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Between the volatility of returns on the portfolio's index and the volatility of returns on P/E portfolio | 0.90 | 0.38 | 0.71 | 0.38 | 0.87 | 0.97 | 0.99 | –0.14 | –0.03 | –0.30 | 0.77 | 0.72 | 0.01 | 0.41 | –0.41 |
| Between the volatility of returns on the portfolio's index and the volatility of returns on P/B portfolio | 0.92 | 0.07 | 0.92 | 0.99 | 0.98 | 0.92 | –0.18 | 0.31 | 0.68 | 0.98 | 0.41 | 0.77 | 0.03 | –0.10 | –0.03 |

*Source:* designed and compiled by the authors. High level of connection with coefficient values over 0.49.

close to zero. Now, the "behavior" of the indicators by year within the studied period should be considered in more detail.

*Table 4* makes it clear that only in two cases out of 12 none of the indicators "showed" a high level of connection (in 2007 and 2013). Over a number of years, the coefficient generally changes the sign from "+" to "–". In this industry, one should consider not only the impact of the financial crisis in the economy in 2008–2010 and in 2014, but also the features of the industry itself, the specifics of the telecommunications company. Thus, in 2006–2011 and 2012–2017, this group does not fully reflect the situation on the market and one should consider the annual calculation results.

The multipliers P/E and P/B were chosen as the most common and basic indicators that evaluators often check first. This study can additionally be conducted for other equally important multipliers: EV/EBITDA (company value / profit before taxes, interest and depreciation), P/CF (price / cash flow) or P/DIV (price / dividends) and others.

Further, to assess the model risk (multiplier technology), we used the method of model risk analysis in stock valuation proposed by V. B. Minasyan [12].

On the example of the method by V. B. Minasyan, it is expedient to conduct calculations for the telecommunications industry, thereby showing that the method is accessible and requires minimal knowledge of statistics and econometrics to be applied. The results are explained below.

## ASSESSMENT OF RISK MEASURES VAR AND ES USING MULTIPLIER VOLATILITY FROM VARIOUS SECTORS OF THE RUSSIAN ECONOMY

The stock price in the next time period depends not only on factors such as the current level of development and the situation in the company, industry, sector and region, but also on the perception of information about the company

by its external consumers: investors, regulatory authorities and other market participants. Thus, the price behaves as a random variable. Of course, the stock price volatility is also significantly affected by speculative operations, sometimes not related to the fundamental characteristics of a company's financial performance, but more related to the ability to use specific information that has a short-term effect or its specific perception. Following assessment risks are of particular interest for the study. The importance of stock price volatility is increasing for potential investors.

In his work [12], V.B. Minasyan first introduced the term "multiplier" stock volatility, i.e. proposed a method to express stock price volatility through the volatility of company multipliers. This interpretation of stock volatility became possible due to the dependence of stock volatility on the volatility of the multipliers P/E and P/B for Russian companies.

The "multiplier" volatility of stocks is a new method to estimate their volatility based on the volatility of the multipliers P/E and P/B considered in the study. In this paper, the multiplier estimates of expected prices and their volatility will be denoted by $E_{M,E}(P)$ and $\sigma_{M,E}(P)$ or by $E_{M,B}(P)$ and $\sigma_{M,B}(P)$, respectively, depending on whether the multipliers P/E and P/B were used. In our opinion, this method will be especially relevant for non-public companies for which there is no available stock price quotation data.

Thus, the following statements are true for the multipliers P/E and P/B [12]:

$$E_{M,E}(P) = E(E) \cdot E\left(\frac{P}{E}\right); \quad (1)$$

$$\sigma^2_{M,E}(P) = \sigma^2(E) \cdot \sigma^2\left(\frac{P}{E}\right) + \sigma^2(E)\left(E\left(\frac{P}{E}\right)\right)^2 + \left(E(E)\right)^2 \cdot \sigma^2\left(\frac{P}{E}\right). \quad (2)$$

(For details related to the idea of multiplier volatility and the derivation of formulas, see [12]).

$VaR_p$ (Value at Risk) indicator is often used to determine the risk of stock investment. $VaR_p$ is the maximum possible deviation for the worse from the company's stock price from its expected value in a set time period $T$ with a given confidence probability $p$ [12–15].

The formula to calculate Value at Risk is:

$$VaR_p = k_p^{0.1} \cdot \sigma(P) \cdot \sqrt{\frac{T}{\tau}}, \quad (3)$$

where $\sigma(P)$ — is the price volatility (here, calculated as its standard deviation for the period $\tau$ (days);

$T$ — is the investment horizon (days); $k_p^{0.1}$ — is the quantile of standardized stock price distribution with the confidence probability $p$ [12–15].

In addition to VaR, it is necessary to calculate the Expected Shortfall with the confidence probability $p$, $ES_p$, reflecting the average value of price deviations from its expected value, which could potentially occur in the worst-case scenarios implemented with a probability of $1 - p$ [12–15].

The formula to calculate the Expected Shortfall is:

$$ES_p = \sigma(P) \cdot \sqrt{\frac{T}{\tau}} \cdot \frac{1}{\sqrt{2\pi}} \cdot \frac{\exp(-0{,}5\left(k_p^{0.1}\right)^2}{1-p}, \quad (4)$$

where $\pi \approx 3.14$, and the standard notation for the exponential function is applied $\exp(x) = e^x$, where $e \approx 2.71$.

In these VaR and ES formulas, volatility values are usually provided by the statistical estimates from a sample of the company's stock price quotations. Since it is now possibile to determine multiplier estimates of the stock price volatility $\sigma_M(P)$ and $\sigma_B(P)$, we will calculate the VaR and ES multiplier values, which we denote by $VaR_p^M$ и $ES_p^M$ $\left(VaR_p^B \text{ и } ES_p^B\right)$ according to the above formulas:

$$VaR_p^M = k_p^{0.1} \cdot \sigma_M(P) \cdot \sqrt{\frac{T}{\tau}},$$

$$ES_p^M = \sigma_M(P) \cdot \sqrt{\frac{T}{\tau}} \cdot \frac{1}{\sqrt{2\pi}} \cdot \frac{\exp(-0{,}5\left(k_p^{0.1}\right)^2}{1-p}. \quad (5)$$

Formula (5) will look similar both for $VaR_p^B$ and for $ES_p^B$.

In the example below, these risk measures will be calculated with the confidence probabilities of 0.95. However, depending on the mission, another confidence probability, different from 0.95, may be chosen.

In terms of the proposed technology, we will now provide the detailed calculations of ROSTELECOM's stocks valuation and the risks of investing in it in three ways:

1. Risk assessment of investing in the company's stocks by usual stock volatility values.

2. Risk assessment of investing in the company's stocks by values of the multiplier P/E and the multiplier valuation of stock volatility.

3. Risk assessment of investing in the company's stocks by values of the multiplier P/B and the multiplier valuation of stock volatility.

Suppose, the management of the company that invested in ROSTELECOM's stocks knows that this company will face serious financial difficulties if the stock price falls below 15 rubles in a year (in 2018). The investor wants to be sure that a probability of difficulties is no more than 5%. It is important to understand whether this scenario is reliable. What will the average stock price be after 5% of the worst-case scenarios are implemented? We expect normal distribution of the stock price within the calculations provided below.

**1. Risk assessment of investing in the company's stocks by usual stock volatility values.**

Statistical estimates of the expected ROSTELECOM stock price and its standard deviation based on a sample of quotes for 2006–2017, amount to 143.93 and 66.33 rubles respectively. VaR calculation:

$$VaR_{0,95} = 1.65 \cdot 66.33 = 109.44 \text{ rubles.}$$

This result suggests that with a probability of 5% the company's stock price may become 109.44 rubles less than expected. Thus, with a probability of 95%, the company can expect the stock price to be no less than 143.93 – 109.44 = = 34.48 rubles > 15 rubles. Therefore, a probability of serious difficulties is no more than 5%. To estimate the company's average stock price, which may occur in 5% of the worst-case scenarios, we calculate ES for the coming year.

$$ES_{0.95} = 66.33 \cdot \frac{1}{\sqrt{2\pi}} \cdot \frac{\exp(-0,5(1.65)^2}{1-0.95} = 135.66.$$

Despite the fact that at the end of 2018, the company expects the stock price to be143.93 rubles, in the worst-case scenarios, implemented with a probability of 5%, the average expected price can be 143.93 – 135.66 = 8.26 rubles <15 rubles. On average, in 5% of the worst-case scenarios, the investors in ROSTELECOM expect serious financial difficulties.

**2. Risk assessment of investing in the company's stocks by values of the multiplier P/E and the multiplier valuation of stock volatility.**

To calculate the expected value of ROSTELECOM at the end of 2018, we first apply industry estimates of the expected value and volatility of the multiplier P/E and the expected profits and profit volatility of ROSTELECOM, provided in *Table 2*:

$$E_{M,E}(P) = E(E) \cdot E\left(\frac{P}{E}\right) = 8.91 \cdot 16.14 =$$

$$= 143.77 \text{ руб.}$$

$$\sigma_{M,E}(P) = (\sigma^2(E) \cdot \sigma^2\left(\frac{P}{E}\right) + \sigma^2(E) \left( \begin{array}{c} E\left(\frac{P}{E}\right)^2 + \\ + \left(E(E)\right)^2 \cdot \sigma^2\left(\frac{P}{E}\right) \end{array} \right)^{\frac{1}{2}} =$$

$$= 6.37^2 \cdot 40.79^2 + 6.37^2 \cdot 16.14^2 + 8.91^2 \cdot 40.79^2)^{\frac{1}{2}} = 458.41 \text{ руб.}$$

Next, we calculate $VaR_{0.95}^{M,E}$:

$$VaR_{0.95}^{M,E} = 1.65 \cdot 458.41 = 756.37 \text{ rub.}$$

With a probability of 5%, the company's stock price may become less than expected by 756.37 rubles compared to the expected value. Thus, when using the multiplier P/E with a probability of 95%, we can expect the stock price to be no less than

143.77 – 756.37 = –612.60 rubles. Given that the stock liability is limited by the stock price, we understand that the stock price cannot be negative. The model claims that in the worst-case scenario, the expected stock price will be zero with a probability of 95%. According to the multiplier model, the company's stock will cost nothing with a probability of more than 5%.

To estimate the average stock price, which may occur in 5% of the worst-case scenarios, we will calculate $ES_{0,95}^{M,E}$ for 2018:

$$ES_{0.95}^{M,E} = 458.41 \cdot \frac{1}{\sqrt{2\pi}} \cdot \frac{\exp(-0.5(1.65)^2}{1-0.95} = 937.58 \text{ rub.}$$

Despite the fact that the company expects the stock price to be 143.77 rubles by the end of 2018, in the worst-case scenarios, implemented with a probability of 5%, the average expected price can be 143.77–937.58 = –793.80 rubles. On average, in 5% of the worst-case scenarios, the investors in ROSTELECOM expect serious financial difficulties associated with a complete loss of the value of the acquired stocks.

In some cases, using the multiplier valuation of a specific stock in calculations, the comparative method does not use the expected value of the multiplier calculated for the industry, but the expected value of the multiplier of a similar company.

ROSTELECOM is a public company and may act as a similar company itself. Let us recalculate, applying the expected value and standard deviation of ROSTELECOM's multiplier P/E. We get the following results:

$$E_{M,E}(P) = 8.91 \cdot 15.37 = 136.88 \text{ rub.}$$

$$\sigma_{M,E}(P) = 6.37^2 \cdot 16.14^2 + 6.37^2 \cdot 15.37^2 + 8.91^2 \cdot 16.14^2)^{\frac{1}{2}} = 202.10 \text{ rub.}$$

Next, we calculate $VaR_{0.95}^{M,E}$:

$$VaR_{0.95}^{M,E} = 1.65 \cdot 202.10 = 333.47 \text{ rub.}$$

With a probability of 5%, the company's stock price may become 333.47 rubles less than expected. Thus, when using the multiplier P/E with a probability of 95%, we expect the stock price to be no less than 136.88 – 333.47 = = –196.59 rubles. Given that the stock liability is limited by the stock price, we understand that the stock price cannot be negative. The model claims that in the worst-case scenario, the expected stock price will be zero with a probability of 95%. According to the multiplier model, the company's stock will cost nothing with a probability of more than 5%.

To estimate the average stock price, which may occur in 5% of the worst-case scenarios, we will calculate $ES_{0.95}^{M,E}$ for the next:

$$ES_{0.95}^{M,E} = 202.10 \cdot \frac{1}{\sqrt{2\pi}} \cdot \frac{\exp(-0.5(1.65)^2}{1-0.95} = 413.36 \text{ rub.}$$

Despite the fact that the company expects the stock price to be 136.88 rubles by the end of the next year, in the worst-case scenarios, implemented with a probability of 5%, the average expected price can be 136.88 – 413.36 = –276.48 rubles. On average, in 5% of the worst-case scenarios, the investors in ROSTELECOM expect serious financial difficulties associated with a complete loss of the value of the acquired stocks.

**3. Risk assessment of investing in the company's stocks by values of the multiplier P/B and the multiplier valuation of stock volatility.**

To calculate the expected value of ROSTELECOM at the end of 2018, we first apply industry estimates of the expected value and the multiplier P/B volatility and the expected profits and profit volatility of ROSTELECOM, provided in *Table 2*:

$$E_{M,B}(P) = 77.11 \cdot 3.13 = 241.73 \text{ rub.}$$

$$\sigma_{M,B}(P) = 39.55^2 \cdot 1.6^2 + 39.55^2 \cdot 3.13^2 + 77.11^2 \cdot 1.6^2)^{\frac{1}{2}} = 185.78 \text{ rub.}$$

Next, we calculate $VaR_{0,95}^{M,B}$:

$$VaR_{0.95}^{M,B} = 1.65 \cdot 185.78 = 306.54 \text{ rub.}$$

With a probability of 5%, the company's stock price may become less than expected by 306.54 rubles compared to the expected value. Thus, when using the multiplier P/B with a probability of 95%, we can expect the stock price value to be no less than 241.73 – 306.54 = –64.80 rubles < 15 rubles. Thus, a probability of serious difficulties is more than 5%.

To estimate the average stock price, which may occur in 5% of the worst-case scenarios, we will calculate $ES_{0.95}^{M,B}$ for 2018:

$$ES_{0.95}^{M,B} = 185.78 \cdot \frac{1}{\sqrt{2\pi}} \cdot \frac{\exp(-0.5(1.65)^2}{1-0.95} = 379.97 \text{ rub.}$$

Despite the fact that the company expects the stock price to be 241.73 rubles at the end of 2018, in the worst-case scenarios, implemented with a probability of 5%, the average expected price can be 241.73–379.97= –138.24 rubles. On average, in 5% of the worst-case scenarios, the investors expect serious financial difficulties associated with a complete loss of the value of the acquired stocks.

We apply the expected value and ROSTELECOM's multiplier volatility:

$$E_{M,B}(P) = 77.11 \cdot 1.45 = 112.14 \text{ rub.}$$

$$\sigma_{M,B}(P) = (39.55^2 \cdot 1.03^2 + 39.55^2 \cdot 1.45^2 + 77.11^2 \cdot 1.03^2)^{\frac{1}{2}} = 142.12 \text{ rub.}$$

Next, we calculate $VaR_{0.95}^{M,B}$:

$$VaR_{0.95}^{M,B} = 1.65 \cdot 142.12 = 234.49 \text{ rub.}$$

With a probability of 5%, the company's stock price may become less than expected by 234.49 rubles compared to the expected value. Thus, when using the multiplier P/B for company valuation with a probability of 95%, we can expect the stock price to be no less than 112.14 – 234.49 = –122.35 rubles.

Given that the stock liability is limited by the stock price, we understand that the stock price cannot be negative. The model claims that in the worst-case scenario, the expected stock price will be zero with a probability of 95%. According to the multiplier model, the company's stock will cost nothing with a probability of more than 5%.

To estimate the average stock price, which may occur in 5% of the worst-case scenarios, we will calculate $ES_{0.95}^{M,B}$ for 2018:

$$ES_{0.95}^{M,B} = 142.12 \cdot \frac{1}{\sqrt{2\pi}} \cdot \frac{\exp(-0.5(1.65)^2}{1-0.95} = 290.67 \text{ rub.}$$

Despite the fact that the company expects the stock price to be 112.14 rubles at the end of the next year, in the worst-case scenarios, implemented with a probability of 5%, the average expected price can be 112.14–290.67= –178.53 rubles. On average, in 5% of the worst-case scenarios, the investors expect serious financial difficulties associated with a complete loss of the value of the acquired stocks.

This example shows the huge risks for the counterparty in the stock valuation by a comparative method using multipliers that can be applied by the evaluator.

It should be noted that the valuation method using multipliers is most frequently applied in equity valuation of non-public companies. For public companies, market valuation is considered the best. At the same time, it is not possible for non-public companies to obtain an estimate of the expected stock price at the end of the next period based on quotes. Therefore, the estimates obtained by using multipliers have nothing to compare.

It should be noted that only 16 of the 46 companies represented in this study did not have serious problems with indicators of net profit and book value, i.e. these indicators had a positive value from 2006 to 2017. This fact further emphasizes the risks of obtaining high-quality estimates by multiplier technology using P/E and P/B.

*Table 5*

**Calculation results of the expected value of investments in ROSTELECOM stocks and the risks of these investments based on risk measures VaR and ES**

| | $E(P)$ (rub.) | $\sigma(P)$ (rub.) | $VAR_{0.95}$ (rub.) | $ES_{0.95}$ (rub.) |
|---|---|---|---|---|
| Standart statistical estimates | 143.93 | 66.33 | 109.44 | 135.66 |
| Estimates using the industry multiplier P/E | 143.77 | 458.41 | 756.37 | 937.58 |
| Estimates using the industry multiplier P/E for PJSC "ROSTELEKOM" | 136.88 | 202.1 | 333.47 | 413.36 |
| Estimates using the industry multiplier P/B | 241.73 | 185.78 | 306.54 | 379.97 |
| Estimates using the industry multiplier P/B for PJSC "ROSTELEKOM " | 112.14 | 142.12 | 234.49 | 290.67 |

*Source:* the author's calculations.

The example of the public company ROSTELECOM is interesting as it provides estimates of the company's expected stock prices applying quotes and the expected values of the industry multipliers P/E and P/B. Also, the risks of investing in ROSTELECOM stocks were assessed based on risk measures VaR and ES calculated on normal distribution applying the usual statistical estimation of volatility and of the P/E and P/B multiplier volatility. *Table 5* provides the results. *Appendix 2* presents the data on the other sectors where one company, the industry representative, was selected.

The above example makes it clear that the company's expected stock valuation by the multiplier method significantly deviate from its statistical estimation.

The difference in estimating the multiplier volatility of the company's stocks using both multipliers is much altered from the usual statistical volatility estimation. This leads to the fact that both the risk measure VaR and the risk measure for catastrophe ("tail"), calculated using multiplier volatility, ultimately provide higher estimates of the corresponding risks compared to the statistical estimation of volatility. These significant differences in assessing the risks of stock investment are associated both with a high risk of valuation using the multiplier method, as well as with the fact that the usual, historical volatility estimation assumes that the future will be an average repetition of the stock history of a particular company. The multiplier volatil-

ity estimation may contain information about "fundamental" changes in the industry that may not have happened in the company yet, but may affect it in the future. This may be the added value of a multiplicative estimation of the company's stock volatility.

It is worth noting that the normal distribution of stock prices was expected in the example above, which is not quite realistic. As a rule, in a real situation, the distribution has a thicker left tail. For this reason, risks can only be greater than the estimates obtained in our example. Moreover, the purpose of this study was to compare relative values of risk assessments using various assessment methods and constant assumptions about the distribution law.

## CONCLUSIONS

The work studied the multiplier method, a classic and commonly used assessment method. The authors calculated the risks of the method use in stock valuation of Russian companies from nine industries. The expected industry average value was used to estimate the multipliers. It is worth revealing how significant the volatility of the applied multipliers is within the industries, i.e. location, distribution by companies within the industry and distribution over time, and how it affects our valuation. The original method of multiplier estimation of stock volatility was used [12]. It clears the estimation of the short-term background and brings it closer to the fundamental industry related to the nature of the business. The risk measures VaR and ES were assessed based on the multiplier volatility estimation. It makes it possible to obtain a different assessment of risk measures to be considered when deciding on long-term investments.

The paper emphasizes the general behavior of the stock value of Russian companies in 2006–2017 depending on the industry. This will help in making decision on the purchase/sale of stocks. It will also provide an opportunity to compare the behavior of indicators between the economic sectors in terms of the multiplier technology for Russian companies' stocks.

The model risk analysis in stock valuation proposed by V. B. Minasyan [12] can be used by any market participant to check estimates of the stock value of Russian companies, both public and non-public, from any industry and any country.

The Russian stock market is relatively young compared to the Western ones (officially, the New York Stock Exchange was founded in 1817, the London Stock Exchange — in 1801, the modern Russian stock market was formed in 1991–1992). Therefore, it is important to apply Western approaches in the stock valuation of Russian companies very carefully.

*Appendix 1*

**Calculation results of the values of mathematical expectation and standard deviation of the indicators for 8 industries according to data for 2006–2017**

| Indicator | Mathematical expectation of indicators | | Standard deviation of indicators (daily value) | |
|---|---|---|---|---|
| | 1 | | | |
| | Oil and gas industry | The company PJSC LUKOIL | Oil and gas industry | The company PJSC LUKOIL |
| **For absolute values** | | | | |
| Multiplier P/E | 8.01 | 3.62 | 5.96 | 3.12 |
| Multiplier P/B | 1.33 | 0.36 | 0.56 | 0.22 |
| Annual profit. rub. | 1 830 989 337 608.95 | 756 689 059 530.53 | 502 810 804 661.20 | 366 427 607 182.75 |
| Annual profit per 1 share. rub. | 80.66 | 889.63 | 22.81 | 430.81 |
| Book value. rub. | 14 567 488 976 545.90 | 6 197 541 987 787.15 | 6 305 752 644 152.43 | 2 614 386 471 775.69 |
| Book value per 1 share. rub. | 1 214 823.17 | 7286.40 | 871 127.12 | 3073.71 |
| Share price. rub. | 557.86 | 1997.40 | 183.59 | 421.63 |
| **For relative values** | | | | |
| Return on multiplier P/E | –0.00026 | 0.00008 | 0.06546 | 0.02491 |
| Return on multiplier P/B | –0.00011 | 0.00008 | 0.02517 | 0.02697 |
| Return on shares | 0.00002 | 0.00014 | 0.02490 | 0.01929 |

*Appendix 1 (continued)*

| Показатель / Indicator | Mathematical expectation of indicators | | Standard deviation of indicators (daily value) | |
|---|---|---|---|---|
| | 2 | | | |
| | Finance industry | PJSC VTB | Finance industry | PJSC VTB |
| **For absolute values** | | | | |
| Multiplier P/E | 21.18 | 23.19 | 1 073.13 | 1 380.49 |
| Multiplier P/B | 1.21 | 1.20 | 4.63 | 10.40 |
| Annual profit, rub. | 170 060 170 087.25 | 32 783 282 318.96 | 174 052 905 920.02 | 42 052 442 932.22 |
| Annual profit per 1 share, rub. | 232.73 | 0.00 | 860.23 | 0.00 |
| Book value, rub. | 2 344 981 714 490.77 | 627 971 033 410.97 | 1 500 775 221 050.48 | 491 819 694 540.61 |
| Book value per 1 share, rub. | 252.41 | 0.06 | 854.88 | 0.04 |
| Share price, rub. | 4550.27 | 0.07 | 19 028.12 | 0.04 |
| **For relative values** | | | | |
| Return on multiplier P/E | –0.00290 | –0.00214 | 0.15560 | 0.08525 |
| Return on multiplier P/B | –0.00136 | –0.00172 | 0.13273 | 10.39668 |
| Return on shares | 0.00234 | –0.00042 | 0.04339 | 0.02663 |

*Appendix 1 (continued)*

| Indicator | Mathematical expectation of indicators | | Standard deviation of indicators (daily value) | |
|---|---|---|---|---|
| | 3 | | | |
| | Customer industry | The company PJSC MAGNIT | Customer industry | The company PJSC MAGNIT |
| **For absolute values** | | | | |
| Multiplier P/E | 2832.91 | 25.65 | 67959.31 | 275.66 |
| Multiplier P/B | 243.79 | 4.71 | 1584.68 | 2.79 |
| Annual profit, rub. | 17066674356.26 | 16544704092.27 | 19561326882.26 | 20040243188.17 |
| Annual profit per 1 share, rub. | 78.99 | 177.85 | 126.39 | 209.81 |
| Book value, rub. | 169886504210.69 | 81322432369.90 | 126242266173.72 | 69616797930.15 |
| Book value per 1 share, rub. | 113.04 | 812.07 | 155.32 | 732.60 |
| Share price, rub. | 1465.50 | 4374.92 | 1945.85 | 4073.63 |
| **For relative values** | | | | |
| Return on multiplier P/E | –0.00144 | 0.00015 | 0.15816 | 0.04435 |
| Return on multiplier P/B | –0.00042 | –0.00039 | 0.17372 | 2.79444 |
| Return on shares | 0.00015 | 0.00042 | 0.01806 | 0.01864 |

*Appendix 1 (continued)*

| Indicator | Mathematical expectation of indicators | | Standard deviation of indicators (daily value) | |
|---|---|---|---|---|
| | 4 | | | |
| | Transportation industry | The company PJSC Aeroflot | Transportation industry | The company PJSC Aeroflot |
| **For absolute values** | | | | |
| Multiplier P/E | 5.87 | 6.65 | 51.42 | 79.26 |
| Multiplier P/B | 1.86 | 1.69 | 21.21 | 46.38 |
| Annual profit, rub. | 6 331 941 468.25 | 5 109 006 025.93 | 23 372 206 808.89 | 12 222 261 643.70 |
| Annual profit per 1 share, rub. | 2.26 | 4.87 | 7.52 | 11.58 |
| Book value, rub. | 71 916 167 710.24 | 24 137 965 364.08 | 55 770 409 229.32 | 21 605 954 180.08 |
| Book value per 1 share, rub. | 4.31 | 21.24 | 7.28 | 20.63 |
| Share price, rub. | 35.40 | 68.77 | 25.59 | 37.72 |
| **For relative values** | | | | |
| Return on multiplier P/E | 0.00086 | –0.00039 | 0.27111 | 0.09091 |
| Return on multiplier P/B | –0.00084 | –0.00041 | 0.12045 | 46.37731 |
| Return on shares | 0.00026 | 0.00028 | 0.01578 | 0.01938 |

*Appendix 1 (continued)*

| Indicator | Mathematical expectation of indicators | | Standard deviation of indicators (daily value) | |
|---|---|---|---|---|
| | 5 | | | |
| | Chemical industry | The company PJSC AKRON | Chemical industry | The company PJSC AKRON |
| **The absolute values** | | | | |
| Multiplier P/E | 8.78 | –1.09 | 156.70 | 164.59 |
| Multiplier P/B | 3.07 | 0.91 | 58.52 | 0.63 |
| Annual profit, rub. | 32 602 971 048.03 | 7 944 940 916.66 | 37 489 187 119.99 | 7 271 191 752.19 |
| Annual profit per 1 share, rub. | 70.53 | 191.10 | 56.22 | 178.37 |
| Book value, rub. | 231 431 009 826.53 | 51 876 676 923.79 | 158 271 296 053.57 | 35 612 154 229.29 |
| Book value per 1 share, rub. | 241.39 | 1256.09 | 184.96 | 888.39 |
| Share price, rub. | 969.07 | 1281.50 | 1477.45 | 643.54 |
| **For relative values** | | | | |
| Return on multiplier P/E | –0.00052 | –0.00135 | 0.19172 | 0.03623 |
| Return on multiplier P/B | –0.00017 | –0.00006 | 0.09435 | 0.63255 |
| Return on shares | 0.00004 | 0.00032 | 0.02184 | 0.02050 |

*Appendix 1 (continued)*

| Indicator | Mathematical expectation of indicators | | Standard deviation of indicators (daily value) | |
|---|---|---|---|---|
| | 6 | | | |
| | Engineering industry | The company PJSC SOLLERS | Engineering industry | The company PJSC SOLLERS |
| **For absolute values** | | | | |
| Multiplier P/E | 10.57 | 31.93 | 511.89 | 2 084.20 |
| Multiplier P/B | 1.13 | 1.14 | 24.51 | 0.66 |
| Annual profit, rub. | –2 082 613 851.85 | 1 313 362 122.83 | 16 049 582 561.59 | 2 992 985 597.40 |
| Annual profit per 1 share, rub. | 40.98 | 39.26 | 77.24 | 91.66 |
| Book value, rub. | 33 249 092 257.79 | 13 915 626 485.91 | 41 626 486 484.96 | 5 594 097 713.03 |
| Book value per 1 share, rub. | 2.78 | 379.25 | 46.91 | 189.63 |
| Share price, rub. | 327.48 | 579.16 | 257.01 | 274.28 |
| **For relative values** | | | | |
| Return on multiplier P/E | –0.00081 | –0.00093 | 0.18086 | 0.10464 |
| Return on multiplier P/B | –0.00006 | –0.00002 | 0.11081 | 0.66188 |
| Return on shares | 0.00005 | 0.00004 | 0.02095 | 0.02248 |

*Appendix 1 (continued)*

| Показатель / Indicator | Mathematical expectation of indicators | | Standard deviation of indicators (daily value) | |
|---|---|---|---|---|
| | 7 | | | |
| | Energy industry | The company PJSC MOSENERGO | Energy industry | The company PJSC MOSENERGO |
| **For absolute values** | | | | |
| Multiplier P/E | –2.22 | –2.27 | 92.88 | 739.54 |
| Multiplier P/B | 1.17 | 0.78 | 1.21 | 1.20 |
| Annual profit, rub. | 54 882 408 818.31 | 13 167 097 228.27 | 98 152 809 167.58 | 18 790 229 575.18 |
| Annual profit per 1 share, rub. | 0.11 | 0.33 | 0.09 | 0.47 |
| Book value, rub. | 2 250 300 581 879.22 | 173 591 451 138.96 | 1 356 430 321 613.57 | 80 443 372 618.84 |
| Book value per 1 share, rub. | 1.39 | 4.09 | 0.81 | 2.23 |
| Share price, rub. | 1.92 | 2.19 | 1.84 | 1.84 |
| **For relative values** | | | | |
| Return on multiplier P/E | –0.00284 | –0.00002 | 0.20966 | 0.06864 |
| Return on multiplier P/B | –0.00018 | –0.00028 | 0.06111 | 1.20330 |
| Return on shares | 0.00007 | –0.00003 | 0.02033 | 0.02044 |

*Appendix 1 (continued)*

| Indicator | Mathematical expectation of indicators | | Standard deviation of indicators (daily value) | |
|---|---|---|---|---|
| | 8 | | | |
| | Metallurgical and mining industry | The company PJSC ALROSA | Metallurgical and mining industry | The company PJSC ALROSA |
| **For absolute values** | | | | |
| Multiplier P/E | 9.38 | 11.77 | 34.97 | 402.14 |
| Multiplier P/B | 2.53 | 0.96 | 1.64 | 1.17 |
| Annual profit, rub. | 94 629 599 320.18 | 19 210 101 413.21 | 109 016 056 884.81 | 32 595 984 754.86 |
| Annual profit per 1 share, rub. | 249.87 | –2202.27 | 191.91 | 31 218.93 |
| Book value, rub. | 932 683 531 461.67 | 103 453 476 277.65 | 354 802 372 875.56 | 79 129 858 172.07 |
| Book value per 1 share, rub. | 309.55 | 67 449.84 | 183.25 | 133 860.34 |
| Share price, rub. | 2 756.38 | 54.33 | 2288.27 | 23.62 |
| **For relative values** | | | | |
| Return on multiplier P/E | –0.00082 | –0.00074 | 0.19693 | 0.06135 |
| Return on multiplier P/B | 0.00017 | –0.00007 | 0.04016 | 1.17394 |
| Return on shares | 0.00035 | 0.00029 | 0.01929 | 0.02244 |

*Appendix 2*

**Results of the assessment of the expected value of investments in companies' stocks and the risks of these investments based on risk measures VaR and ES**

| Industry | | *E*(*P*). rub. | σ(*P*). rub. | $VaR_{0.95}$. rub. | $ES_{0.95}$. rub. |
|---|---|---|---|---|---|
| Oil and gas | Standard statistical estimates | 1997 | 422 | 696 | 862 |
| | Estimates using the P/E multiplier calculated for the industry | 7123 | 6825 | 11 262 | 13 960 |
| | Estimates using the P / E multiplier calculated for Lukoil | 3225 | 3459 | 5708 | 7075 |
| | Estimates using the P / B multiplier calculated for the industry | 9705 | 6056 | 9993 | 12 387 |
| | Estimates using the P / B multiplier calculated for Lukoil | 2654 | 1632 | 2693 | 3339 |
| Financial | Standard statistical estimates | 0.07 | 0.04 | 0.06 | 0.07 |
| | Estimates using the P/E multiplier calculated for the industry | 0.06 | 5.32 | 8.77 | 10.88 |
| | Estimates using the P / E multiplier calculated for VTB | 0.06 | 6.84 | 11.29 | 13.99 |
| | Estimates using the P/B multiplier calculated for the industry | 0.07 | 0.32 | 0.53 | 0.65 |
| | Estimates using the P / B multiplier calculated for VTB | 0.07 | 0.70 | 1.16 | 1.43 |

*Appendix 2 (continued)*

| Industry | | *E*(*P*). rub. | σ(*P*). rub. | $VaR_{0.95}$. rub. | $ES_{0.95}$. rub. |
|---|---|---|---|---|---|
| Consumer sector | Standard statistical estimates | 4375 | 4074 | 6721 | 8332 |
| | Estimates using the P / E multiplier calculated for the industry | 503 843 | 18 701 860 | 30 858 069 | 38 250 886 |
| | Estimates using the P / E multiplier calculated for MAGNIT | 4561 | 76 011 | 125 418 | 155 465 |
| | Estimates using the P / B multiplier calculated for the industry | 197 973 | 1 742 321 | 2 874 830 | 3 563 567 |
| | Estimates using the P / B multiplier calculated for MAGNIT | 3827 | 22 432 | 37 013 | 45 880 |
| Transport | Standard statistical estimates | 69 | 38 | 62 | 77 |
| | Estimates using the P / E multiplier calculated for the industry | 29 | 650 | 1072 | 1329 |
| | Estimates using the P / E multiplier calculated for Aeroflot | 32 | 999 | 1648 | 2043 |
| | Estimates using the P / B multiplier calculated for the industry | 39 | 629 | 1038 | 1287 |
| | Estimates using the P / B multiplier calculated for Aeroflot | 36 | 2009 | 3315 | 4109 |

*Appendix 2 (continued)*

| Industry | | *E*(*P*). rub. | σ(*P*). rub. | $VaR_{0.95}$. rub. | $ES_{0.95}$. rub. |
|---|---|---|---|---|---|
| Chemical | Standard statistical estimates | 1282 | 644 | 1062 | 1316 |
| | Estimates using the P / E multiplier calculated for the industry | 1678 | 40 993 | 67 638 | 83 842 |
| | Estimates using the P / E multiplier calculated for AKRON | –209 | 43 027 | 70 995 | 88 003 |
| | Estimates using the P / B multiplier calculated for the industry | 3857 | 90 072 | 148 619 | 184 224 |
| | Estimates using the P / B multiplier calculated for AKRON | 1149 | 1069 | 1765 | 2187 |
| Machine-building | Standard statistical estimates | 579 | 274 | 453 | 561 |
| | Estimates using the P / E multiplier calculated for the industry | 415 | 51 051 | 84 234 | 104 414 |
| | Estimates using the P / E multiplier calculated for PJSC SOLLERS | 1253 | 207 840 | 342 936 | 425 095 |
| | Estimates using the P / B multiplier calculated for the industry | 430 | 10 394 | 17 151 | 21 259 |
| | Estimates using the P / B multiplier calculated for PJSC SOLLERS | 433 | 440 | 727 | 901 |

*Appendix 2 (continued)*

| Industry | | *E*(*P*). rub. | σ(*P*). rub. | $VaR_{0.95}$. rub. | $ES_{0.95}$. rub. |
|---|---|---|---|---|---|
| Energy | Standard statistical estimates | 2 | 2 | 3 | 4 |
| | Estimates using the P / E multiplier calculated for the industry | –1 | 54 | 89 | 110 |
| | Estimates using the P / E multiplier calculated for PJSC MOSENERGO | –1 | 429 | 707 | 877 |
| | Estimates using the P / B multiplier calculated for the industry | 5 | 6 | 10 | 13 |
| | Estimates using the P / B multiplier calculated for PJSC MOSENERGO | 3 | 6 | 9 | 11 |
| Metallurgy | Standard statistical estimates | 54.33 | 23.62 | 38.97 | 48.30 |
| | Estimates using the P / E multiplier calculated for the industry | –20 665 | 1 132 935 | 1 869 343 | 2 317 190 |
| | Estimates using the P / E multiplier calculated for PJSC ALROSA | –25 928 | 12 590 815 | 20 774 844 | 25 751 975 |
| | Estimates using the P / B multiplier calculated for the industry | 170 398 | 417 829 | 689 419 | 854 586 |
| | Estimates using the P / B multiplier calculated for PJSC ALROSA | 64 992 | 79 181 | 130 650 | 161 950 |

## REFERENCES


1. Limitovskii M.A., Lobanova E.N., Minasyan V.B., Palamarchuk V.P. Corporate financial management. Moscow: Urait; 2017. 990 p. (In Russ.).
2. Cherkasova V.A., Grigor'eva S.A., Kozlov S.O. Modeling market multipliers in emerging capital markets. *Upravlencheskii uchet i finansy = Management Accounting and Finance Journal*. 2016;(2):108–129. (In Russ.).
3. Ivko D.G. Multipliers method application when estimating the cost of the RF oil and gas companies. *Problemy ekonomiki i upravleniya neftegazovym kompleksom = Problems of Economics and Management of Oil and Gas Complex*. 2017;(4):40–49. (In Russ.).
4. Ivko D.G. Features of the valuation of Russian companies by the method of market multipliers. *Finansy i upravlenie = Finance and Management*. 2017;(1):34–46. (In Russ.). DOI: 10.7256/2409–7802.2017.1.22087
5. Ivko D.G. Assessing the value of Russian companies: The risks of using the market multipliers method. *Finansy i upravlenie = Finance and Management*. 2018;(1):8–22. (In Russ.). DOI: 10.25136/2409–7802.2018.1.25448
6. Cheng C., McNamara R. The valuation accuracy of the price-earnings and price-book benchmark valuation methods. *Review of Quantitative Finance and Accounting*. 2000;15(4):349–370. DOI: 10.1023/A:1012050524545
7. Barnes R. Earnings volatility and market valuation: An empirical investigation. *SSRN Electronic Journal*. 2002. DOI: 10.2139/ssrn.335380
8. Fama E.F., French K.R. Value versus growth: The international evidence. *The Journal of Finance*. 1998;53(6):1975–1999. DOI: 10.1111/0022–1082.00080
9. Koutmos D. The P/E multiple and market volatility revisited. *International Research Journal of Finance and Economics*. 2010;(43):23–32.
10. Liu J., Nissim D., Thomas J. Equity valuation using multiples. *Journal of Accounting Research*. 2002;40(1):135–172. DOI: 10.1111/1475–679X.00042
11. Seghal S., Pandey A. The behaviour of price multiples in India (1990–2007). *Asian Academy of Management Journal of Accounting and Finance*. 2009;5(1):31–65. URL: http://web.usm.my/journal/aamjaf/Vol%205–1–2009/5–1–2.pdf
12. Minasyan V.B. Assessment of risks arising from the application of technology multipliers for stock valuation. *Finansy: teoriya i praktika = Finance: Theory and Practice*. 2018;22(3):124–135. (In Russ.). DOI: 10.26794 / 2587–5671–2018–22–3–124–135
13. Crouhy M., Galai D., Mark R. The essentials of risk management. Transl. from Eng. Moscow: Urait; 2017. 390 p. (In Russ.).
14. Limitovskii M.A., Minasyan V.B. Investment project risks analysis. *Upravlenie finansovymi riskami*. 2011;(2):132–150. (In Russ.).
15. Minasyan V.B. Incentives and moral risks in the relationship between a principal and an agent. *Upravlenie finansovymi riskami*. 2015;(3):172–184. (In Russ.).

## ABOUT THE AUTHORS

***Vigen B. Minasyan*** — Cand. Sci. (Phys.-Math.), Associate professor, Head of Limitivsky Corporate finance, investment design and evaluation Department, Higher School of Finance and Management, Russian Presidential Academy of National Economy and Public Administration, Moscow, Russia
minasyanvb@ranepa.ru, minasyanvb@yandex.ru

***Daria G. Ivko*** — Junior researcher of Limitivsky Corporate finance, investment design and evaluation Department, Higher School of Finance and Management, Russian Presidential Academy of National Economy and Public Administration, Moscow, Russia
dania_1602@mail.ru

*The article was submitted on 10.07.2019; revised on 24.07.2019 and accepted for publication on 20.10.2019.*
*The authors read and approved the final version of the manuscript.*

ORIGINAL PAPER



DOI: 10.26794/2587-5671-2019-23-6-117-130
UDC 336.717(045)
JEL G12

# Fractal Asset Pricing Models for Financial Risk Management

**I.Z. Yarygina**[a], **V.B. Gisin**[b], **B.A. Putko**[c]
Financial University,
Moscow, Russia
[a] http://orcid.org/0000-0001-8684-1684;
[b] https://orcid.org/0000-0002-7269-0587;
[c] http://orcid.org/0000-0002-3330-9819

## ABSTRACT

The article presents the analysis findings of the problems and prospects of using the fractal markets theory to mathematically predict the price dynamics of assets as part of a financial risk management strategy. The aim of the article is to find out the features of value of bank assets and to develop recommendations for assessing financial risks based on mathematical methods for forecasting economic processes. Theoretical and empirical research methods were used to achieve the aim. The article reveals the features of mathematical modeling of economic processes related to asset pricing in a volatile market. It was proved that using financial mathematics in banking contributes to the stable development of the economy. Mathematical modeling of the price dynamics of financial assets is based on a substantive hypothesis and supported by an adequate apparatus of fractal pair pricing models in order to reveal specific market relations of business entities. According to the authors, the prospects of using forecast models to minimize the financial risks of derivative financial instruments are positive. The authors concluded that the considered methods contribute to managing financial risks and improving forecasts, including operations with derivatives. Besides, the studied fractal volatility parameters proved the predictive power regarding extreme events in financial markets, such as the bankruptcy of Lehman Brothers investment bank in 2008. The relevance of the article is due to the fact that the favorable investment climate and the use of modern financing methods largely depend on the effective financial risk management.

***Keywords:*** banking; asset valuation; economic and mathematical methods; financial risk management; hedging

***For citation:*** **Yarygina I.Z., Gisin V.B., Putko B.A. Fractal asset pricing models for financial risk management. *Finance: Theory and Practice.* 2019;23(6):117-130. DOI: 10.26794/2587-5671-2019-23-6-117-130**

## INTRODUCTION

As has been demonstrated globally, the traditional approach to the study of asset price dynamics is based on revealing economic trends and mathematical modeling of these trends to manage financial risks. For example, the classical Black-Scholes-Merton model is associated with the efficient market hypothesis (EMH) that assumes that the asset price is due to multiple random factors. The mathematical model of asset price dynamics contributes to disclosing its features. Using this model minimizes financial risks and ensures banking security in a volatile market.

Over the past century, financial mathematics has proved that to be viable, a mathematical model must be based on a substantive hypothesis and supported by an adequate mathematical apparatus. Models that do not have these two components, "unpaired" models, turn out to be unviable.

For example, the mathematical apparatus used by Bachelier in 1900 in his dynamic pricing model was ahead of his time, and the Bachelier model remained unclaimed for more than 60 years. After the efficient market hypothesis was developed, the Bachelier model became the basis for the modern pricing models.

In a sense, the opposite is exemplified by the fractal market hypothesis that appeared simultaneously with the efficient market hypothesis [1]. However, the mathematical apparatus of this theory (a model based on fractional Brownian motion) "did not keep up" with the substantial concept [2]. The lack of an adequate mathematical fractal dynamics pricing model at the time of the fractal market hypothesis formation prevented the formation of a full theory.

The attempts to revise the classical theory are due to the development peculiarities of market relations and the observable volatility of asset price dynamics under the influence of stylized facts of market participants [3], namely:

- excess volatility of asset returns, which can not be estimated by traditional methods of economic processes;
- heavy tails: the distribution of returns, indicating asymmetry of the market, which contributes to the growth of risks and the likelihood of extreme events;
- autocorrelation in returns, where homogeneous assets can exhibit the absence of dependence of profitability increments and the presence of a significant long-term memory of economic processes that can find manifestation in homogeneous processes of market relations
- volatility clustering, where the jumps in profitability tend to be followed by jumps of the opposite sign, significant for the market and asset price dynamics, which contribute to the probability of significant losses;
- volume/volatility correlation: trading volume is positively correlated with market volatility. Moreover, trading volume and volatility show the same type of "long-term memory" behavior.

The study of these phenomena began in the 1980s of the XX century [4]. However, mathematical modeling of individual stylized facts was first carried out by researchers at the beginning of the XXI century [5–7]. Currently, representatives of various scientific schools have shown that market development features are directly related to risk assessment and the need to use predictive mathematical models for adequate asset management solutions aimed at the stable manifestation of economic processes. It is important to note that a universal mathematical model of market asset price dynamics has not yet been found. For example, conducted within the European Central Bank in 2014 and based on the data analysis of the developed economies of the EU countries, the studies are aimed at finding a theoretical model that explains the market relations phenomena [8]. It is not possible to use the considered approach to predict the processes of emerging markets. Moreover, the study of cryptocurrency price

dynamics by the representatives of the European mathematical school in 2017 showed the features of forecasting the use of assets in cyberspace [9].

In this regard, the observation made in 2019 in the field of stochastic financial mathematics is interesting [10]. Analyzing the stylized facts of economic development on a large statistical material, the authors found that emerging markets behave similar to prediction markets, which confirms the role of general and specialized information in banking. An attempt to connect the stylized facts of market phenomena and the behavior of economic agents involves multi-agent models, including those with artificial intelligence, where market participants implement a relatively rational asset management strategy aimed at maintaining profit and risk management [11–13]. However, criticisms against multi-agent forecasting models, especially in emerging markets, remain valid [14].

In complex forecasting models of a highly volatile non-traditional market, the use of "non-standard" models is promising. Thus, the main asset pricing theorem was proved for markets where mathematical modeling was not possible [15].

In 2018, representatives of the University of Jerusalem introduced the notion of fully incomplete markets and attempted mathematical prediction of an asset hedging strategy [16]. To calculate asset price dynamics and manage financial risks, it is necessary to use comprehensive information about real prices and virtual derivative financial instruments.

The variety of methods and models used in modern financial mathematics shows that a unifying concept that generalizes the classical one and explains the stylized facts of market relations is not represented in modern science. The most systematic and consistent explanation of stylized facts of economic development is obtained within the concept of a fractal market, involving the dependence of the predicted value of asset price dynamics on the history of market development. This article analyzes the concept.

## MODELS BASED ON SELF-SIMILAR PROCESSES

The key assumption of the fractal market hypothesis is self-similarity of dynamic price series of assets. As a rule, the price dynamics of financial market assets is modeled using self-similar processes. This is supported by statistical observations and economic arguments [17].

Self-similarity is a consequence of a large number of market participants with different investment horizons and acting in the same conditions. Moreover, market participants behave in the same way with respect to their investment horizon, providing invariance of market characteristics relative to the time scale of asset use. The Hurst exponent $H$ [17] is the statistical characteristic of scale invariance. Its value ranges from 0 to 1. For Brownian motion, underlying the classical models of the volatile market, the value of the Hurst exponent equals to 0.5. A value $H$ in the range 0.5–1 indicates persistent (trend-stable) dynamics in the time series. A value in the range 0 – 0.5 indicates antipersistent dynamics in the time series and demonstrates the property of returning to the average value.

The mathematical apparatus to describe self-similar random processes was proposed by A.N. Kolmogorov. Methods for obtaining accurate numerical market predictions related to asset pricing have been developing for about half a century. However, no decisive results such as the Black-Scholes model have been received yet. The reason is that the use of fractional Brownian motion for asset price modeling in the stock market faces a difficult problem. Unlike classical mathematical modeling, models based on the fractional Brownian motion have arbitrage opportunities that cannot be described by the rational pricing theory.

For a long time, researchers believed that the existence of arbitrage opportunities was inextricably linked with autocorrelation and the memory of financial time series. A deeper penetration into the mathematics of the fractal market shows that arbitrage, autocorrelation, and self-similarity are due to various factors. Work [18] provides examples of Gaussian random processes that have the same long-term memory as the processes based on fractional Brownian motion with the Hurst exponent greater than 0.5, and at the same time lead to arbitrage-free market models. To build the price model, work [18] used the idea of a moving average, which successfully connects the mathematical apparatus with market realities understood by the financier.

Nevertheless, most researchers find it more promising to use precisely the fractional Brownian motion to build a market model. Replacing Ito integration by Wick integration can solve the availability problem of arbitrage opportunities [19, 20]. Experience has shown that, modified integration has still no convincing economic interpretation. Therefore, it is advisable to be careful when using mathematical modeling with Wick integration.

The solution to minimizing financial risks by mathematical modeling of pricing financial derivatives lies in complete accounting of the characteristics of trading financial instruments in a particular financial market. The fractal market with proportional transaction costs is arbitrage-free. The exact pricing financial derivatives in such a market is fundamentally impossible; it is only possible to establish more or less accurate price limits that do not allow arbitration. However, the fractal market hypothesis attracts the participants by the opportunity to minimize financial risks of asset management.

Classical predictive models suggest that a random process with underlying Brownian motion describes the risky asset price dynamics. Namely, let $S(t)$ be the price of the risky asset at time $t$. Then the profitability for time interval $\Delta t$ is as follows:

$$\frac{S(t+\Delta t)-S(t)}{S(t)} = \mu\Delta t + \sigma\Delta W(t), \qquad (1)$$

where $\mu+\frac{\sigma^2}{2}$ — is the expected return; $\sigma$ — is the profitability volatility; $\Delta W(t) = W(t+\Delta t) - W(t)$; $W(t)$ — is the so-called Wiener random process (Brownian motion). Value $\Delta W(t)$ is considered normally distributed with an average value of 0 and dispersion $\Delta t$. It is assumed that for different values of $t$, increments $\Delta W(t)$ are independent (unless the time intervals overlap).

Wiener processes belong to self-similar random processes. In general, a random market process is self-similar if a change in the time scale leads to a change in the spatial scale, and the probabilistic characteristics of the process remain unchanged. More precisely, random process $X(t)$, $t \geq 0$, is called self-similar if for any $a > 0$ we can find $b > 0$ so that random processes $X(at)$ and $bX(t)$ have the same probabilistic characteristics. If parameter $b$ is also related to parameter $a$ so that $b = a^H$ for some constant $H$ for all $a > 0$, constant $H$ is called the Hurst exponent and it is said that the process is self-similar with the Hurst exponent $H$. For the Wiener process, the Hurst exponent equals 0.5.

Levy processes are used in the models if the changes in profitability at disjoint time intervals are considered independent. Models based on Levy processes provide a good approximation of real price series, sometimes much better than classical models [21]. They allow considering such features of financial time series as asymmetry and heavy tails of probability distributions, and thereby more adequately assess risks (for example, ignoring heavy tails leads to underestimation of risks associated with extreme events). This is achieved by the fact that Levy processes are determined by a larger number of parameters than Wiener processes. Typically, four pa-

rameters are used. In some way, two of them are similar to the parameters of the Wiener process: μ is the shift parameter (similar to the average value that may be determined in the Levy process); σ is the scale parameter (similar to the average deviation that may not be determined the Levy process). The other two parameters allow considering the features of time series not captured by Wiener processes: β is the skewness parameter (allows considering the asymmetry in the differences between the probability distributions in the loss zone and in the zone of inflated expectations).

Work [21] showed that using Levy processes to describe the returns of world stock indices provides satisfactory results. At the same time, it is possible to consider the dynamic features of financial series, missing in classical models. Similar results are obtained regarding the Russian market [22].

Predictive ability is an important property of the model. To be considered qualitative and predictively valuable, the model should be sufficiently stable with respect to small fluctuations in the initial data and relatively small shifts along the time axis. In this regard, increasing number of parameters allows for a more accurate calibration on historical data, but the stability of the estimates is problematic. Data analysis shows that models with a normal distribution show good results for periods of 1–2 months. With a forecast period of more than 200 days, both classical models and those based on Levy processes are not entirely reliable. Finally, for periods of 100–150 days, models based on Levy processes provide the best result [23].

The use of non-classical models for the Russian market is more significant. For example, for the DJA index, the distributions in the corresponding Levy processes are close to normal, and both are consistent with empirical data. It is no longer the case for the RTS index due to high transaction costs (we also include the costs due to insufficient liquidity).

Fractional Brownian motion is a basic example of a self-similar random process with dependent increments. The dependence of increments makes it possible to simulate processes with long-term memory using fractional Brownian motion. The phenomena related to the trend formation are explained within the framework of such models.

***The most systematic and consistent explanation of stylized facts of economic development is obtained within the concept of a fractal market, involving the dependence of the predicted value of asset price dynamics on the history of market development.***

Applying financial time series models based on self-similar processes can face fundamental difficulties, regardless of the processes involved: with dependent or independent increments. In the classical Black-Scholes-Merton model, pricing is based on the fact that this model has an equivalent martingale probability measure for price random processes. Substantially, this measure can be interpreted as some rational forecast, and the price of a derivative instrument is determined considering this forecast with respect to its future prices. In general, there is an infinite family of "rational forecasts" for self-similar random processes with independent increments. Accordingly, there appears an interval of prices interpreted as "fair". Sometimes, but not always, it is possible to estimate the boundaries of these intervals. These boundaries are often shallow. In models using fractional Brownian motion, with the Hurst exponent other than 0.5, there is no "rational forecast" (equivalent martingale measure), and there are arbitrage opportunities. Building pricing models within such

models is only possible considering the features of the real financial market functioning. Transaction costs are among these features.

*To manage financial risks in difficult market conditions when forecasting asset price dynamics, using the fractal modeling method is promising.*

In classic models, the price of a derivative is determined by replicating strategies. In the presence of transaction costs, an exact replication may be too expensive. It is then replaced by a similar one, obtained as a result of solving the problem of stochastic control by dynamic programming methods. The solution to this problem in many cases is too complicated (even considering today's computing power). Facilitations are achieved by narrowing the class of acceptable investment strategies, for example, portfolio rebalancing can only be possible at fixed intervals. In this case, it is possible to obtain more or less acceptable estimates of the trading boundaries using upper and lower hedging [24]. Work [25] presents fundamentally important results of the estimates of the trading boundaries obtained under general assumptions. The authors managed to connect trading volumes, liquidity and dynamic parameters of price movement and to get estimates allowing for optimal trading strategies [26]. These works make relevant the issue of a consistent use of the so-called market time in models. Technically, this concept was used in many works. The results obtained in these works open up new possibilities for the Tobin tax. In our opinion, the studies indicate quite clearly that in financial market models it is advisable to link time with financial events, and not just with the rotation of the Earth around the Sun [25, 26].

To manage financial risks in difficult market conditions when forecasting asset price dynamics, using the fractal modeling method is promising.

## FRACTIONAL BROWNIAN MOTION AND MARKET MODELS

Formally, fractional Brownian motion with the Hurst exponent $H$, $0 < H < 1$, is a random process $\{B^H(t)\}$, where random variables $B^H(t)$ are normally distributed for all times $t$ and $B^H(0) = 0$, the mean value of $B^H(t)$ is 0 for any $t$, and the covariance of $B^H(t)$ and $B^H(s)$ is as follows:

$$E\left[B^H(t)B^H(s)\right] = \frac{1}{2}\left(t^{2H} + s^{2H} - |t-s|^{2H}\right). \quad (2)$$

In an equivalent way, we can assume that the variance $B^H(t)$ is proportional to $t^{2H}$ (in the case of the Wiener process, the dispersion is proportional to $t$).

The trajectory of fractional Brownian motion is a fractal object with a fractal dimension $D = 2 - H$.

By means of fractional Brownian motion, it is possible to build market models with many important properties, whose manifestation is demonstrated by real markets. We will call such models fractal markets for short.

One of the most important and studied is a model similar to the classical (1), where the risky asset price dynamics is described as follows:

$$\frac{S(t+\Delta t) - S(t)}{S(t)} = \mu\Delta t + \sigma\Delta B^H(t). \quad (3)$$

The behavior of the autocovariance yield function with the lag $\tau$ is similar to the behavior of the function $2H(2H-1)\tau^{2H-2}$ (we take a period equal to 1). For all values of the Hurst exponent, autocorrelation tends to 0 with an increase in the time lag.

At $H > 0.5$, autocorrelation is positive and decreases more slowly, the higher the value

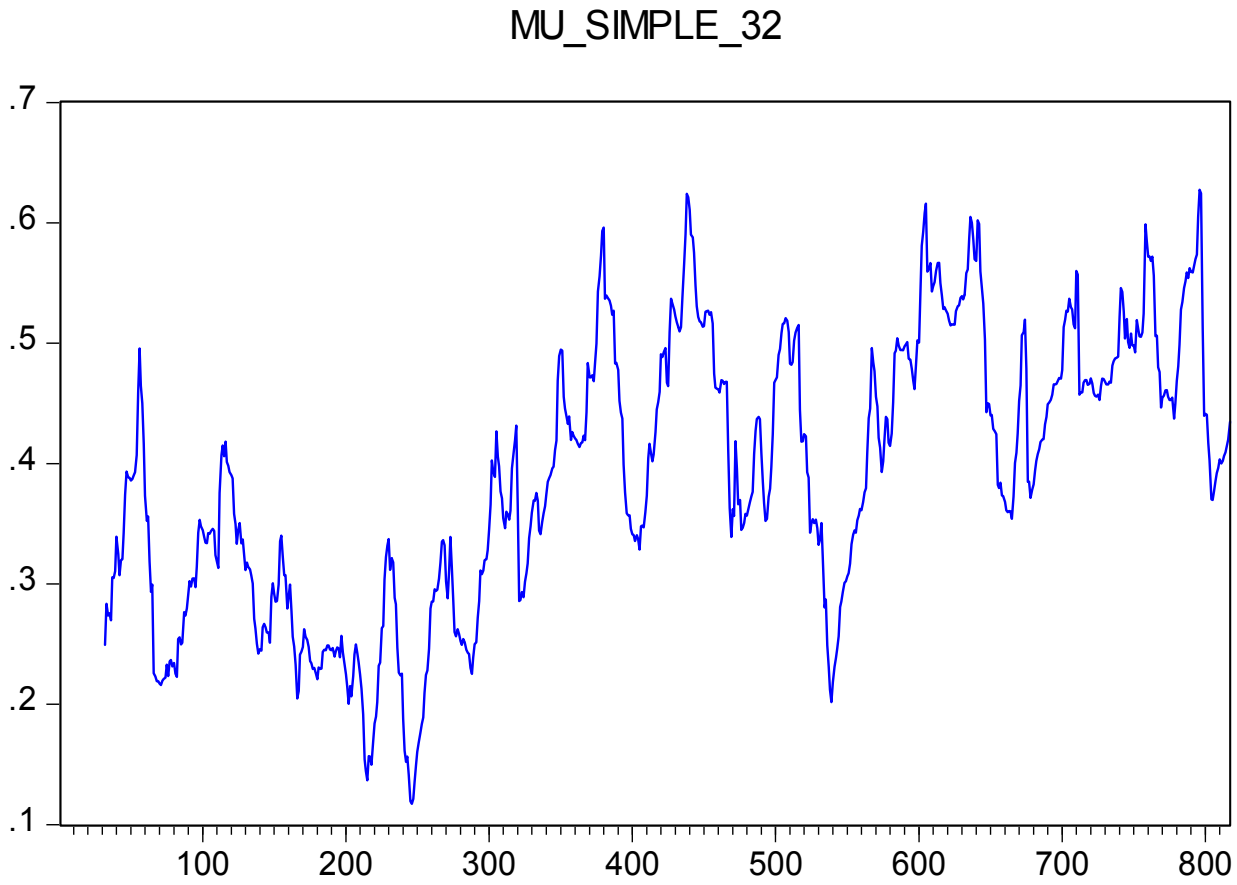



*Fig. 1.* **Graph of** $\mu(t)$

*Source:* compiled by the authors.

of $H$ is. For example, at $H = 0.8$, autocorrelation remains quite noticeable (approximately 0.2) even at $\tau = 10$. This case is corresponds to persistence.

At $H < 0.5$, autocorrelation becomes negative at $\tau < 1$, reaches its minimum value, and then tends to zero with increasing lag. This case corresponds to antipersistency.

These properties of the Hurst exponent are associated with crisis phenomena. Empirical observations allow us to conclude that a decrease in the fractal dimension of the price trajectory precedes large changes in the markets. The fractal characteristics of markets in the period up to 2014 were analyzed in work [27]. With this in mind, studying the dynamics of the Hurst exponent becomes relevant. This problem was studied in works [28, 29], as well as the concept of the fractality index μ associated with the Hurst exponent by the relation $H \approx 1 - \mu$.

The fractality index dynamics allows a statistically reliable description and, due to this can be used for forecasting. Work [30] proposed promising econometric approaches to describing the dynamics of the Hurst exponent.

## FRACTALITY INDEX

Values characterizing the fractal structure of the market are used to model volatility. The asset price is seen as a continuous random process. The amplitude $A(\delta) = h(\delta) - l(\delta)$ is used as a measure of volatility over an interval of length $\delta$, where $h(\delta)$ is the maximum and $l(\delta)$ is the minimum price in this interval.

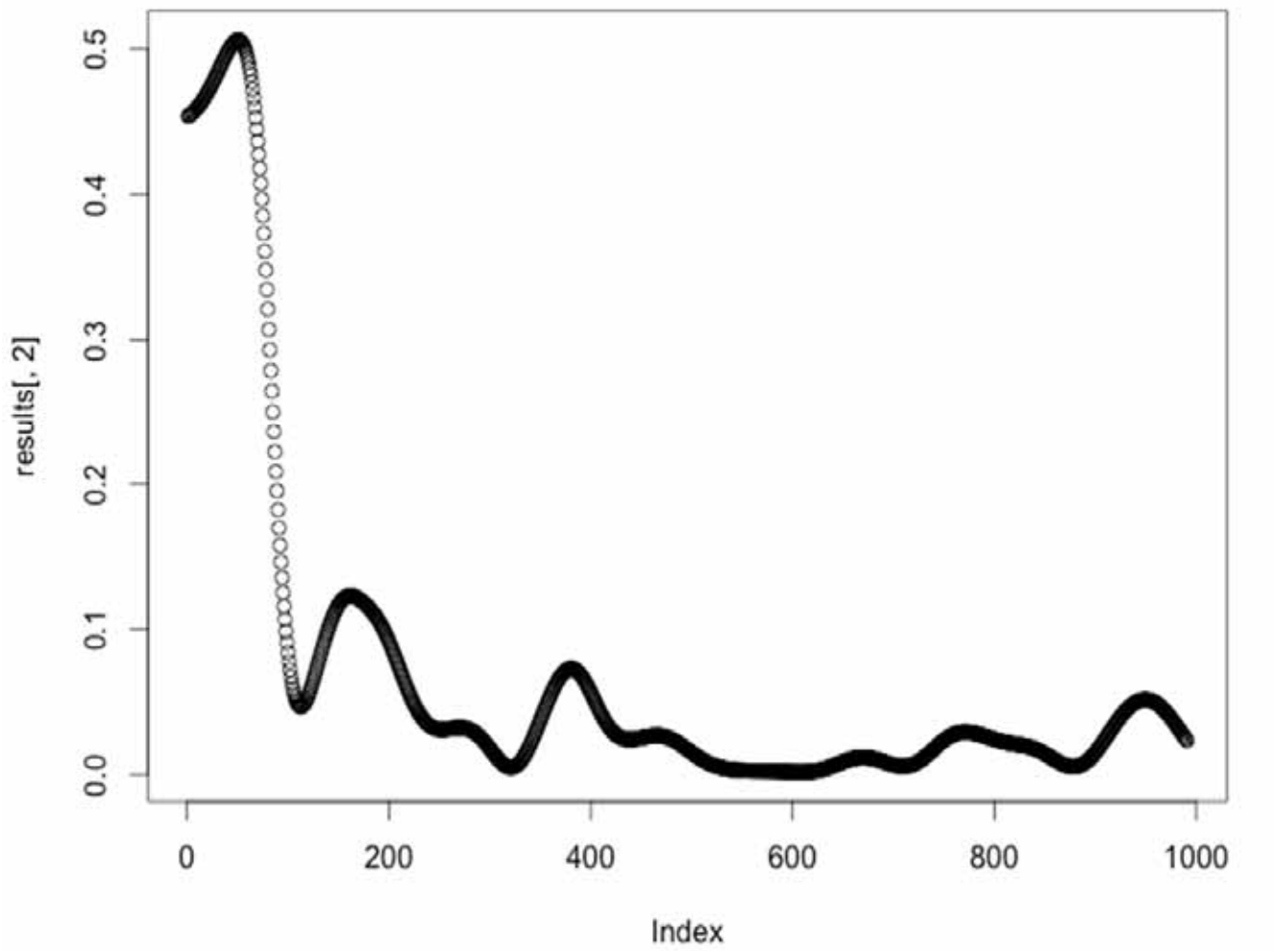



*Fig. 2.* **Graph of** $R^2(\omega)$.
*Source:* compiled by the authors.

Two values $\delta_0$ and $\delta_c$, are selected, with $\delta_c = n\delta_0$. Two values $\delta_c$ is usually called the characteristic scale. At time $t$, the interval $[t-\delta_c, t]$. is considered. Let δ be a divisor of a characteristic scale and a multiple of the minimum. adjacent spaces in the interval. The total of the amplitudes at these intervals is denoted by $V(\delta)$. The regression is considered

$$\log V(\delta) = \alpha - \mu \log(\delta). \qquad (4)$$

BWork [28] showed that regression (4) has a very high coefficient of determination, that almost coincides with 1, in a rather wide range (the authors considered the ratio of the characteristic and the minimum scale from 8 to 1024). Thus, the estimate of μ is practically independent of the choice of divisors, and we can consider the dynamic quantities $\mu(t, \delta_0, \delta_c)$ and $\alpha(t, \delta_0, \delta_c)$. As a rule, $\delta_0 = 1$, and dynamic quantities are denoted by $\mu_{\delta_c}(t)$ and $\alpha_{\delta_c}(t)$.

The function μ (unlike α) does not depend on the base of the logarithm in equality (4) and is an intrinsic characteristic of the fractal structure of the financial series. In work [28], the value μ is called the fractality index. When the minimum scale tends to 0, the fractality index tends to the value $D - 1$, where $D$ is the fractal dimension of the random price process. Moreover, the aspiration turns out to be very fast (quick approach to asymptotics), which allows us to estimate the fractal dimension using very few observations.

As a consequence of the very high coefficient of determination of regression (4), we can use simplified estimates of the parameters $\mu_0$, $\alpha_0$ (assuming $\delta_0 = 1$):

$$\mu_s = \log_{\delta_c} V(\delta_0) - \log_{\delta_c} V(\delta_c);$$

$$\alpha_s = \log_{\delta_c} V(\delta_0). \quad (5)$$

which gives a decomposition of volatility on a characteristic scale:

$$\log_{\delta_c} V(\delta_c) = \alpha_s - \mu_s \approx \alpha - \mu. \quad (6)$$

## USING FRACTAL CHARACTERISTICS TO FORECAST VOLATILITY

Work [29] considers regression models of volatility components α and μ that can be used to forecast future dynamics of the volatility of the foreign exchange market. While the future value is predicted in most models, but, as a rule, over a rather short interval, the fractal model allows predicting only the growth direction for α and μ, but over a sufficiently long interval (from one to eight months).

An empirical fact is used to build an econometric model: the function $\mu(t)$ has a quite clearly defined quasicyclic structure (*Fig. 1*). It should be noted that the quasicyclicity of fractal characteristics (in particular, the most dynamic series of Hurst) was noted and discussed at a qualitative level earlier [1, 2]. Since the quantity μ has a much faster asymptotics than the estimate of the *R/S*-analysis, it is natural to expect that the quasicyclicity of the function μ (t) is more pronounced.

Thus, it is logical to use periodic functions to model the fractality index:

$$\hat{\mu}(t) = \sum_{i=1}^{k} \left[ a_i \sin(\omega_i t) + b_i \cos(\omega_i t) \right]. \quad (7)$$

The econometric model corresponding to (7) is constructed as follows. The equation is considered

$$\mu(t) = x + b_1 \sin(\omega t) + b_2 \cos(\omega t) + \varepsilon(t). \quad (8)$$

The frequency ω runs from 0 to 0.1 with 0.0001 per step. For each value of ω, the coefficient of determination of regression is determined (8). The resulting function $R^2(\omega)$ has pronounced extrema. It can be obtained for any segment of the time series $[T_0, T_1]$. A typical graph is shown in *Fig. 2*.

The smallest maximum with the highest determination coefficient is the main, trending frequency. Besides, there are frequencies of quasicycles — usually three or four.

Thus, both the extreme frequencies and the corresponding values of the determination coefficients turn out to be functions of two parameters: $T_0$ — the starting point and the length $\Delta = T_1 - T_0$ of the interval on which the econometric model (window width) is built. In this case, the picture shown in *Fig. 2*, at large intervals of the values of the parameters $T_0$, $\Delta$ does not change qualitatively and changes little quantitatively, which confirms the quasicyclic nature of the structure. At the same time, at some values of $T_0$, phase transitions take place. The main trend frequency in (8) bifurcates with the subsequent "overflow" — the attenuation of the initial "hump" and the growth of a new one.

These ideas were used in work [30] to forecast trends in the ruble exchange rate. At the same time, the regressions had a rather high coefficient of determination: $R^2 \sim 0.7 \div 0.75$. Backtesting the model showed that the direction prediction of the trend is correct in 60–70% of cases. The 2008 crisis found good agreement with the model.

Works [31, 32] presented data on the values of the Hurst exponent in the stock market, based on the analysis of voluminous statistical material. These data generally confirm the indicated pattern. In this regard,

observed in 2019, the increase in the values of the Hurst exponent in the domestic oil sector is alarming. Typical for the Russian stock market, the values of the Hurst exponent close to 0.6 (Aeroflot — 0.58–0.63; Gazprom — 0.53–060; Sberbank — 0.57–0.64; Rosneft — 0.53–0.57 in 2014–2018) were replaced in the first half of 2019 by the higher ones (Tatneft — 0.70; Surgutneftegas — 0.77; Rosneft — 0.72).

We refer to the study by a scientific school of the Utrecht University (Netherlands) that estimated the "normal" values of the Hurst exponent for various sectors: information technology — 0.50–0.67; finance — 0.38–0.62; raw materials sector — 0.38–0.63 [33].

***The presented justification of the feasibility of using fractal models of asset price dynamics and their practical application in the financial sector can help minimize risks and strengthen the stable development of market relations.***

There is no martingale measure in the fractal market. Therefore, there are arbitrage opportunities associated with the features of the Ito integral. Mathematically, the situation of forecasting price dynamics can be corrected by using Wick integration [19]. However, this integration method has not yet received an economic interpretation that is adequate to modern conditions of market relations. This approach can be easily explained by a discrete approximation of fractional Brownian motion, which serves as the main tool for calculations. A brief description of the discrete approximation follows next.

Let the time interval [0; $T$] be divided into $n$ equal intervals. For each $n$, we can calculate the coefficients $k_{l,i}^{(n)}$, $l=1,\ldots,n$, $i=1,\ldots,l$, so that the sums

$$B^H(t) \approx \sum_{i=1}^{l} k_{l,i}^{(n)} \xi_i, \qquad (9)$$

where $\xi_i$ — are random variables taking one of the two values $\{-1;1\}$ approximate the values for $t = l \cdot \frac{T}{n}$ in the interval $[0;T]$.

Then,

$$\Delta B^H(t) = k_{l+1,l+1}\,\xi_{l+1} + \sum_{i=1}^{l} \left(k_{l+1,i} - k_{l,i}\right)\xi_i \qquad (10)$$

[we omit the index $n$ in the notation $k^{(n)}$ from (9)]. Equation (10) allows approximating the risky asset price in the fractal market at sufficiently large $n$.

Assuming that $\Delta t = \frac{T}{n}$ and $S_0 = S(0)$, we have:

$$S(\Delta t) = S_0\left(1 + \mu\Delta t + k_{11}\xi_1\right); \qquad (11)$$

$$S(2\Delta t) = S(\Delta t)\begin{pmatrix} 1 + \mu\Delta t + k_{2,2}\xi_2 + \\ + \left(k_{2,1} - k_{1,1}\right)\xi_1 \end{pmatrix}\ldots . \qquad (12)$$

Ito integration corresponds to the usual multiplication of brackets. Wick integration corresponds to a multiplication where the terms containing $\xi_i^2$, are discarded. For example, when calculating $S(2\Delta t)$ the term $k_{11}\left(k_{2,1} - k_{1,1}\right)$, obtained by term-by-term multiplication of (11) and (12), at $\xi_1^2 = 1$, should be discarded. There is still no economically rational explanation why such terms should be discarded. We should be cautious about the results obtained by Wick integration.

## CONCLUSIONS

Let us dwell on the results associated with pricing in markets with transaction costs. Studies [25, 34 suggested an approach to describe optimal strategies in markets with transaction costs.

Under general assumptions, the proportion of capital invested in the risk component should be within the boundaries

$$\pi_{-} = \frac{\rho - \lambda}{\gamma\sigma^2} \text{ and } \pi_{+} = \frac{\rho + \lambda}{\gamma\sigma^2}, \quad (13)$$

where $\rho$ — is the excess return; $\gamma$ — is the relative risk aversion; $\varepsilon$ — is the spread between supply and demand prices, and the quantity $\lambda$ is the following

$$\lambda = \gamma\sigma^2 \left( \frac{3}{4\gamma} \pi_*^{\,2} (1 - \pi_*)^2 \right)^{1/3} \varepsilon^{1/3} + O(\varepsilon) \quad (14)$$

$$\text{with } \pi_* = \frac{\rho}{\gamma\sigma^2}.$$

For example, the calculations according to formulas (13) and (14) for ordinary shares of Sberbank at the beginning of 2014 yielded the values $\pi_{-} = 45.6\%$, $\pi_{+} = 48.2\%$. The liquidity premium calculated by the methodology of work [25] equaled 0.04%. For less attractive and liquid assets, the buy and sell limits were much lower, and the liquidity premium increased sharply. For example, it was 0.15% for JSCB Primorye.

A significant number of recent studies have been devoted to modeling volatility using fractional Brownian motion. It is possible to explain the effects of short-term and long-term memory, the paradox of the "volatility smile" and some other features in terms of the constructed models [35].

The concept of Rough Fractional Stochastic Volatility (RFSV) became widespread [36, 37]. The RFSV concept generalizes models used for over 20 years (see [38]). In the standard stochastic volatility model described by equations

$$\frac{dS(t)}{dt} = \mu\left(t, S(t)\right)dt + \sigma(t)dW^{(1)}(t); \quad (15)$$

$$d\left(\ln\sigma(t)\right) = k\left(\theta - \ln\sigma(t)\right)dt + \gamma dW^{(2)}(t), \quad (16)$$

it is proposed to use the fractional Brownian motion instead of the Wiener process $W^{(2)}(t)$.

Research in this area was stimulated by the empirically revealed stable pattern: the volatility dynamics is fractal by nature, the Hurst exponent for process $W^{(2)}(t)$ equals 0.1 for fixed-income instruments. This Hurst exponent corresponds to a very high variability of volatility with a tendency to return to its average values. This observation can significantly improve volatility forecasts, and, most importantly, much more accurately than with other models, describe possible risks and implied volatility of asset price dynamics. The proposed approach is also promising in the formation of forecast models of asset price dynamics of derivative financial instruments [37]. Moreover, the fractal volatility parameters demonstrate predictive power regarding extreme events in the financial sector. An example is the collapse of Lehman Brothers and other US investment banks in 2008, which caused the global financial and economic crisis [36].

The presented justification of the feasibility of using fractal models of asset price dynamics and their practical application in the financial sector can help minimize risks and strengthen the stable development of market relations.

## ACKNOWLEDGEMENTS

The article is based on the results of budgetary-supported research according to the state task carried out by the Financial University as part of research on the topic "Mechanisms for creating a highly productive export-oriented sector among the basic sectors of the economy of the Russian Federation within the global disintegration and Eurasian integration processes". Financial University, Moscow, Russia.

## REFERENCES


1. Mandelbrot B.B., Van Ness J.W. Fractional Brownian motion, fractional noises and applications. *SIAM Review*. 1968;10(4):422–437. DOI: 10.1137/1010093
2. Mandelbrot B.B. When can price be arbitraged efficiently? A limit to the validity of the random walk and martingale models. *The Review of Economics and Statistics*. 1971;53(3):225–236. DOI: 10.2307/1937966
3. Cont R. Volatility clustering in financial markets: Empirical facts and agent-based models. In: Teyssière G., Kirman A.P., eds. Long memory in economics. Berlin, Heidelberg: Springer-Verlag; 2007:289–309.
4. Pagan A. The econometrics of financial markets. *Journal of Empirical Finance*. 1986;3(1):15–102. DOI: 10.1016/0927–5398(95)00020–8
5. Cont R. Empirical properties of asset returns: Stylized facts and statistical issues. *Quantitative Finance*. 2001;1(2):223–236. DOI: 10.1080/713665670
6. Ding Z., Granger C., Engle R. A long memory property of stock market returns and a new model. *Journal of Empirical Finance*. 1983;1(1):83–106. DOI: 10.1016/0927–5398(93)90006-D
7. Guillaume D., Dacorogna M., Davé R., Müller U., Olsen R., Pictet O. From the bird's eye view to the microscope: A survey of new stylized facts of the intraday foreign exchange markets. *Finance and Stochastics*. 1997;1(2):95–129. DOI: 10.1007/s007800050018
8. Hiebert P., Jaccard I., Schüler Y. Contrasting financial and business cycles: Stylized facts and candidate explanations. *Journal of Financial Stability*. 2018;38:72–80. DOI: 10.1016/j.jfs.2018.06.002
9. Bariviera A.F., Basgall M.J., Hasperué W., Naiouf M. Some stylized facts of the Bitcoin market. *Physica A*: *Statistical Mechanics and its Applications*. 2017;484:82–90. DOI: 10.1016/j.physa.2017.04.159
10. Restocchi V., McGroarty F., Gerding E. The stylized facts of prediction markets: Analysis of price changes. *Physica A*: *Statistical Mechanics and its Applications*. 2019;515:159–170. DOI: 10.1016/j.physa.2018.09.183
11. Pruna R.T., Polukarov M., Jennings N.R. An asset pricing model with loss aversion and its stylized facts. In: IEEE Symposium Series on Computational Intelligence (SSCI). (Athens, 6–9 Dec. 2016). New York: IEEE; 2016:1–8. DOI: 10.1109/SSCI.2016.7850003
12. Gisin V.B., Shapoval A.B. Two agent based models and market stylized facts. *International Journal of Pure and Applied Mathematics*. 2008;42(4):521–527.
13. Dhesi G., Ausloos M. Modelling and measuring the irrational behaviour of agents in financial markets: Discovering the psychological soliton. *Chaos, Solitons & Fractals*. 2016;88:119–125. DOI: 10.1016/j.chaos.2015.12.015
14. LeBaron B., Agent-based computational finance: Suggested readings and early research. *Journal of Economic Dynamics and Control*. 2000;24(5–7):679–702. DOI: 10.1016/S 0165–1889(99)00022–6
15. Acciaio B., Beiglböck M., Penkner F., Schachermayer W. A model-free version of the fundamental theorem of asset pricing and the super-replication theorem. *Mathematical Finance*. 2016;26(2):233–251. DOI: 10.1111/mafi.12060
16. Dolinsky Y., Neufeld A. Super-replication in fully incomplete markets. *Mathematical Finance*. 2018;28(2):483–515. DOI: 10.1111/mafi.12149
17. Shyriaev A.N. Fundamentals of stochastic financial mathematics (in 2 vols.). Moscow: Nauka; 2004. 1018 p. (In Russ.).
18. Cheridito P. Gaussian moving averages, semimartingales and option pricing. *Stochastic Processes and their Applications*. 2004;109(1):47–68. DOI: 10.1016/j.spa.2003.08.002
19. Rostek S., Schöbel R. A note on the use of fractional Brownian motion for financial modeling. *Economic Modelling*. 2013;30:30–35. DOI: 10.1016/j.econmod.2012.09.003
20. Biagini F., Hu Y., Øksendal B., Zhang T. Stochastic calculus for fractional Brownian motion and applications. London: Springer-Verlag; 2008. 330 p.

21. Schoutens W. Lévy processes in finance: Pricing financial derivatives. Chichester: John Wiley & Sons Ltd; 2003. 170 p.
22. Gisin V. B., Konnov V. V., Sharov V. F. Probabilistic models for analyzing asset pricing in stock markets. Moscow: Financial University; 2012. 152 p. (In Russ.).
23. Borusyak K. K. Application of the Meixner model of the distribution of return on financial assets to the Russian stock market. In: Gisin V. B., Shapoval A. B., eds. Mathematical methods for analyzing financial time series: Coll. sci. pap. Moscow: Financial Academy; 2008:4–23. (In Russ.).
24. Kabanov Y., Safarian M. Markets with transaction costs: Mathematical theory. Berlin, Heidelberg: Springer-Verlag; 2010. 294 p.
25. Gerhold S., Guasoni P., Muhle-Karbe J., Schachermayer W. Transaction costs, trading volume, and the liquidity premium. *Finance and Stochastics*. 2014;18(1):1–37. DOI: 10.1007/s00780–013–0210-y
26. Guasoni P., Weber M. Dynamic trading volume. *Mathematical Finance*. 2017;27(2):313–349. DOI: 10.1111/mafi.12099
27. Navascués M. A., Sebastián M. V., Latorre M. Stock indices in emerging and consolidated economies from a fractal perspective. In: Rojas I., Pomares H., eds. Time series analysis and forecasting: Selected contributions from the ITISE conference. Cham: Springer International Publ.; 2016:113–122.
28. Dubovikov M. M., Starchenko N. V., Dubovikov M. S. Dimension of minimal cover and fractal analysis of time series. *Physica A: Statistical Mechanics and its Applications*. 2004;339(3–4):591–608. DOI: 10.1016/j.physa.2004.03.025
29. Putko B. A., Didenko A. S., Dubovikov M. M. Exchange rate volatility model (RUR/USD) based on the fractal characteristics of a financial series. *Prikladnaya ekonometrika = Applied Econometrics*. 2014;(4):79–87. (In Russ.).
30. Bertrand P. R., Combes J.-L., Dury M.-E., Hadouni D. Overfitting of Hurst estimators for multifractional Brownian motion: A fitting test advocating simple models. *Risk and Decision Analysis*. 2018;7(1–2):31–49. DOI: 10.3233/RDA-180136
31. Ikeda T. Fractal analysis revisited: The case of the US industrial sector stocks. *Economics Bulletin*. 2017;37(2):666–674.
32. Ikeda T. A fractal analysis of world stock markets. *Economics Bulletin.* 2017;37(3):1514–1532.
33. Karp A., Van Vuuren G. Investment implications of the fractal market hypothesis. *Annals of Financial Economics*. 2019;14(1):1–27. DOI: 10.1142/S 2010495219500015
34. Nika Z., Rásonyi M. Log-optimal portfolios with memory effect. *Applied Mathematical Finance*. 2018;25(5–6):557–585. DOI: 10.1080/1350486X.2018.1542323
35. Guennoun H., Jacquier A., Roome P., Shi F. Asymptotic behavior of the fractional Heston model. *SIAM Journal on Financial Mathematics*. 2018;9(3):1017–1045. DOI: 10.1137/17M1142892
36. Bayer C., Friz P., Gatheral J. Pricing under rough volatility. *Quantitative Finance*. 2016;16(6):887–904. DOI: 10.1080/14697688.2015.1099717
37. Gatheral J., Jaisson T., Rosenbaum M. Volatility is rough. *Quantitative Finance*. 2018;18(6):933–949. DOI: 10.1080/14697688.2017.1393551
38. Comte F., Renault E. Long memory in continuous-time stochastic volatility models. *Mathematical Finance*. 1998;8(4):291–323. DOI: 10.1111/1467–9965.00057

## ABOUT THE AUTHORS

***Irina Z. Yarygina*** — Dr. Sci. (Econ.), Professor, Department of World Economy and World Finance, Financial University, Moscow, Russia
jiz4@yandex.ru

***Vladimir B. Gisin*** — Cand. Sci. (Math.), Professor, Head of the Chair of Information Security, Financial University, Moscow, Russia
vgisin@fa.ru

***Boris A. Putko*** — Cand. Sci. (Math.), Associate Professor, Department of Data Analysis, Decision Making, and Financial Technologies, Financial University, Moscow, Russia
baputko@fa.ru

***Authors' declared contribution:***
Yarygina I. Z. — disclosed the features of the economic content of value of bank assets and developed recommendations for assessing financial risks based on mathematical methods for forecasting economic processes.
Gisin V. B. — analyzed the features of fractal Brownian motion to describe price dynamics; described the method for assessing the boundaries of the fair prices of financial assets in the fractal market.
Putko B. A. — used the observed quasicyclicity of the fractality index to construct an econometric model with a fractality index as an explanatory variable and periodic harmonics as explanatory variables. A long-term forecast was based on this model. The result of backtesting the model was given.

*The article was submitted on 30.09.2019; revised on 14.10.2019 and accepted for publication on 20.10.2019.*
*The authors read and approved the final version of the manuscript.*

ORIGINAL PAPER



DOI: 10.26794/2587-5671-2019-23-6-131-142
JEL G32, G39

# Narcissism of Executive Officer: Profit Quality of Government Corporation

**P. Febrina**[a], **T. Wahyudi**[b], **Azwardi**[c]
Sriwijaya University, Palembang, Indonesia
[a] https://orcid.org/0000-0002-7683-1447; [b] https://orcid.org/0000-0003-4056-5105;
[c] https://orcid.org/0000-0003-0066-2445

## ABSTRACT

The study was motivated by the increasingly widespread phenomenon of narcissism of CEOs in various companies throughout the world, including Indonesia.he purpose of this study was to determine the impact of narcissism of the *Chief Executive Officer* on the profit quality of the company.The study was conducted on the *purposive sampling* of 20 state-owned companies listed on the Indonesia Stock Exchange in 2015 to 2018. The impact of narcissism of the CEO on the profit quality and the financial performance of the company was assessed.The author provided the mathematical justification of some provisions of the issue. The *Modified Jones Model* was used to evaluatethe company's financial management. The data were analyzed by means of Multiple Liner Regression.The study showed that the narcissism of the CEO negatively affects the financial results of the company and leads to lower profits. This is consistent with the Upper Enchelons Theory, which states that the organization is a reflection of the values of its leader.

***Keywords:*** Narcissism; Chief Executive Officer; Profit Quality; Financial Statements

***For citation*: Febrina P., Wahyudi T., Azwardi. Narcissism executive officer: The quality prodit on government corporation. *Finance: Theory and Practice*. 2019;23(6):131-142. DOI: 10.26794/2587-5671-2019-23-6-131-142**

## INTRODUCTION

One important component in a company's financial statements that attracts the attention of the external parties is profit. Management that reports financial statements with conditions that are not in accordance with its circumstances will produce poor quality, and it will affect all users of financial statements.

In the success of a company, CEO has an important role which is reflected from the results of the company's performance. According to Helfert (1996) decisions taken individually by management represent company performance. In the accrual basis process, management may have opportunities to manipulate earnings or profit in order to increase or decrease the accrual rate in the income statement. Profit value cannot be explained based on market value if investors use profit to shape the market value of the company. This research on narcissism may be important for shareholders because narcissism can be „an important responsibility on jobs (like a CEO) where a realistic conception of one's talents and abilities is very important" (Judge et al. 2006: 772). Responsibility arises because narcissism can affect collaboration, trust, risk taking, motivation, decision making, and long-term performance (Campbell et al. 2004, Judge et al. 2006). Not only does his research make its contribution by providing preliminary evidence regarding the nature of the relationship between CEO narcissism and accounting income, but it also begins to explore the impact of personality traits such as narcissism on the potential for incorrect financial reporting (Hobson and Resutek 2008; Schrand and Zechman 2012). Thus, for shareholders and even regulators, the influence of narcissism on CEO decisions, behavior, and motivation can be an important consideration.

PT. Telekomunikasi was an example of a company that conducted profit management by creating a net profit growth of 2 percent to Rp 7.4 trillion in the first half of this year, from Rp 7.29 trillion in

net profit for the same period in 2014. However, in fact, the actual performance was rated below the expectation. Consequently, it resulted on declining share prices. Ariyanto Kurniawan, a Research Analyst at Mandiri Sekuritas, said that Telkom's net profit was pressured by higher maintenance costs that had to be paid in the first half of this year. "In addition, Telkom's early retirement program costs are also higher. The most recent case is still in the State-owned companies, Garuda Indonesia. As published on April 1, 2019, Garuda Indonesia reported its financial performance of fiscal year 2018 to the Indonesia Stock Exchange. In its financial statements, the company with the GIAA stock code managed to reap a net profit of US $ 809 thousand, unlike to its condition on the previous year which suffered deficit US$ 216.58 million.

The company held an Annual General Meeting of Shareholders (AGMS) in Jakarta whose one of the agenda was to approve the financial statements for the 2018 fiscal year. Two Garuda Indonesia commissioners, Chairul Tanjung and Dony Oskaria as representatives of PT Trans Airways expressed their objections through 'letter of objection' to the AGMS. Chairul had asked that the objection be read out at the AGM, but upon the decision of the chair of the meeting the request was not granted. The results of the shareholders' meeting finally approved the Garuda Indonesia financial report in 2018. Trans Airways believed that the US$ 239.94 million transaction with Mahata was too highly significant, thus affecting Garuda Indonesia's financial balance sheet. If the nominal of the cooperation was not included as revenue, then the company actually still lost US$ 244.96 million. Two commissioners believed that the impact of revenue recognition was confusing and misleading because Garuda Indonesia's finances had changed from previously loss to profit. This performance was quite surprising because in the third quarter of 2018 the company also lost US $ 114.08 million.

In this phenomenon, if investors used earnings like this in decision making, the earnings contained in the financial statements could not explain the true quality of profit. Profit quality and the quality of financial statements were generally important for those who used financial statements for contractual purposes and investment decision making (Schipper and Vincent, 2003). This research was motivated by the increasingly widespread narcissism phenomenon of a CEO that occured in various companies in the world, including in Indonesia. The Telkom, Akra and Garuda cases attracted researchers to study CEO narcissism as one of the aspects that influenced the conditions and / or activities within the company. Some researches showed that CEO narcissism could encourage unethical actions in the company. State-Owned Enterprises became the unit of research analysis because this sector was the favorite of many investors. It was therefore not surprising that the Indonesian State Owned Enterprises were considered to have a competitive advantage for relatively high growth.

To determine the relationship of CEO narcissism with profit quality and financial statements, state-owned companies listed on the Indonesia Stock Exchange in the period of 2015–2018 were used in this study with the CEO's narcissism mindset as the independent variable, profit quality as the dependent variable and company size, DER, Auditor Reputation and Board of Commissioners' Educational Background as the control variables. State-owned companies were choosen as the object of the research because they had been the main actor in the national economy. Furthermore, this study used a photo of the CEO in an annual report to measure the level of narcissism of the CEO. This measurement adapted the method carried out by Olsen et al. (2014). Crowe's theory also stated that the number of CEO photos displayed in an annual company report could represent the level of arrogance or superiority that they possessed. The quality of the company's profit was measured by profit management, spesifically accrual profit management. Accrual profit management was measured using the *Modified Jones Model*.

## LITERATURE REVIEW

### The Upper Echelon Theory and Freud's Psychoanalyst Theory

Zein (2016) stated that the theory of Upper Echelon could be used to help explain that knowledge, beliefs and characteristics could influence leaders. On the other hand, Wan Yusof (2010)

emphasized that the theory of upper echelon provided company performance as the reflection of top management. Therefore it was important to study the characteristics of a leader. Leaders play an important role in strategic decision making and resource allocation. Hambrick and Mason, through Upper Echelon Theory, stated that the strategies chosen by leaders were the reflection of their values and cognitive abilities. This theory also shows that age, experience, education, social background, economic conditions, and the characteristics of the group they are associated to, are filters when they digest, analyze, and try to understand the anatomy of a problem. This determines their ability to interpret complex situations and in what way the situation must be managed. Then, Age, according to Hambrick and Mason and several other academics, was one of the important characteristics of leaders. This theory considered the concept of top management as the main strategic decision maker in the organization. Thus, strategic decisions made by leaders had a direct impact on organizational outcomes because executives who hade responsibility for the organization as a whole, their characteristics, what they do, and how they do it, specifically affected organizational outcomes (Finkelstein and Hambrick 1996).

Psychoanalysis is a branch of science developed by Sigmund Freud and his followers, as a study of the functions and psychological behaviors of humans. Sigmund Freud (1856–1939) was a pioneer of psychodynamic theory. The theory put forward by Freud focuses on the subconscious problem, as one aspect of one's personality. Freud's emphasis on the unconscious came from his tracking of the personal experiences of his patients, which found that events that occurred in childhood greatly influenced the patient's life in the future. His impression of the importance of the early period of human life, whose information was then embedded in the subconscious, convinced him that information in the subconscious was very important, because from that arose various emotional disturbances. Freud's psychoanalytic theory (2006) considered that human behavior was determined by innate instincts that are largely unconscious. This unconscious process according to Freud was the process of being affected by the behavior of the mind, fear or desires that were not based on the person. There was a structural division in human personality by Freud. The most important thing about the psychoanalysis approach is that human action has a cause. However, the causes are often unconscious motives, not rational reasons given by someone for their behavior. In the psychoanalyst's view, human personality is an interaction between idea, ego, and superego.

**Previous research**

Frino, et al (2015) stated in their paper that investigated the relationship between CEO narcissism and income manipulation that there was growing evidence that narcissistic leaders overly identify themselves with the organizations they led and spent enormous resources to achieve their goals, including involvement in unethical behavior. They provided evidence that companies with more narcissistic CEOs were more likely to conduct manipulation to present better profit. Their results highlighted the importance of the CEO's personality to the company's accounting decisions.

Rispayanto (2019) said that CEOs with high levels of narcissism focused more on setting company targets unrealistically. Highlighted on the bonus distribution scheme given by shareholders to the company's CEO, company profits were important to consider as an indicator of the CEO's success in managing the company, and at the same time would influence the decision to award the CEO. Too high and unrealistic targets set by a narcissistic CEO would encourage the CEO to take unethical actions by carrying out profit management in order to achieve predetermined profit targets. The higher narcissism owned by a CEO led to the lower quality of profit.

Researches conducted by Risjenbilt and Commandeur (2013) found evidence that CEO narcissism could encourage him to commit fraud on the financial statements of the companies they led. Narcissism among executives was developing. The study, mostly from the financial and management literature, had examined the relationship of

overly confident CEOs and decisions related to corporate investment policies, acquisitions, CEO selection, corporate governance, and innovation (Malmendier and Tate 2005; Brown and Sarma 2007; Goel and Thakor 2008; Malmendier and Tate 2008; Galasso and Simcoe 2011). For instance, a current study by Schrand and Zechman (2011) looked at whether certain personality tendencies of CEOs were associated with a higher probability of being involved in earnings management. They explored why companies overestimated revenue by looking at how bias toward optimism was related to the excessive nature of trust that was manifested by executives. They provided evidence of how financial reporting errors could begin with unintentional mistakes due to optimism bias that was common in executives who were overly confident, and then grew into greater intentional profit management. Their overall findings highlighted that certain personality tendencies could have a large impact on accounting-related behaviors and decisions.

Armenic and Craig (2010) mentioned that a company's financial accounting had a special character that could facilitate CEO narcissism. Profits published in financial statements became an ideal means for narcissistic CEOs to meet their need for continual recognition of their excellence (Chatterjee and Hambric, 2007). Periodically published financial reports (for example: quarterly, annual, etc.) provided a conducive environment for narcissistic CEOs who needed to be rewarded in each financial reporting period (Armenic and Craig, 2010). Accounting capacity to express the results of various complex and diverse company activities in a single performance measurement mad accounting, with its main product in the form of financial statements CEOs could use to show their superiority (Armenic and Craig, 2010).

Chatterjee & Hambrick (2007) stated that narcissistic relationships possessed by the CEO contained in the annual financial statements in the form of photographs could be risky for a CEO. Someone who had a high level of narcissism would focus more on the final goal achieved than the process of achieving that goal (Furtner et al., 2011; Morf & Rhodewalt, 2001).

## HYPOTHESIS DEVELOPMENT

### The unfluence of Chief Executive Officer Narcissism on profit quality

Based on the theoretical basis and previous studies, it can be hypothesized that the higher the narcissism possessed by a Chief Executive Officer will lead to lower profit quality. Research on Narcissism Chief Executive Officer can be based on Upper Echelon theory. Thus the following hypothesis can be made:

**H1: CEO narcissism has a negative effect on profit quality.**

### The influence of Company Size on profit quality

Company Size is a measure that can explain how big or small a company is, which consists of the market value of shares, log size and total assets related to company profits. The company is divided into three groups, namely large companies, medium companies and small companies. From this description, the following hypothesis is made:

**H2: Firm size has a positive effect on profit quality.**

### The influence of DER on profit quality

The amount of debt illustrates the quality of the company and the company's progress in the future. Therefore, if the leverage level of a company is high, it will have a tendency to conduct large profit management so that it can produce low profit quality. From this description, the following hypothesis is made:

**H3: Leverage has a negative effect on profit quality.**

### The influence of Auditors' Reputation on profit quality

Previous studies mentioned that quality auditors will add credibility to profit information submitted by the company. To be able to protect their reputation, auditors must utilize superior knowledge to detect profit management. This shows that companies that use the services of reputable public accounting firms will have better profit quality. Based on this description, the following hypothis can be made:

**H4: Auditor's reputation has a positive effect on profit quality.**

### The influence of the board of commissioner's educational background on profit quality

Based on previous research, if the board of commissioners have a management education background, it is considered that decisions made will be more ethical and accounting fraud could be avoided. Education is very influential on the use of financial information. The level of education affects the use of accounting information, the higher the level of education the executive has, the higher the level of rationalization used in decision making by utilizing the use of accounting information. With the description above, a hypothesis can be made as follows:

**H5: The educational background of the board of commissioners has a positive effect on earnings quality.**

## RESEARCH METHOD

This study consisted of Narcissism as the independent variable, Company Size, DER, Auditor Reputation and Board of Commissioners Education Background as control variables and Profit Quality as dependent variable. The author would conduct partial and simultaneous testings. Prior conducting the test, the writer would measure the independent and dependent variables with the specified proxy. Secondary data in this study were the annual financial statements of state-owned companies listed on the Indonesia Stock Exchange (BEI) in 2015–2018.

This was the quantitative data with secondary data in the form of financial and non-financial data of BUMN companies listed on the Indonesia Stock Exchange in the 2015–2018 period as the source. the independent variable measured from the CEO's photo in the company's annual report, and profit quality and company size data were obtained from the Indonesian Capital Market Directory (ICMD), Fact Book and financial statements. The data collection method was documentation, which was a type of data collection that examines various kinds of documents that were useful for analysis material. Documents collected were secondary documents in the form of annual finances that had been published by the companies studied on the IDX website (http://www.idx.co.id).

The population in this study were 20 state-owned companies that had been listed on the Indonesia Stock Exchange in 2015 until the observation period in 2018. The sample was taken using purpose sampling.

To be able to find out the significance influence of the independent variable on the dependent variable, a linear regression model was used. A classic assumption test must be performed on the testing of this regression analysis tool to obtain valid results.

Equation:

$$Y = a + b1\,(\text{Narcissism CEO}) + b2\,(\text{Size}) + b3\,(\text{DER}) + b4\,(\text{AUD}) + b5\,(\text{EDUC}) + e$$

Information:

Y is Profit Quality

α is a constant

X1 is Narcissism CEO

X2 is Company Size

X3 is DER

X4 is the Auditor's Reputation

X5 is the educational background of the board of commissioners

β1 is the CEO Narcissism regression coefficient

β2 is the Firm Size regression coefficient

β3 is the Financial Leverage regression coefficient

β4 is the Auditor Reputation Regression Coefficient

β5 is the regression coefficient of the educational background of the board of commissioners

ε is Standard error

CEO narcissism was measured by the size of the CEO's photo in the company's annual report, adopting the method used by Olsen (2014), where the measurement was done by giving one point for an annual report that did not display financial statements, 2 points for an annual report that displayed a photo of the CEO along with other executives, 3 points for an annual report with a photo of the CEO himself with a size of less than half a page, 4 points for an annual report with a CEO's own photo that was more than half a page

size but did not meet one full page, and 5 points for the company's annual report that displayed the CEO's own photo with a full page size.

In this study, profit quality was measured using absolute numbers from Accrual Earnings Management (AEM). Thus, the higher the AEM conducted by the company, the lower the quality of the profits owned by the company. Accrual earnings management measurements were carried out using the Modified Jones Model. Dechow et al. (1995) said a more robust model because this model included revenue-based earnings management that was not detected in the original Jones model formulation. The Jones (1991) model proposed a model that simplified the notion that non-discretionary accruals were constant. The model tried to control the effect of changes in the company's economic environment on non-discretionary accruals. The value of discretionary accruals (DACC) to measure the level of earnings of the modified Jones model (Modified Jones Model) in (Dechow et al., 1995). Modified Jones Model could detect earnings management better than other models similar to the results of research (Dechow, et al., 1995).

Company size variable could affect the extent of financial statement disclosure in the company. The larger company would have greater information compared with smaller companies. Because large companies would face greater political risk than small companies. In addition, large companies got more attention. The policy of disclosure of social and environmental responsibility would help companies to avoid huge costs due to community demands. Roychowdhury (2006) explains that company size can explain variants in earnings manipulation significantly. Several other studies provide evidence that company size had an impact on disclosure of social responsibility (Prior et al., 2008; Yip, 2011; and Kim et al., 2012). The size of the company was formulated as follows: *SIZE = log (book value of total assets)*.

Leverage was the company's ability to fund its operation that would show the amount of collateral available to pay creditors. Leverage would be measured by Debt to Equity Ratio (DER).

The size of the KAP (public accounting firm) in this study was the difference in the size of the public accounting firm, where the size of the KAP was divided into two; big KAP (big 4) and small KAP (non big 4). Shockley (1981), Saksakotama and Cahyonowati (2014) dummy variables were used to measure KAP variables. If the client company was audited by a large KAP (big 4), then it would be given a value of 1. But if the client company was audited by a small KAP (non big 4), then it would be given a value of 0.

The educational background of the independent board of commissioners could be seen from the business education pursued by members of the board of commissioners compared the number of commissioners who possessed a total business and economic education background with the existing members of the board of commissioners. The total educational background of the independent board of commissioners could be seen in the Annual report of the company profile section of the board of commissioners.

## RESULT AND DISCUSSION

Descriptive analysis was conducted to recognize patterns, summarize information in the data, and present the information in the desired form. Descriptive analysis in this study was conducted to find the mean and standard deviation of the variables tested in the study.

The population used in this study were 20 state-owned companies listed on the Indonesia Stock Exchange from 2015–2018. The following is the descriptive analysis of each research data using a statistics program (*Table 1*).

From the results of SPSS output above, the minimum value, maximum value, average and standard deviation of each research data are presented. NCEO shows the level of CEO narcissism seen from the photos attached to the annual report. NCEO of *JSMR: PT Jasa Marga (Persero) Tbk, BBNI: PT Bank BNI (Persero) Tbk*, and *KRAS: PT Krakatau Steel (Persero) Tbk* had the highest value of 5,000, which were constantly from 2015 to 2018 became the highest number for narcissism of the CEO; a lowest value of 1,000 and *PT. ANTM: PT Aneka Tambang (Persero) Tbk* in 2016 was in the lowest place with a value of 1; the average value was 4.04000 and the standard deviation was 1.0872170. This showed that the average CEO of a BUMN company does have

*Table 1*

**Descriptive Statistics**

| | N | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| Y | 50 | −9.9649 | −.3437 | −1.845340 | 1.7938781 |
| NCEO | 50 | 1.0000 | 5.0000 | 4.040000 | 1.0872170 |
| SIZE | 50 | 27.9543 | 34.6563 | 31.526204 | 1.6498986 |
| DER | 50 | .1100 | 9.5600 | 1.810200 | 2.1226201 |
| AUD | 50 | .0000 | 1.0000 | .640000 | .4848732 |
| EDUC | 50 | .0000 | 87.5000 | 30.006600 | 21.7501255 |
| Valid N (Listwise) | 50 | | | | |

*Source:* compiled by the author.

*Table 2*

**Normality Test Result**
**One-Sample Kolmogorov-Smirnov Test**

| | Unstandardiz ed Residual |
|---|---|
| N | 50 |
| Normal Parameters [a.b] Mean | 0E-7 |
| Std.Deviation | 1.56159106 |
| Most Extreme Differences Absolute | .141 |
| Positive | .122 |
| Negative | −.141 |
| Kolmogorov-Smirnov Z | .999 |
| Asymp. Sig. (2-tailed) | .271 |

*Source:* compiled by the author.

*Table 3*

**Multicollinearity Test Result**

| Coefficients[a] | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Model | | Unstandardized Coefficients | | Standardized Coefficients | T | Sig. | Collinearity Statistics | |
| | | B | Std. Error | Beta | | | Tolerance | VIF |
| 1 | (Constant) | −11.911 | 6.929 | | −1.719 | .093 | | |
| | X1 | .109 | .247 | .066 | .442 | .016 | .769 | 1.300 |
| | X2 | .300 | .247 | .276 | 1.211 | .232 | .332 | 3.008 |
| | X3 | −.379 | .144 | −.448 | −2.638 | .011 | .597 | 1.675 |
| | X4 | .648 | .597 | .175 | 1.086 | .283 | .662 | 1.511 |
| | X5 | .015 | .012 | .181 | 1.197 | .238 | .756 | 1.322 |

*Source:* compiled by the author.

*Table 4*

**Autocorrelation Test Result**
**Model Summay [b]**

| Model | R | R Square | Adjustd R Square | Std.Error of the Estimate | Durbin-Watson |
|---|---|---|---|---|---|
| 1 | .492 [a] | .242 | .156 | 1.6479310 | 1.914 |

*Source:* compiled by the author.

*Table 5*

**Multiple Linear Regression Analysis Result**
**Coefficients[a]**

| Model | | Unstandardized Coefficients | | Standardized Coefficients | T | Sig. | Collinearity Statistic | |
|---|---|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | | Tolerance | VIF |
| 1 | (Constant) | .003 | .002 | | 1.553 | .129 | | |
| | NCEO | –.001 | 0.05 | –.751 | –4.836 | .002 | .769 | 1.300 |
| | SIZE | –.004 | .002 | –.244 | –2.437 | .107 | .332 | 3.008 |
| | DER | –.006 | .000 | 1.072 | 6.621 | .000 | .597 | 1.675 |
| | AUD | .001 | .005 | .175 | 1.075 | .283 | .662 | 1.551 |
| | EDUC | .036 | .012 | .299 | 3.000 | .640 | .756 | 1.332 |

*Source:* compiled by the author.

a high narcissism during the observation period, from 2015 to 2018.

The control variable used in this study was profit quality. The first one was SIZE. The highest value of SIZE was 34.6563 possessed by *BBRI: PT Bank BRI (Persero)* Tbk with total assets of 1,202,252,094,000,000 in 2018; the lowest value was 27.9543 possessed by *INAF: PT. Indofarma (Persero) Tbk* with total assets of 1,381,633,321,120 in 2016; the average was 31.526204 and a standard deviation was 1.6498986.

DER highest value was 9.5600 represented by *BBTN: PT Bank BTN (Persero) Tbk* in 2015; the lowest value was .1100 presented by SMBR: PT Semen Baturaja (Persero) Tbk in 2015; the average value was 1.810200 and the standard deviation was 2.1226201. This indicated that of all the 20 State-owned companies, the amount of debt used to finance business activities when compared to equity was 1.810200.

The auditor reputation variable has the highest value of 1; the lowest value of 0; and the average value of .640000. It indicated that only 32 companies used auditors that were categorized as the Big Four, the remaining 18 companies used auditors that were not included in the Big Four category. The standard deviation was .4848732.

The EDUC variable had the highest of 87.5000 represented by *BMRI: PT Bank Mandiri (Persero) Tbk* in 2016. This indicated that most CEOs and board of commissioners at BMRI have a management education background. The lowest value was .0000 represented *ADHI: PT Adhi Karya (Persero) Tbk* in 2018. EDUC had an average value of 30.006600 and a standard deviation of 21.7501255. From the data distribution, it could be seen that there were still many boards of commissioners in BUMNs that did not have management background (*Table* 2).

After clearing data from outliers (data deviating far from the average), the Asymp.Sig. (2-tailed) value was 0.271. The results indicated that the residual data in this regression model was normally distributed because of the Asymp value. Sig. (2-tailed) above 0.05 (*Table 3*).

*Table 6*

**The Analysis of Determination Coeficient Test Result**
**Model Summary[b]**

| Model | R | R. Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|---|
| 1 | .607 [a] | .368 | .344 | .0186640 |

*Source:* compiled by the author.

*Table 7*

**F Test Result**

| Model | Sum of Squares | Df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| 1 Regression | .015 | 3 | .005 | 14.781 | .000[b] |
| Residual | .026 | 76 | .000 | | |
| Total | .042 | 79 | | | |

*Source:* compiled by the author.

*Table 8*

**t Test Result**
**Coefficients[a]**

| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. |
|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | |
| 1 | (Constant) | .003 | .002 | | 1.553 | .129 |
| | X1 | –,001 | 0.05 | –.751 | –4.836 | .002 |
| | X2 | –.004 | .002 | –.244 | –2.437 | .107 |
| | X3 | –.006 | .000 | 1.072 | 6.621 | .000 |
| | X4 | .001 | .005 | .175 | 1.075 | .283 |
| | X5 | .036 | .012 | .299 | 3.000 | .640 |

*Source:* compiled by the author.

Based on the multicollinearity test analysis results above, the tolerance value was > 0.1 and VIF value was <10. These results showed that there was no multicollinearity problem in this regression model and could be used for further analysis (*Table 4*).

From the results in table 4 above, the Watson durbin was at 1,914. This value then would be compared with the DW table with a sample size of 50, four independent variables and a confidence level of 5% at the lower limit (dl) = 1,3779 and upper limit (du) = 1.7214. Because the DW value of 1.914 was between the upper limit (du) = = 1.7214 and (4-du) = 2.2786, it could be concluded that autocorrelation did not occur (*Table 5*).

From the results of the multiple linear regression analysis above, the regression equation model developed in this study was as below:

$$Y = 0.003 + -0.001NCEO - 0.004SIZE - - 0.06DER + 0.001AUD + 0.36EDUC + e.$$

Based on the above analysis, the Narcissism variable of CEO, SIZE, DER had negative influences on profit quality while the Auditor Reputation and EDUC variables provided positive influences on profit quality (*Table 6*).

In the determination coefficient, the regression model obtained *adjusted R square value* of 0.344. This showed that 34.4% of profit management variations can be explained by the company size, financial leverage, auditor's reputation, and board of commissioners' educational background as control variables, while the remaining 65.6% could be explained by other variables not included in this study.

According to *Table 7*, the F value$_{calculated}$ was 14.781 with a significance value of 0.000 <alpha 0.05. It explained that all control variables such as company size, financial leverage, auditor reputation, and educational background of the board of commissioners jointly affected the profit quality (*Table 8*).

The first hypothesis looked at the influence of CEO Narcissism on profit quality. The test result using linear regression were presented in table 4.10. Based on the above test result, a regression coefficient was at — 001 with a significance value of 0.02 (<0.05). Thus, it could be concluded that Narcissism CEO had a negative effect on profit quality. Then, the first hypothesis which stated that CEO Narcissism negatively affected profit quality was accepted. The first hypothesis test result showed that Narcissism CEO negatively affected profit quality. These finding was in line with the results of researches conducted by Leela et al (2017), Vita and Slamet (2018) and Krishnan (2008). In other words, Narcissism CEO led to lower profit management. The higher the Narcissism of a CEO in a company was, the smaller the profit management actions taken by the company would be. This finding was in contrary to the results of researches done by Rispantyo (2019), Frino et al (2015), Lynn (2011), Campbell (2004), Chatterjee (2011), Daniel (2010), and Creig (2011) which stated that CEO Narcissism provided a positive effect on profit quality. Chatterjee and Hambrick (2006) stated that narcissism was one of the causes for someone to assume the power and influence they had (Kernberg, 1975). In addition, narcissism could help and arouse one's emotions for the advancement of his profession when it was linked to self-esteem. (Raskin, et al, 1991). Therefore, with narcissism, someone would try to create a positive image, which would also lead to optimism and a strong belief in the results obtained later. The result of this study was in line with the Upper Enchelon Theory (Ingersol et al, 2017) which suggested that the organization was a reflection of the values held by its leaders (Hambrick and Mason, 1984). The personality of the company leader would determine the various strategies, policies and practices that run in the company. State-owned companies were always under the supervision of the government so that the alleged practice of profit management or the desire to conduct profit manipulation was very small. The result of this study supported the statement.

The second hypothesis looked at the effect of company size on profit quality. Based on the test result, the regression coefficient was –0.004 with a significance value of 0.107 (>0.05). Thus it could be concluded that company size had no effect on profit quality. Therefore, the second hypothesis which stated that company size had a positive effect on profit quality was rejected. The result of this study were supported by research by Palupi (2006), Collins and Kothari (1989) which mentioned that company size gave no effect on profit quality. This finding was also in line with Rizki's (2012). Watt and Zimmerman (1986) in their third hypothesis (the existence of an agency relationship between management and government) included in positive accounting theory stated that large companies which in many cases easily became the public spotlight had a strong urge not to be too accentuating profits because of concerns over the emergence of accusations of getting special facilities and monopolies from the government.

The third hypothesis looked for the effect of leverage on profit quality. Based on the test result, the regression coefficient was –0.006 with a significance value of 0.000 (<0.05). Thus it could be concluded that leverage affected profit quality in a negative direction. Therefore the third hypothesis which stated that leverage had a negative effect on earnings quality was accepted. These results supported the research of Sadiah (2015), Ghosh and Moon (2010). Scott (2009) stated that investors would assume a negative effect on the use of debt in the company and that the company would prioritize debt payments rather than paying dividends. Therefore, the higher the leverage level of the company, the lower the profit quality because there was an indication that the management practiced poor profit management.

The fourth hypotheses aimed to see the effect of the auditor's reputation on profit quality. Based on the test result, the regression coefficient was 0.001 with a significance value of 0.283 (<0.05). Thus it could be concluded that the Auditor's reputation did not affect profit quality. Therefore, the fourth hypothesis which stated that the company's Auditor Reputation had a positive effect on profit quality was rejected. This indicated that if a company was audited by a high-reputed auditor, the level of trust in the quality of its profits would get higher, thereby minimizing unlawful profit management practices.

The fifth hypothesis looked at the influence of the board of commissioner's educational background on profit quality. Based on the test result, the regression coefficient was 0.036 with a sig-

nificance value of 0.640 (<0.05). Thus it could be concluded that the educational background of the board of commissioners had no effect on the quality of profit. Therefore, the fifth hypothesis which stated that the board of commissioners' educational background had a positive effect on profit quality was rejected. This result was in line with the research of Bagus (2014) and Setyaningrum (2012) mentioning that educational background had a significant effect on professional skills. The result of this research was in contrary to Kusumastuti et al (2006), Bray, Howard and Golan 1995) and Moerdiyanto (2011) which supported the positive impact of manager education on the company's stock performance.

## CONCLUSION

Based on the results of the research on the influence of CEO narcissism on profit quality in the financial statements of state-owned enterprises in the 2015–2018 period, the following conclusions can be drawn. There was a relationship between CEO narcissism on company profit quality that provided a negative impact. This finding was consistent with the results of Frino et al (2015) stating that the higher the level of CEO narcissism, the higher the risk of profit management and led to lower profit quality. Likewise, the effect of DER on profit quality had a negative effect because the use of debt would be responded negatively by investors. Consequently, the company was assumed to prioritize debt payments rather than dividend payments. Therefore, the higher the leverage of the company, the lower the profit quality because there were indications that the management conducted unlawful and poor profit management practices. Since there was still lack of researches conducted on the narcissistic characteristics of a CEO, some limitations occured in this study. Future researchers could further expand the scope of the researches as this research used only state-owned enterprises as the research object. In addition, further researches were encouraged to redevelop this study by combining variables related to narcissism and other profit quality.

## REFERENCES


1. Amernic J.H., Craig R.J. Accounting as a facilitator of extreme narcissism. *Journal of Business Ethics*. 2010;96(1):79–93. DOI: 10.1007/s10551–010–0450–0
2. Campbell W.K., Goodie A.S., Foster J.D. Narcissism, confidence, and risk attitude. *Journal of Behavioral Decision Making*. 2004;17(4):297–311. DOI: 10.1002/bdm.475
3. Campbell W.K., Hoffman B.J., Campbell S.M., Marchisio G. Narcissism in organizational contexts. *Human Resource Management Review*. 2011;21(4):268–284. DOI: 10.1016/j.hrmr.2010.10.007
4. Chatterjee A., Hambrick D.C. It's all about me: Narcissistic chief executive officers and their effects on company strategy and performance. *Administrative Science Quarterly*. 2007;52(3):351–386. DOI: 10.2189/asqu.52.3.351
5. Dechow P.M., Sloan R.G., Sweeney A.P. Detecting earnings management. *The Accounting Review*. 1995;70(2):193–225.
6. Finkelstein S., Hambrick D.C. Strategic leadership: Top executives and their effects on organizations. St. Paul, MN: West Publishing Co.; 1996. 457 p.
7. Freud S. A general introduction to psychoanalysis. Transl. from Eng. Yogyakarta: Pustaka Pelajar; 2006. 707 p. (In Indones.).
8. Galasso A. Simcoe T.S. CEO overconfidence and innovation. *Management Science*. 2011;57(8):1469–1484. DOI: 10.1287/mnsc.1110.1374
9. Goel A.M., Thakor A.V. Overconfidence, CEO selection, and corporate governance. *The Journal of Finance*. 2008;63(6):2737–2784. DOI: 10.1111/j.1540–6261.2008.01412.x
10. Helfert E.A. Techniques of financial analysis. Transl. from Eng. Jakarta: Erlangga; 1996. 436 p. (In Indones.).
11. Ingersoll A.R., Glass C., Cook A., Olsen K.J. Power, status and expectations: How narcissism manifests among women CEOs. *Journal of Business Ethics*. 2019;158(4):893–907. DOI: 10.1007/s10551–017–3730–0
12. Judge T.A., LePine J.A., Rich B.L. Loving yourself abundantly: Relationship of the narcissistic personality to self- and other perceptions of workplace deviance, leadership, and task and contextual performance. *Journal of Applied Psychology*. 2006;91(4):762–776. DOI: 10.1037/0021–9010.91.4.762

13. Olsen K.J., Dworkis K.K., Young S.M. CEO narcissism and accounting: A picture of profits. *Journal of Management Accounting Research.* 2014;26(2):243–267. DOI: 10.2308/jmar-50638
14. Prior D., Surroca J., Tribó J.A. Are socially responsible managers really ethical? Exploring the relationship between earnings management and corporate social responsibility. *Corporate Governance: An International Review*. 2008;16(3):160–177. DOI: 10.1111/j.1467–8683.2008.00678.x
15. Rijsenbilt A., Commandeur H. Narcissus enters the courtroom: CEO narcissism and fraud. *Journal of Business Ethics.* 2013;117(2):413–429. DOI: 10.1007/s10551–012–1528–7
16. Rispayanto. CEO narcissism and profit quality. *Research Fair Unsiri.* 2019:3(1). (In Indones.).
17. Roychowdhury S. Earnings management through real activities manipulation. *Journal of Accounting and Economics.* 2006;42(3):335–370. DOI: 10.1016/j.jacceco.2006.01.002
18. Schipper K., Vincent L. Earnings quality. *Accounting Horizons*. 2003;17(1S):97–110. DOI: 10.2308/acch.2003.17.s-1.97
19. Yusoff W.F.W. Characteristics of boards of directors and board effectiveness: A study of Malaysian public listed companies. PhD thesis. Melbourne: Victoria University; 2010. 445 p. URL: http://vuir.vu.edu.au/15798/1/yusoff.pdf.
20. Zein A.K., Surya R.A.S., Silfi A. The effect of earnings growth, capital structure, liquidity and independent commissioners on earnings quality with independent commissioners moderated by the competence of independent commissioners: Study on manufacturing companies listed on the Indonesia Stock Exchange in the period 2013–2014. *JOM Fekon.* 2016;3(1):980–992. URL: https://jom.unri.ac.id/index.php/JOMFEKON/article/view/10628/10284 (In Indones.).

## ABOUT THE AUTHORS

***Poppy Febrina*** — Bachelor of Economics, Master Student, Sriwijiaya University, Palembang, Indonesia
poppyazora@yahoo.co.id

***Tertiarto Wahyudi*** — Master Of Accountancy and financial information systems, lecturer, Sriwijaya University, Palembang, Indonesia
tertiarto_wahyudi@unsri.ac.id

***Azwardi*** — Master of Science of Economics, lecturer, Sriwijaya University, Palembang, Indonesia
Azwardi_unsri@yahoo.com

***Authors' declared contribution:***
Poppy Febrina — Theoretical part, methodology, research data collection, analysis of data processing results.
Tertiarto Wahyudi — Disscusion about adding control variables and research results.
Azwardi — Disscusion about research results and general conclusion.

*The article was submitted on 10.10.2019; revised on 24.10.2019 and accepted for publication on 20.11.2019. The authors read and approved the final version of the manuscript.*