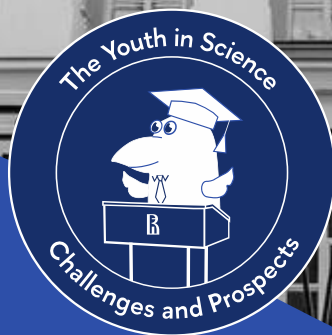# HSE University
School of Foreign Languages

# The Youth in Science: Challenges and Prospects

Proceedings of the IInd scientific student conference

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National Research University Higher School of Economics

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SCIENTIFIC STUDENT CONFERENCE
"THE YOUTH IN SCIENCE: CHALLENGES AND PROSPECTS"

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The conference proceedings are published basing on the results of the 2nd Scientific Student Conference, which was held by the HSE School of Foreign Languages on March 15, 2021.

This edition is aimed at a wide audience interested in the issues of economics, computer science and law as well as the researchers, undergraduate, graduate and postgraduate students.

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# CONTENT

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## An assessment of Russia's comparative advantages in the global market on the example of agricultural products

**ABSTRACT.**
In recent years, as Russia's agro-industrial sector (AIS) is switching from import substitution to export development, the task of identifying potential opportunities for increasing exports has gained special relevance. The article presents an analysis of competitiveness of Russia's agri-food exports based on the calculation of revealed comparative advantage (RCA) index of agricultural and food commodities on a product-by-product basis. As shown, only 20% of commodity items of Russia's agricultural exports had a comparative advantage in foreign markets in 2019. However, the commodities within this group accounted for almost 80% of the total agri-food exports. The list of goods with a competitive advantage is composed mainly of primary commodities and low value-added products. In addition, the structure of export with comparative advantages has a high concentration on individual products (sunflower oil, wheat and frozen fish). Though some commodity items have comparative advantages in the world market, their RCA value is still relatively low. Most likely, if market conditions change, these products can lose their comparative advantage. This situation is limiting the growth and diversification potential of agri-food exports from the Russian Federation (RF).

**Keywords:** *competitiveness; revealed comparative advantages; agri-food exports; Balassa index; Russia.*

At the time when the Russian Soviet Federative Socialist Republic (RSFSR) was a part of the USSR, its economy relied heavily on imports of agricultural and food products. Russia's 1998 financial crisis became a pivotal point in the development of its agrarian sector as the crisis suspended imports into Russia and boosted the growth of investments in the food industry and later in the agricultural sector. By the mid-2000s, the country had defined an import-substitution strategy and moved to its successful implementation. Russia has become the world's leading wheat and buckwheat exporter and has been in the top 10 exporters of other crops. In addition, Russia has achieved almost complete self-sufficiency in certain types of products, and a risk of overproduction occurred on some of the markets. In view of this situation, an issue of the agricultural sector reorientation to export came up [8]. In 2019, within the federal project on exports of AIS products a target indicator was set up:

to increase the value of agricultural product exports to the amount of USD 45 billion by 2024. However, at the end of 2020 the achievement of this goal was postponed to 2030.

From the perspective of global integration, Russia needs to find out the most promising export opportunities in terms of product types and market outlets. In this context, focus is made on identifying commodities which will offer export competitive advantages and thus provide a potential for further growth.

The goal of this research is to assess comparative advantages of Russia's agri-food exports in foreign markets. As Russia only starts exporting its AIS products, the research tests a hypothesis that the amounts of exported agri-food commodities with comparative advantage are comparatively limited and represented mainly by primary goods.

The following tasks should be addressed to achieve this goal:

1.      to conduct a review of the scientific literature and available methodological approaches for assessing the country's competitiveness in global trade;

2.      to calculate the revealed comparative advantage (RCA) indices for Russia's agri-food exports on a product-by-product basis;

3.      to draft recommendations which could be useful in the context of Russia's food export development policy.

The scientific literature review shows that the most common approach for assessing the competitiveness of commodities in the global market is based on the measurement of the country's comparative advantage in the trade of these commodities. The theory of comparative advantage was first developed by David Ricardo. According to this theory, a country has a comparative advantage when a good can be produced at a lower cost compared to other countries [3]. As assumed by Ricardo in his theory, a comparative advantage arises when a country produces a commodity with lower labor costs than another country.

In the 1930s, E. Hekscher and B. Olin developed a theory of relative factor endowments. They assume that comparative advantages exist because countries vary in the required factors of production (labor and capital). The theory states that a country will export the commodities which require the use of their abundant factors of production and will import the products which use the countries' relatively scarce factors [7].

Among indicators used for assessing the competitiveness of a country's international trade, the comparative advantage index developed by Balassa has become the most common metric. The Balassa approach suggests that a certain country has a comparative advantage in given commodities supported by its specialization in the exports of these commodities [1]. In other words, a country's comparative advantage will manifest itself in the structure of its international trade. Therefore, the index was called "revealed comparative advantage (RCA)".

Later, multiple alternative indicators were proposed in the scientific literature based on the concept of comparative advantage. For example, T. Vollrath [9] and G. Lafay [4] suggest indices that take country's both export and import flows into consideration in the analysis of its comparative advantages. Using these indices, it is possible to assess the degree to which countries are integrated into the international division of labor. The authors believe that a country's net trade balance is important for making a more thorough analysis of its existing comparative advantages, since the country with high export flows can also import a significant added value of given commodities and at the same time add little value to its products locally.

L. Latruffe [5] described pros and cons of various approaches and indicators used in the international practices for measuring competitiveness, productivity, and efficiency in the agri-food sector. The author confirms that the RCA index is the most popular measure of a revealed comparative advantage. This indicator is based on a clear economic concept and can be readily calculated.

Only a limited number of publications analyzing the competitiveness of Russia's agri-food sector is available. It is underpinned by the fact that recently the Russian Federation has had the status of a large food importer and only more recently its national strategy in the agricultural sector has shifted to exports. In their study, N. Ishchukova and L. Smutka [2] assess the comparative advantage of Russian agricultural exports in the period 1998-2010 using the Balassa, Vollrath and Latruffe indices. They revealed a group of commodities which had a sustainable comparative advantage in the studied period: grain crops (wheat and barley), by-products (e.g. wheat bran) and products of their processing (flour), as well as oil crops, vegetable oil and chocolate. Concurrently, a number of goods with a comparative advantage increase constantly. The review on a region-by-region basis has demonstrated that Russia enjoyed a comparative advantage against the CIS and Asian countries due to its geographical position and well-developed trade links.

In the article of W. Liefert [6] the comparative advantage of the Russian agricultural sector is considered from the standpoint of value of the resources required for manufacturing crop and livestock products. The empiric results presented in the publication prove that in the second half of the 1990s the country's resource base supported a comparative advantage in the production of grain crops. However, it was economically unprofitable to produce meat, and this finding had an impact on the foreign trade structure during that period. In 1996-97, Russia was a large meat importer (the import share made up 30% of the total domestic consumption). At the same time, Russia had a status of net exporter of wheat and grain crops taken as a whole. Thus, the available results of assessment of the Russian agriculture competitiveness are related mainly to the period when Russia was a net importer of the most AIS products and therefore they require updating in view of the latest trends in the sector.

**Research Methodology and Description of Data**

The research builds on the method of assessment of a revealed comparative advantage using the Balassa index [1]. Benefits of this approach include the simplicity of calculations, as compared to alternative indicators, and the use of international trade data available in the public domain for a broad range of countries.

The RCA index is measured by the product's share in the country's exports in relation to its share in total world exports:

$$RCA_{i,t} = \frac{e_{i,t}/e_t}{E_{i,t}/E_t} RCA_{i,t} = \frac{e_{i,t}/e_t}{E_{i,t}/E_t},$$

(Formula 1)

where $RCA_{i,t} RCA_{i,t}$ – the revealed comparative advantage index for product $i$ in year t

$e_{i,t} e_{i,t}$ – volume of product $i$ export from the RF to the world market in year $t$,

$e_t e_t$ – total volume of agri-food export from the RF to the world market in year $t$,

$E_i, t E_i, t$ – global product $i$ exports in year $t$,

$E_t E_t$ - total global exports of agri-food products in year $t$.

If RCA>1, the country enjoys a comparative advantage in trade of a given product in the world market, namely the country specializes in trading this product. In case where the RCA index lies within the interval [0; 1], the country does not have a comparative advantage in a given product in the world market.

However, with all benefits of this approach, the RCA index reveals some drawbacks. For example, due to the barriers that can be imposed by other countries on international trade, a country's comparative advantage would not be fully reflected in its export specialization. Changes in the restrictions on a country's exports may have an impact on its

comparative advantages. These restrictions should be taken into consideration for assessing the Russian agricultural sector competitiveness in foreign markets.

The index was calculated for commodities included in Classification Groups 1 – 24 of the Harmonized Commodity Description and Coding System (HS), which constitute a classification catalogue of goods used for their identification during customs procedures. The HS System divides goods into sections, groups and subgroups and assigns relevant codes. Agricultural raw materials and foods are included in HS Groups 1-24. Four-digit HS codes were used for making calculations. Thus, the research assessed the comparative advantages of 191 agri-food products exported from Russia.

The research data are built on RF foreign trade and international trade statistics available in the UN Comtrade database. The RCA index was calculated using the 2019 data.

**Comparative Advantages of Russia's Agri-food Exports**

The calculated RCA indices were used to identify agri-food products exported from Russia in 2019 which represented a comparative advantage, in particular, those with a RCA value above 1 (Fig. 1).

According to the results, Russia's agri-business had a revealed competitive advantage in exporting a comparatively limited number of products. In 2019, Russia exported 191 agri-food commodity items, and the research demonstrated that only 38 of them (19.9%) had revealed competitive advantage (RCA>1). However, the commodities within this group accounted for the highest export volumes of AIS products in value terms – 77.3% (Fig. 2). It means that approx. 20% of products exported to other countries account for almost 80% of the total exports. Other 80% of products supplied by Russia to other countries did not have comparative advantages and, as a result, they made only a modest contribution to agri-food exports in value terms – 22.7%.

*Fig. 1. Agri-food products with revealed comparative advantage (RCA>1) based on 2019 export values*
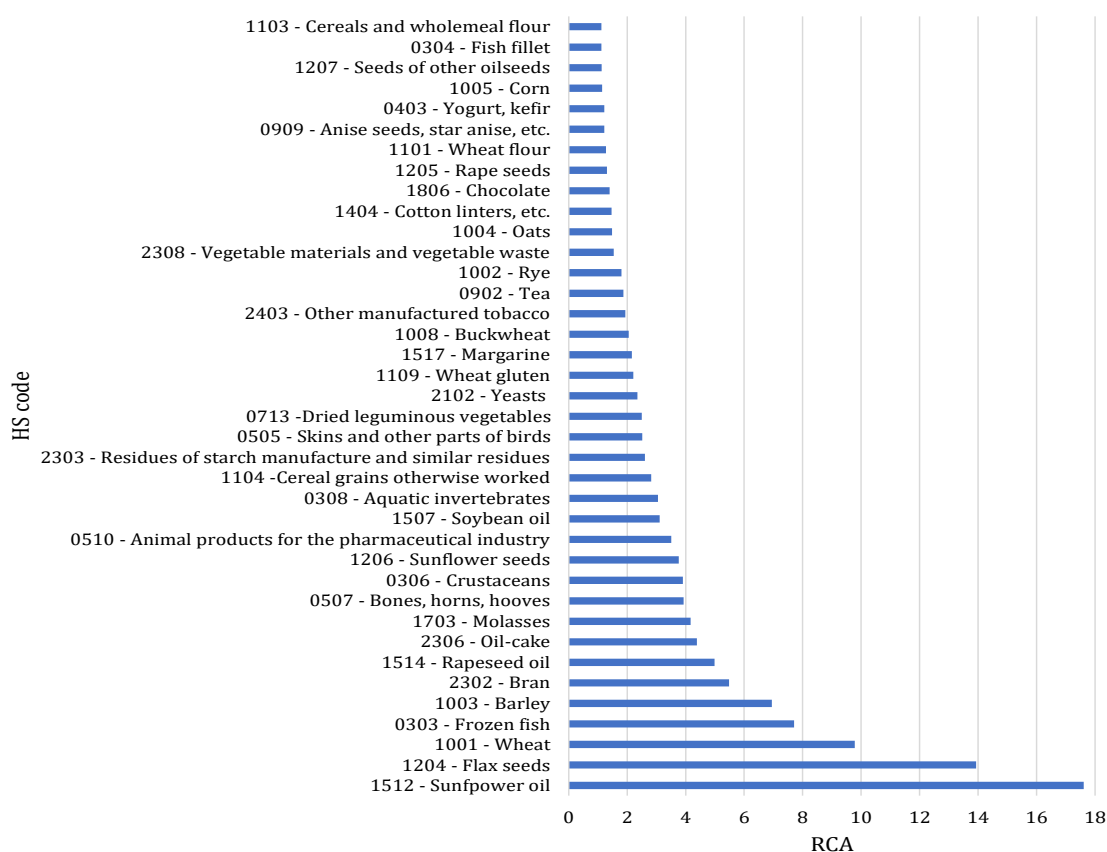


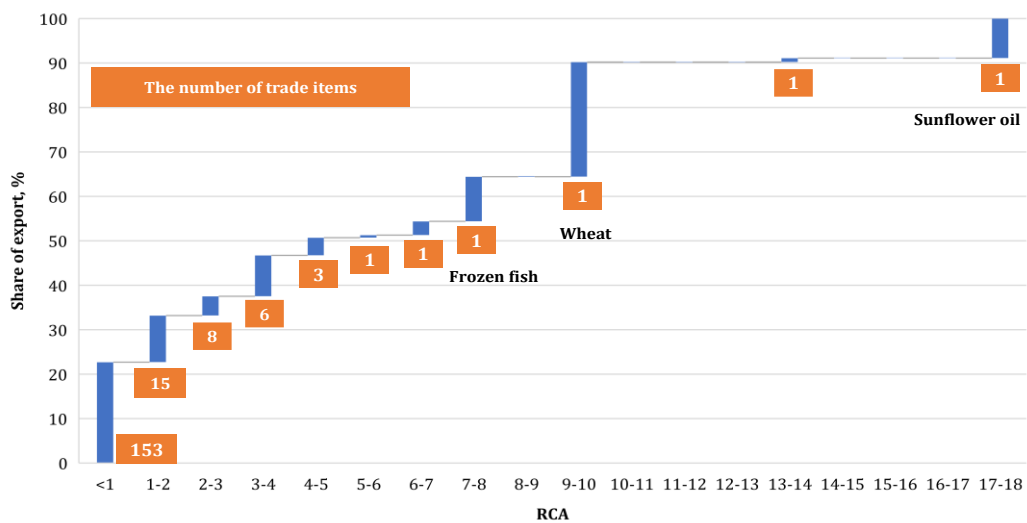Source: author's calculations using the UN Comtrade data

*Fig. 2. The share of products with comparative advantages (RCA>1)*
*in Russia's agri-food exports, 2019*
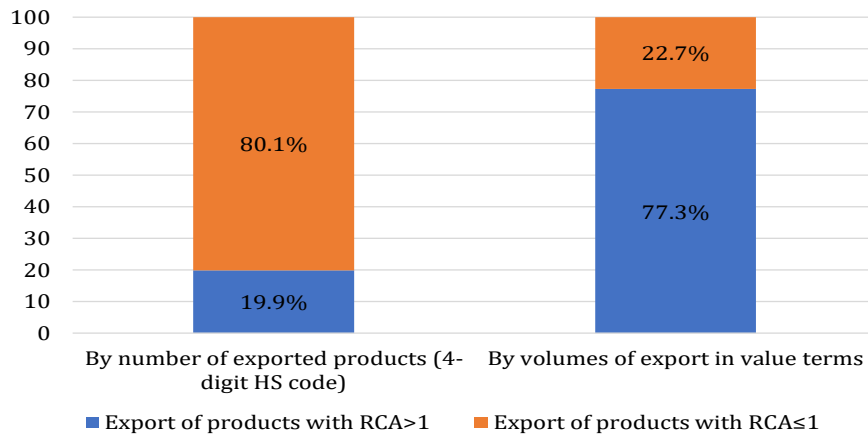


Source: author's calculations using the UN Comtrade data

If we look at the structure of export with comparative advantages, we will notice its high concentration on individual products. To this end, about a half (44.7%) of exports dropped by only three commodity items with a high RCA value (Fig. 3): sunflower oil (RCA=17.6); wheat (RCA=9.8); and frozen fish (RCA=7.7). These core products account for the highest proportion of RF export specialization.

*Fig. 3. RF agri-food exports with comparative advantages (RCA>1)*

*by RCA value and number of products, 2019*



Source: author's calculations using the UN Comtrade data

Basically, primary commodities and low value-added goods prevail in exports of AIS products. The main share of export of these products is made up by grain crops, flour, and cereals – 42.4%, fish and seafood – 23.5%, vegetable oil and animals fats – 17.3% (Fig. 4). Such products have relatively low export prices as compared to high value-added goods, which are currently exported in comparatively insignificant quantities. This situation has complicated the task of increasing agri-food exports to USD 45 billion by 2024. Calculations performed with the use of the UN Comtrade data demonstrated that in 2019 Russia's export of agricultural and food products amounted to USD 24.8 billion.

*Fig. 4. Exports of AIS products with comparative advantages (RCA>1)
in value terms by product, 2019*
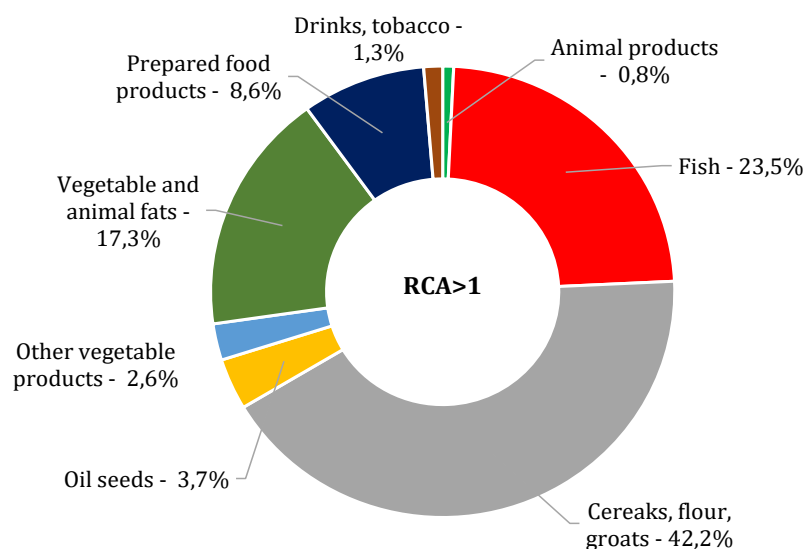


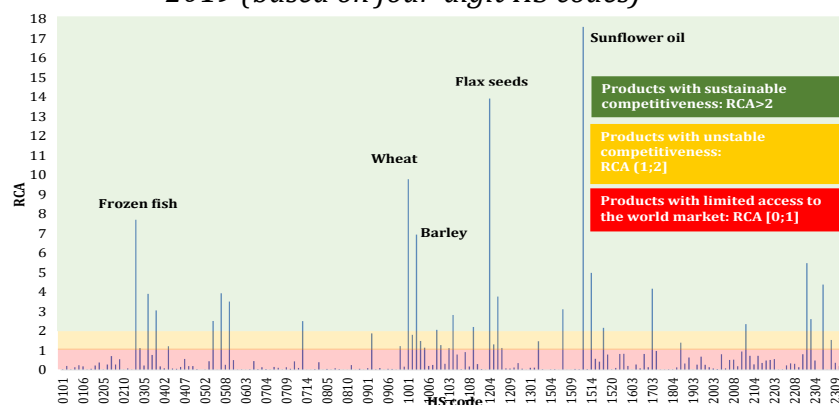Source: author's calculations using the UN Comtrade data

Based on RCA values, the list of goods with comparative advantages could be divided into three groups from the perspective of their competitive positions in the global market (Fig. 5):

- products with sustainable competitiveness which have a RCA value above 2. Basically, this group includes those commodity items that are traditionally exported by Russian AIS and/or account for a substantial share in the export mix. In total, there are 23 commodity items: sunflower oil, flax seeds, wheat, frozen fish, barley, bran, rapeseed oil, oil cake, molasses, bones, horns and hooves, crustaceans, sunflower seeds, animal products for the pharmaceutical industry, soybean oil, aquatic invertebrates, oat, residues of sugar and starch manufacture, skins, leguminous vegetables, yeasts, wheat gluten, margarine, and buckwheat.

- products with unstable competitiveness for which a RCA value lies within the interval [1; 2]. Though these commodity items have comparative advantages in the world market, their RCA value is still relatively low. Most likely, if market conditions change (international price movements, the emergence of stronger competitors) these products can lose their comparative advantage, and their competitiveness in the world market will remain unstable. It total, there are 15 commodity items: tobacco, tea, rye, vegetable waste, oats, cotton linters, chocolate, rape seeds, wheat flour, anise seeds and star anise, yogurt and kefir, corn, seeds of other oilseeds, fish filet, cereals, and wholemeal flour.

- products with limited access to the world market for which a RCA value lies within the interval [0; 1]. This group comprises agricultural products that Russia has exported to other countries, but so far it has not enjoyed a comparative advantage in these products. The above products have low international market shares which could be linked both to a lack of competitiveness and weak exports due to the imposition of trade barriers by the importer countries, for example requirements and standards, import restrictions. In total, there are 153 commodity items. However, consideration should be given to RCA value limitations: due to the presence of barriers that can be imposed by some countries to international trade, the country's comparative advantages would not be reflected fully in its export specialization. It means that, if such barriers are lifted, the competitive advantages of Russia's agricultural sector may change.

*Fig. 5. Revealed comparative advantage (RCA) index values for RF agri-food exports, 2019 (based on four-digit HS codes)*

Source: author's calculations using the UN Comtrade data

The analysis of competitiveness of RF agri-food exports based on the revealed comparative advantage index (Balassa index or RCA) with the product-wise break-up proves the assumption that there is a noticeably limited range of exported agri-food products which have comparative advantage in foreign markets. For the most part, it includes agricultural raw materials and low value-added products. At the same time, though 80% of commodity items were exported in small volumes, they did not have comparative advantages due to a lack of competitiveness in foreign markets or the restrictions imposed on Russian products by the importer countries.

The limited competitive advantages of Russia's AIS products diminish the potential for export growth and diversification. Moreover, the dependence on agricultural raw material exports poses risks for Russia's economy stemming from the volatility in world commodity prices (for example, grains). Under these circumstances, to achieve the goal of increasing AIS product exports, it is necessary to develop the production of high value-added goods which will be competitive in the global market. This approach will require investments in upgrading production capacities and an introduction of modern technologies, and therefore it can be implemented in a long-term perspective. The task of increasing export volumes can be also addressed through the promotion of traditional Russian exports (wheat, frozen fish, sunflower oil) to new market outlets. This process will be facilitated by conducting intergovernmental negotiations on the coordination of the veterinary and phytosanitary certificates with other countries; harmonization of the quality standards with the international regulations; building strategies for the promotion of domestic products in foreign markets; and the development of export infrastructure and transport logistics.

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**Correlations between the Prices of Exchange Traded Funds (ETFs) and the Value of their Benchmarks**

**ABSTRACT.**
The purpose of the work is to study the correlation of mutual funds/ETFs and their benchmarks in short-term time periods. The hypothesis of the existence of deviations of ETFs from their benchmarks on the days of additional tranches of securities is being tested. The analysis uses a correlation tool for two values: the ETF price and the dynamics of the benchmark index. In fact, in the short term, during the days of additional tranches of ETFs, there is a violation of the long-term stable correlation, which at first glance is an abnormal result. The proven fact made it possible to derive a number of trading strategies based on algorithmic trading and allowing various types of investors to receive additional income. An in-depth reading of the work allows us to trace the confirmation of the revealed fact on specific examples from 2021-2022 and to identify the scale of the existing deviations.

**Keywords:** *exchange traded fund (ETF); benchmark; index; deviation; intraday; correlation; additional tranches.*

The purpose of this study is to determine the relationship between different ETFs and their benchmarks. There should be a determined strong correlation between them, but is it right? In addition, as tasks, the following aspects are considered: there are many types of ETFs that are on foreign benchmarks. The dynamics of financial instruments and their index on long-term period is obviously strong, and it is regarded as the main aim of instrument. But what happens if short-term periods are taken? Is the correlation stay same strong?

The research of deviations of correlations between ETFs and their benchmarks on short time frames seeks to determine dependency of them and describe some trading strategies aimed to make profit from this phenomenon.

There are no studies that researched this phenomenon, whereas some theme-related works (dated by 2018) have been published, but they describe absolutely different things. After that many new ETFs appeared and the existing funds became more liquid, which creates a wide field for research.

**Some Research Methods are employed:**
- Statistical estimation of distribution parameters (interval estimates).
- Graphical visual and tabular spot analysis.
- Highlighting the trend component of a time series.
- Methods of correlation analysis.
- Index analysis method.

**The Information Database consists of:**
- Yahoo Finance! - real estate price data
- Solactive – official statistical indices data

**Delimitations of the study**

A trend - is the main tendency for something to change: for example, in mathematics, a time series. Trends can be described by various equations - linear, logarithmic and so on. The actual type of trend is based on the selection of its functional model by statistical methods or by smoothing the initial time series.

A time series - is a sequence of numerical data points in successive order.

Correlation - is a term that is a measure of the strength of a linear relationship between two quantitative variables (e.g., age, gender).

Index (in this work) - a statistical measure for tracking economic data. Aggregate indicator that shows the dynamic changes on the financial market.

Now such stock market instruments as a Mutual Fund and ETF are gaining more and more popularity. But what is the difference between them?

In addition to all the differences in creation and management, we will single out one of the greatest interest for research. As noted by Legkostupov, the accuracy of following the declared index in ETFs is provided by the custodian and administrator, and in the Mutual Fund, it is not provided by anyone [4]. As a result, it suggests that the deviation from the benchmark in the Mutual Fund will be greater than that of the ETF. Moreover, the basket of basic instruments of the Mutual Fund, unlike ETFs, is collected by a management company, which is why the index may not be followed so accurately [3]. According to Troshin, the average annual deviation of Russian mutual funds from the dynamics of the MICEX index (the benchmark of the Russian economy) constitutes 5%, while the deviation of ETFs from their benchmarks accounts for 1% [7].

Ferri describes the mechanism of how exactly ETFs and Mutual Funds ensure that their benchmark is followed [2]. As is noted, the phenomenon of "self-fulfilling expectations" plays a pivotal role in this process: people believe that following the ETF will be subordinated to the movement of the index and, with sharp short-term changes, make a deal in the direction of the index movement, directing it even more. Lydon and Wasik include this point in the description of one of investment strategies [5]. But does the ETF price always move after the benchmark? It is known that the ETF does not always exactly repeat the movement of the index. Why this happens is described in more detail by Lydon [6]. Having studied all kinds of phenomena in this area, we can form a certain pool of trading strategies that allow you to generate profits and supplement the list represented by Connors et al. [1]. An interesting fact considered in this paper is concerned with the non–obvious relationship between an additional tranche of an ETF and its deviation from the benchmark price, which can be useful for the ETF market research and search for profitable investment solutions.

## Methods

The relationship between the price movement of mutual funds and ETFs and their benchmark was investigated using the well-known correlation method, which allows us to assess the degree of relationship between two data series. The correlation index is a coefficient whose value ranges from -1 to 1, where -1 means a linear negative relationship, 1 means a linear positive relationship, and 0 means the absence of any linear relationship.

The correlation formula below is employed in the study:

$$corr(X,Y) = \frac{cov(X,Y)}{\sqrt{D(X)}\sqrt{D(Y)}}, где$$

$$cov(X,Y) = E(XY) - E(X)E(Y)$$
$$D(X) = E(X^2) - (E(X))^2$$
$$D(Y) = E(Y^2) - (E(Y))^2$$

## Results achieved

I. Mutual Fund TBIO Study

The correlation value for long periods really turned out to be high, despite weekly transactions with securities within the fund and the issuance of additional investment units, and equal to 0.985, since it characterizes the global movement of the Mutual Fund price, which (as stated) is similar to the dynamics of the benchmark.
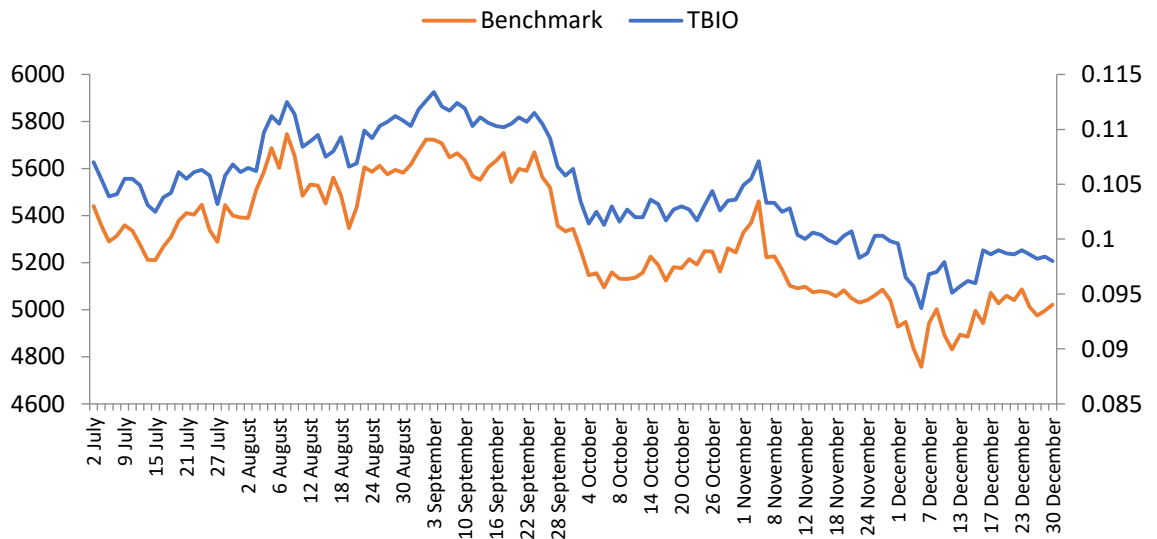


**Figure 1.1** Dynamics of the benchmark.

However, the correlation for short periods of time on the day of the issue of additional shares is extremely low and even negative, it is -0.729 - December 29 and 0.265 - December 30.

December 29:



14
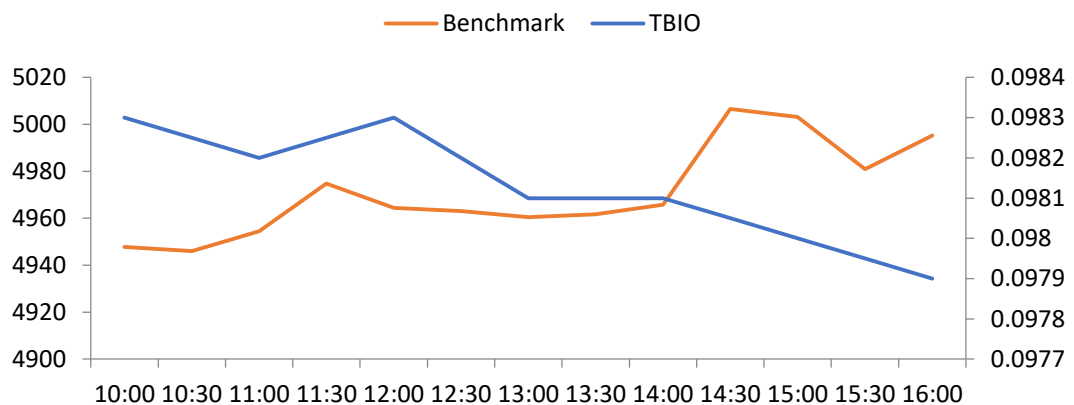
**Figure 1.2** Dynamics of the benchmark.
December 30:
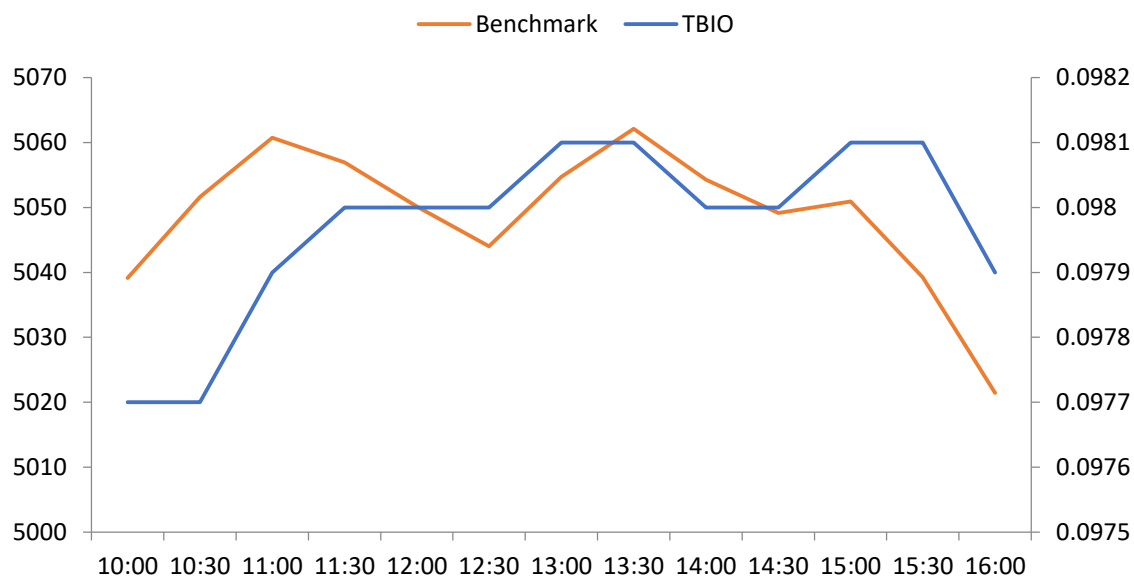


**Figure 1.3** Dynamics of the benchmark.

These results are not accidental. On December 29 and 30, there were large tranches of the issue of additional Briefings (by 746.1 and 405.4 thousand dollars, respectively).
Although on the days without additional tranches (February 9, 2022), the correlation amounted to 0.86:

February 9:



**Figure 1.4** Dynamics of the benchmark.

**Table 1** Period, correlation value, event.

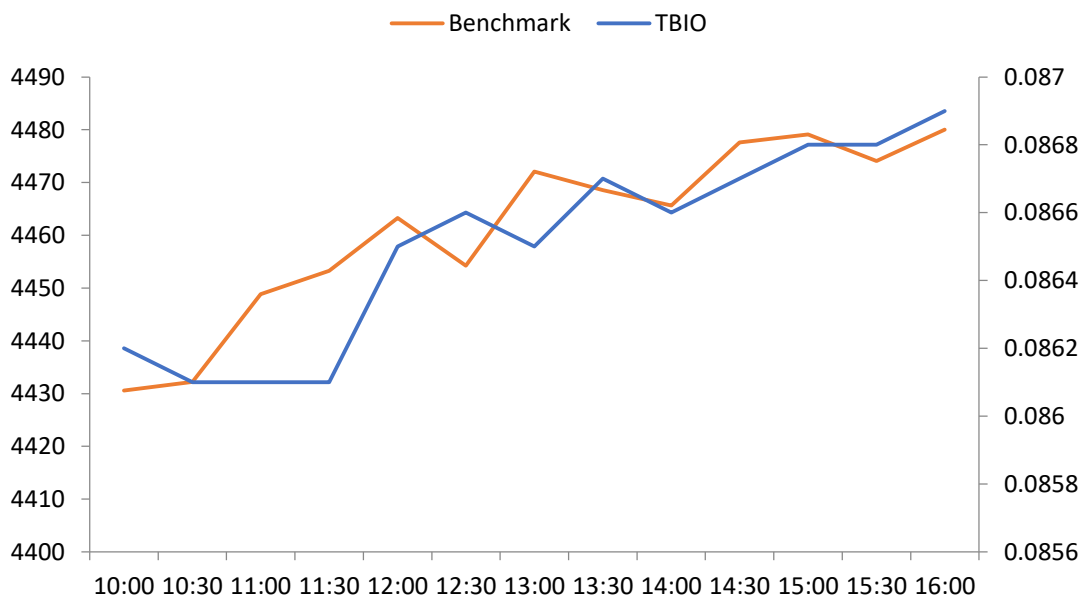| Period | Correlation Value | Event |
|---|---|---|
| July - December 2021 | 0,985003247 | - |
| 29.12.2021 | -0,728781438 | The authorized Person of the fund contributed 746.1 thousand dollars to pay for additional investment units |
| 30.12.2021 | 0.265298058 | Authorized Person of the fund contributed 405.4 thousand dollars to pay for additional investment units |
| 9.02.2022 | 0.862681329 | No event |

It can be noted that with a tranche of almost twice as much, there is a negative correlation between the price of the instrument and the value of the benchmark, which is an interesting result, since the Mutual Fund should follow the index, as it happens on days without additional tranches.

Thus, the deviation of the TRIO's price from its index (the NASDAQ Biotechnology Total Return Index) exists, which is associated with the issuance of additional Mutual Funds.

II. Mutual Fund TSPX Research

The value of the relationship between the Mutual Fund price and its benchmark for a long period of time is comparatively high and constitutes 0.984, which is natural, since TSPX was created with the idea of following its S&P 500 Total Return Index.
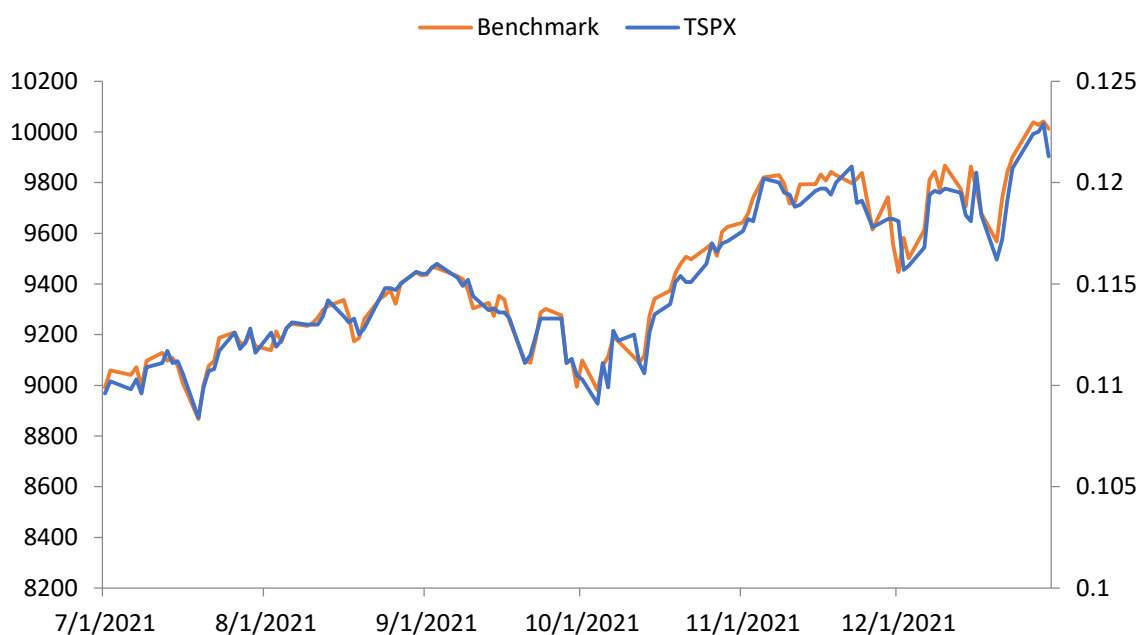


**Figure 2** The value of the relationship between the Mutual Fund price and its benchmark for a long period of time.

However, for short periods of time on the days of additional TSPX tranches (December 29 and 30), the correlation is negative and equals -0.66 and -0.52, respectively.

December 29:



**Figure 3.1** The value of the relationship between the Mutual Fund price and its benchmark for a short period of time.

December 30:



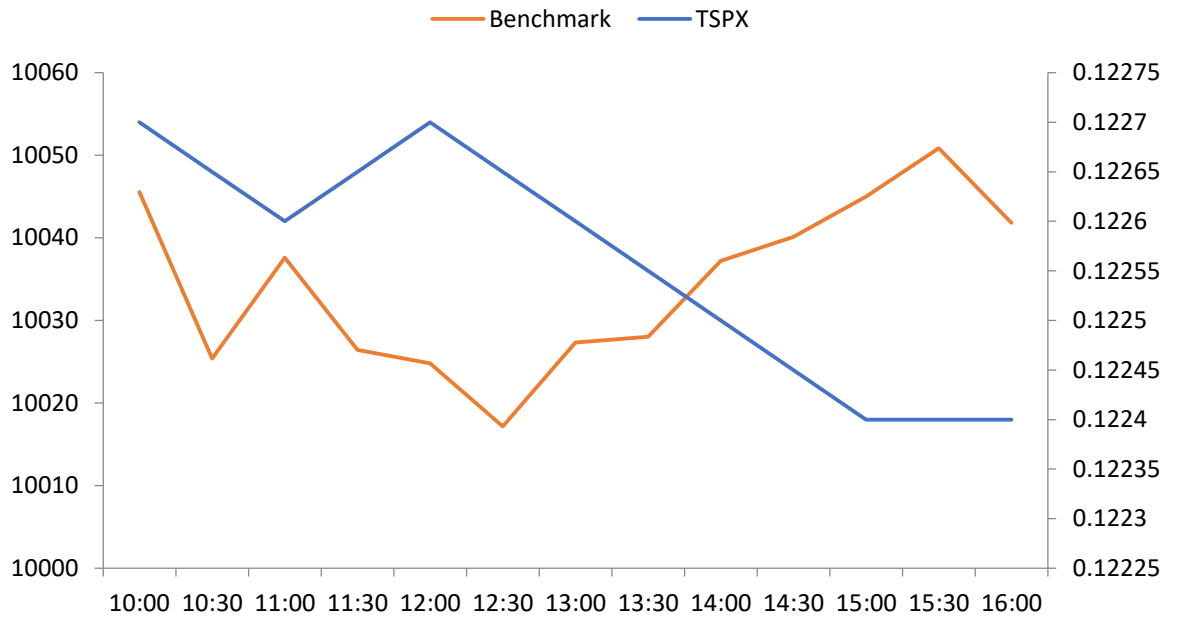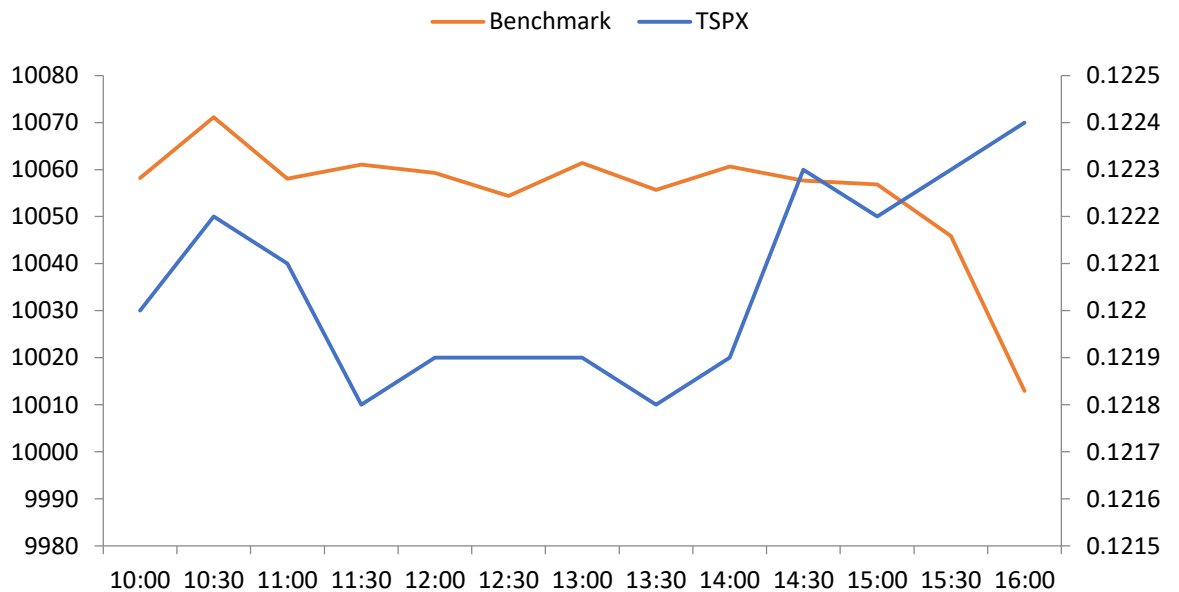**Figure 3.2** The value of the relationship between the Mutual Fund price and its benchmark for a short period of time.

These negative correlations are not accidental. On December 29 and 30, large tranches of additional Briefings were issued (by $813.9 thousand and $1.4 million, respectively).

Although on the days without additional tranches (February 7 and 8), the correlation reached 0.78:

February 7-8:
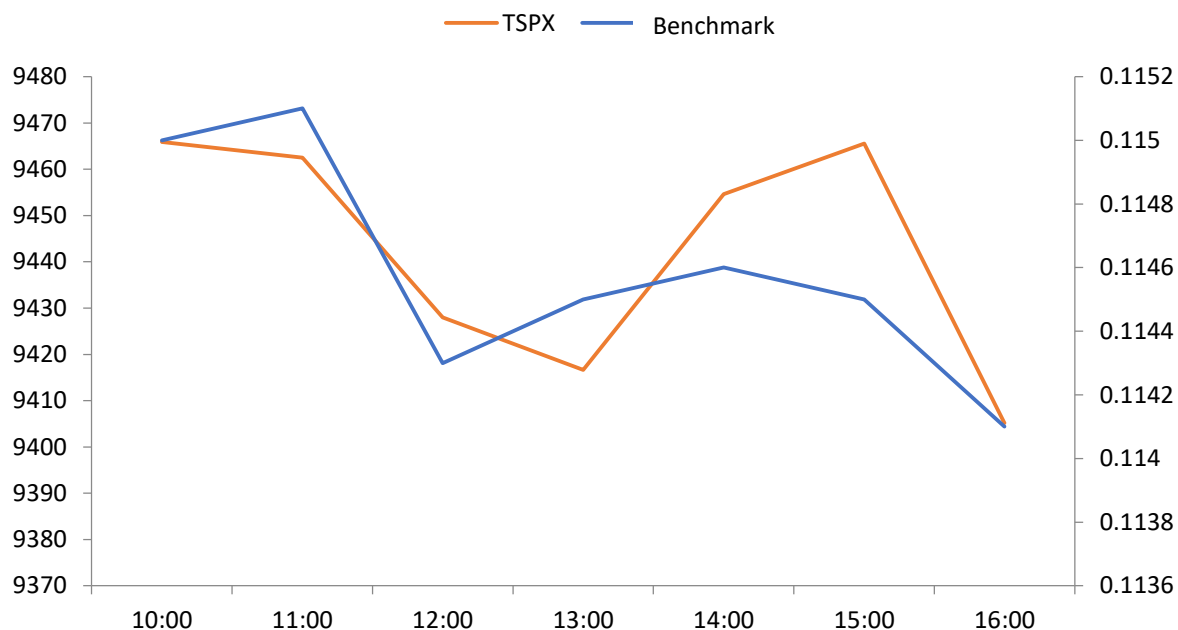


**Figure 4** The value of the relationship between the Mutual Fund price and its benchmark on the days without additional tranches.

**Table 2** Period, correlation value, event.

| Period | Correlation Value | Event |
|---|---|---|
| July - December 2021 | 0,983704212 | - |
| 29.12.2021 | -0,660311021 | The authorized Person of the fund contributed 813.9 thousand dollars to pay for additional investment units |
| 30.12.2021 | -0,517656223 | The Authorized Person of the fund contributed $ 1.4 million to pay for additional investment units |
| 7-8.02.2022 | 0,779344223 | No event |

As is obvious from the results, both correlations are negative, which means that during large tranches of additional shares, the dependence is reversed. Thus, the deviation of the price of the TSPX from its index (the S&P500 Total Return Index) exists, and it is associated with the issuance of additional Mutual Funds.

**Applying the results**

How can the results obtained be applied in the financial world? Since the proven interesting results are of a short-term nature, their application is possible only in the implementation of short-term strategies.

1. Robotic trading

Algorithmic trading users often play on a small price change. In this case, the information about the negative correlation of the Mutual Fund/ETF price and their benchmark on the day of a large additional tranche of securities can be used as follows: after

receiving news about a large issue of additional funds (it can be identified by keywords on the page of each specific fund), a short position on this Mutual Fund is placed. Since the benchmark index is increasingly growing, and the correlation on a particular day is negative, then, in most cases, the Mutual Fund will fall. At the end of the day, the short position is closed (in order not to pay the overnight commission).

2. Earnings of a market maker

It is known that the earnings of a market maker are a percentage of the bid-ask spread. The larger the bid-ask spread, the more the market maker can earn. In our situation, when there is a tranche of additional securities, the uncertainty of price movement increases, the correlation with the index drops significantly. The price of the Mutual Fund fluctuates under the influence of an undirected and uninformed flow of applications, the bid-ask spread increases, the market maker can earn well. Accordingly, it is advantageous for the market maker to work with new and unstable Mutual Funds, which constantly have additional releases.

The intraday correlation between prices of ETFs and the value of their benchmarks on the days of additional tranches of securities is really far from 1and in most cases negative. This result was confirmed on 2 Mutual Funds by Tinkoff Bank (they post actual information about additional tranches of money into Mutual Funds). This interesting fact can be used in algorithmic trading and other trading strategies to make a profit, like Robotic Trading and Earnings of Market Maker.

In the future, after exposing this fact to algorithmic traders, the spread between the ETF and its benchmark are likely to decrease or even collapse to 0. However, at the moment, a trading strategy based on the fact of a negative correlation between an ETF and its benchmark is applicable. Further development in the sphere of this issue can be directed to the study of smaller relationships and the establishment of a relationship between an additional tranche of securities and the price of an ETF.

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**Dynamic analysis of the largest gold-mining companies in Russia**

**ABSTRACT.**
Gold has always been one of the most valuable and rare metals. In addition, it has numerous applications and therefore is of great interest to both ordinary people and researchers. For centuries, people all over the world have lost their minds trying to find it and become rich. Even though gut motives barely changed, many institutions and regulation mechanisms have been created in order to prevent illegal actions and control gold-mining. For such a resource-rich country as Russia, it is crucial to understand the state in which this industry has been recently. In the current report, strategy and dynamics of key financial indicators of two largest Russian gold-mining companies over the last 15 years have been analysed. At first, they were examined separately and afterwards a comparative analysis was conducted. As a result, the understanding of main gold-mining companies' strategy has been achieved, as well as the influence of decisions concerning the firm's further development on financial indicators. Moreover, the trends and perspectives of each company and the whole industry were stated.
**Keywords:** *gold-mining; financial indicators; dynamic analysis; comparative analysis; financial efficiency; market leaders.*

As artifacts show, mankind has been familiar with gold for several millennia. In ancient Egypt, India and other countries, gold was highly valued and used to make coins, jewelry, and in the burial of pharaohs. Over time, the purpose of gold changed, interest in the precious metal only grew though. Countries sought to increase the volume of gold mining, using various methods for this. In the 16th -18th centuries, rich deposits were discovered in different countries, which caused a wave of gold rushes around the world. In the 19th and 20th centuries, an era of technological progress and industrial development, many countries invested in improving methods for extracting gold and processing ores. Thanks to joint efforts, the world has come to what is now experiencing the fastest and most sustainable growth in gold production. Currently, gold is used in multiple spheres, including rocket ship construction, chemistry, building and dentistry.

In 2019-2020, the extraction of minerals and precious metals amounted to 12.9% of the total GDP of the Russian Federation [2] and 6.9% of the global GDP [3]. This indicates that this industry is not the last component in the global economy, significant for the Russian Federation. Over the past years, the leaders in gold mining have remained unchanged. They

are China, Australia, Russia, the USA and Canada, with their shares of the world volume constituting 12%, 10%, 9%, 7% and 6% respectively [6]. Russia exports $5.7 billion worth of gold.

In 2020, the largest gold mining companies in the Russian Federation were Polyus, Polymetal and Petropavlovsk Group, which accounted for more than half of the total gold production [6]. For 15 years, these companies have been actively developing themselves and new deposits, improving technologies and increasing the volume of gold mining.

To analyse the impact of gold mine management on the financial position of companies, this study is concerned with PJSC Polyus and Polymetal as their key financial indicators for the period from 2005 to 2020 [1]. The companies' reports were downloaded from the Bloomberg and Capital IQ databases. Focus is given to the main indicators from the balance sheet (total assets, total liabilities, equity, PPE), income statement (revenue, ROA, ROE, market capitalization of companies), as well as the D/E ratio calculated by companies. Thus, it has been revealed how the purchase and development of gold mines affects each of the indicators individually and in combination.

Prior to all others, PJSC Polyus is considered the largest gold mining company in the Russian Federation over the past few years. Overall, the company has shown a stable growth rate, namely 19.2% in 2019/2018. Its market capitalization equalled $26 billion, and the volume of gold produced exceeded 30% of the total volume in the Russian Federation.

Polyus owns 5 actively exploited gold mines and 4 being prepared for opening mines in Siberia. Active gold mines are Olympiada – the largest asset, Blagodatnoye, Verninskoye, Kuranah and Natalka. Blagodatnoye, which were put into operation in 2009. In 2020, the company decided to build a new manufactory by the end of 2025. Verninskoye started operating in 2011. At the moment, it has a 90% recovery rate, which is the highest in Polyus' assets. Having been used for 55 years, Kuranah is the oldest asset in comparison with the others. In 2017, certain improvements were made, whereby productivity could increase. Natalka was put into operation in 2017. Since then the company has invested considerably in its development.

Revenue, PPE, total assets and liabilities, capital expenditures are the first to be examined.



Total Revenue, $ mln



Net Property, Plant & Equipment, $ mln

**Total assets and liabilities, $ mln**



**CapEx, mln $**
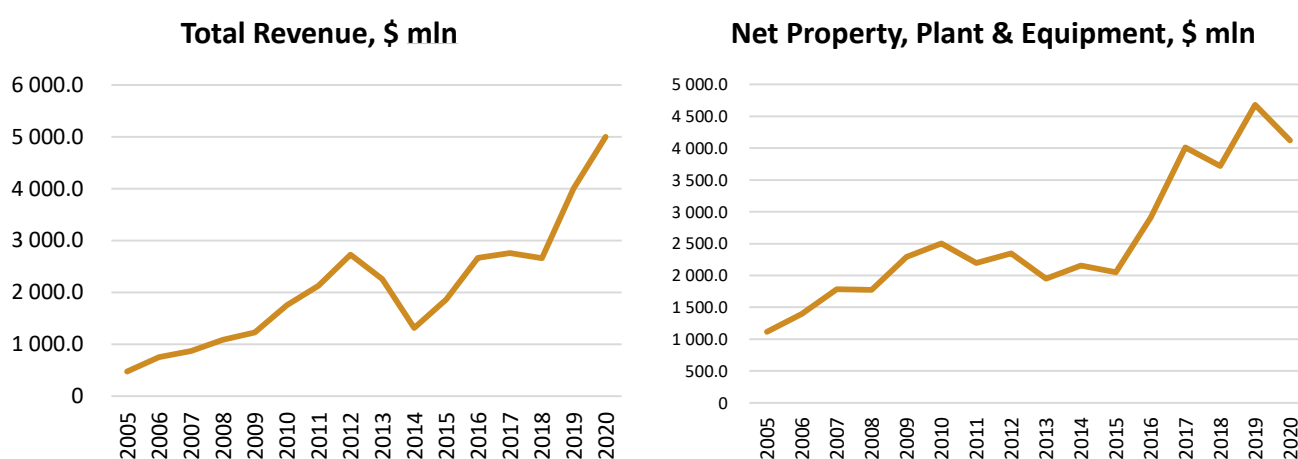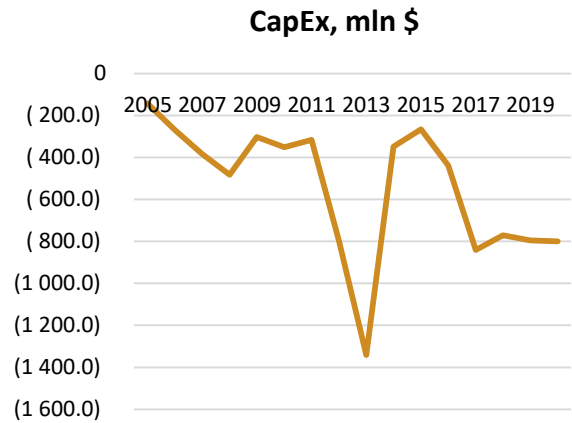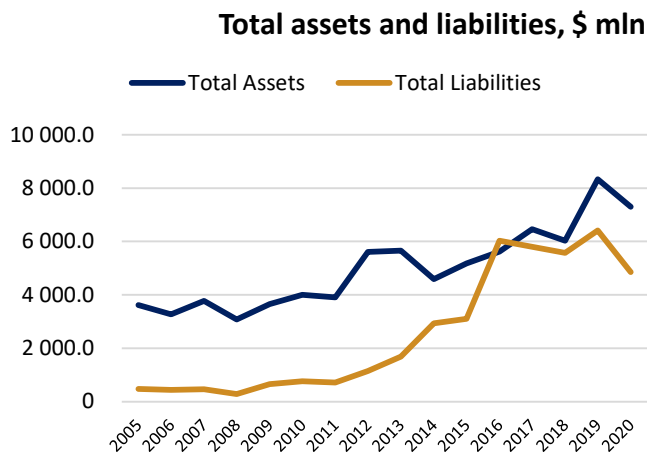


It is remarkabe that Blagodatnoye and Verninskoye were launched in 2011. As is evident from the graphs, this event did not reflect on the financial indicators instantly. However, a steady growth in revenue was noticeable, with fluctuations in parallel with gold price changes. Until 2012, there was a stable growth, followed by a 3-4-year sharp decline, and then again there was a recovery of the previous values and subsequent growth. This dependence is easily explained, since the proceeds are calculated as the product of the price of gold and the volume of its sales. A price decline in 2013 occurred due to a 15% drop in demand and the US Federal Reserve easing policy [4]. Gold mines increased in price and generated additional profit, which we see on the graphs. In 2017 Polyus worked on two of its largest mines which made PPE also increase significantly. Total assets do not show rapid dynamics, unlike liabilities, which started increasing shortly after the purchase of gold mines.

Capital expenditures include investment activities of the company, costs of acquiring new equipment, buildings, construction, and others. In the gold mining industry, companies constantly incur such costs to extract gold and develop new ores, and increase the production capacity. Over the past 15 years, Polyus has incurred huge costs, which indicates a serious geological exploration and work on the development of new deposits in Siberia. In annual reports, the company reports about its capital expenditures and expansion of production, all of which are supported and verified statistically by means of numerical and visual data. It also adds up to the fact that the volume of gold mining in the Russian Federation has been increasing in recent years, which means that capital expenditures of firms are worth it and bring the desired results associated with an increased volume of gold mining and revenue.
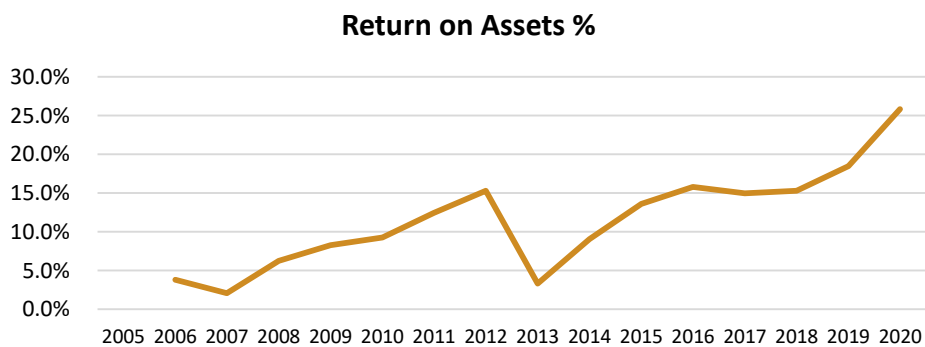
**Return on Assets %**



Return on assets (ROA) indicates how profitable a company is in relation to its total assets. Total assets have maintained stable over the years. As is noticeable from the above

graphs, there was a sharp fall in profit and a subsequent recovery during the same years as in ROA. Changes in profit, which have been explained before, can be applied to this indicator as well.

### D/E, %



### Return on Equity %
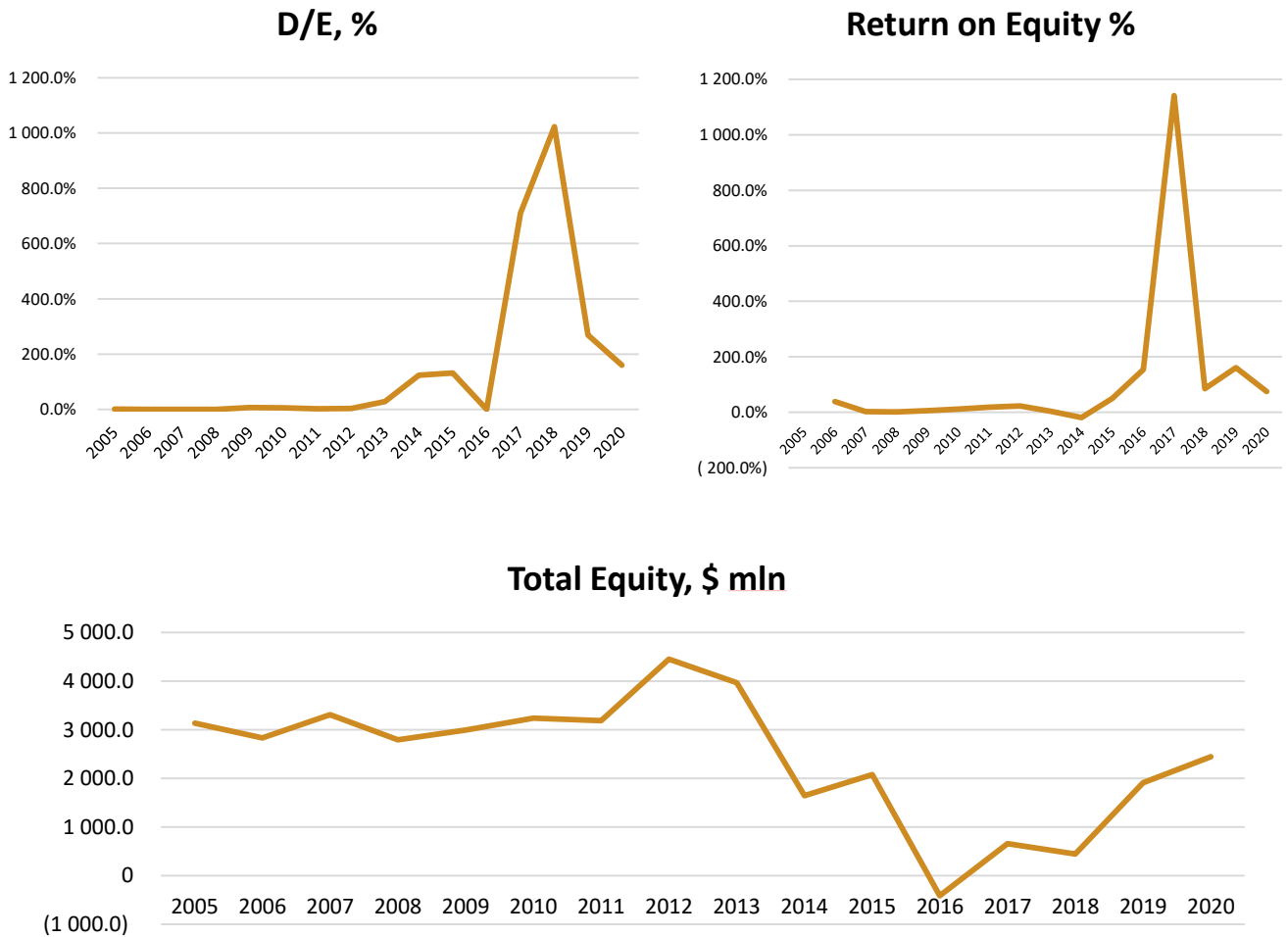


### Total Equity, $ mln



As is clear from the graphs, activities of the mines in 2011 did not have any effect on the financial indicators. In relation to total equity, it fell dramatically between 2012 and 2017. It means that the company took money from its shareholders for some reasons. In 2017, Polyus put into operation Natalka and improved Kuranah, which demanded large investments. Subsequently, it may be suggested that the company needed to increase its savings in order to spend them on a new mine.

There was a slight rise in D/E in 2014, caused by a decrease in equity. At Polyus, this indicator jumped sharply in 2017-2018. The analysis of the company's financial statements reveals the reason for the phenomenon: not an exorbitant increase in debt, but a reduction in capital. In 2016, it took a negative value of $410.5 million, in 2017-18 it began to return to normal values, but still remained inconsiderable. Previously, the company's capital ranged from 2 to 5 billion dollars, while in 2018 it amounted to only 448 million dollars. The company explains this reduction by "active investments in the development of the Natalka field and the implementation of projects for the development of existing assets" [9].
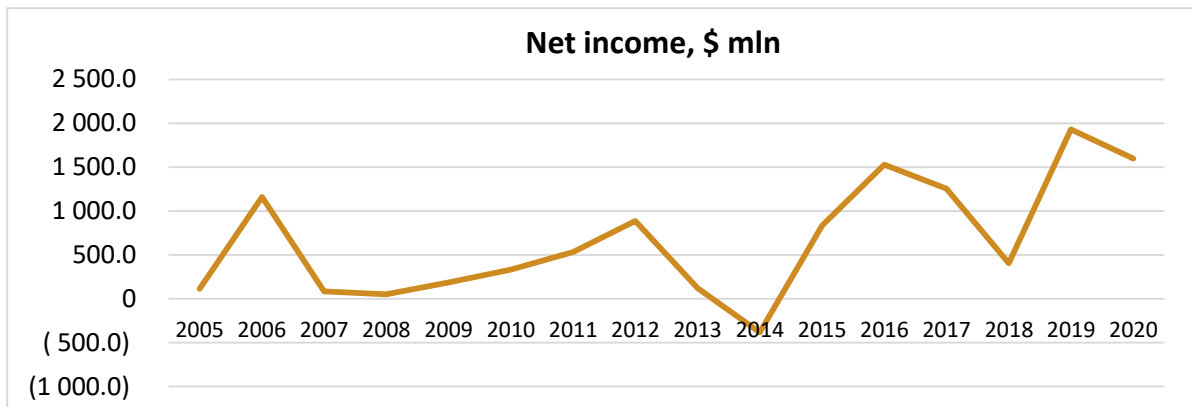
**Net income, $ mln**



Based on the net income graph, it can be assumed that the company prefers to make serious investments every few years, and then "recover" and reap the benefits of its costs or raise capital. In 2014, its profit fell to negative values for the first time, which most likely happened due to the general market situation and low income during that period of time.

The next point to consider is Petropavlovsk, the third largest gold mining company in Russia. Its market capitalization totals $1 billion. Amur is regarded as the main region where the company works. It has 3 main gold mines: Pioneer, Malomyr and Albyn, the first of which started its activities in 2008, the second – 2010, the last one – in 2011.

**Total Revenue, $ mln**



**Net Property, Plant & Equipment, $ mln**
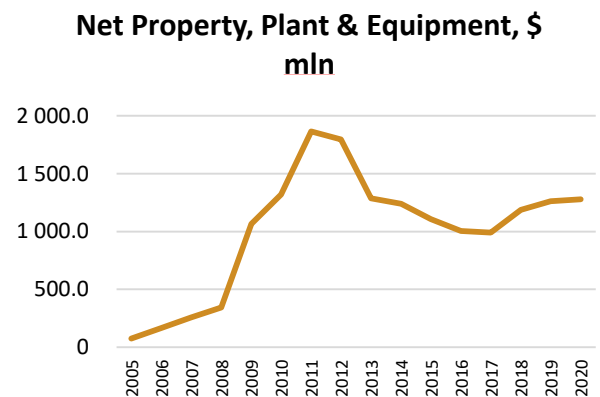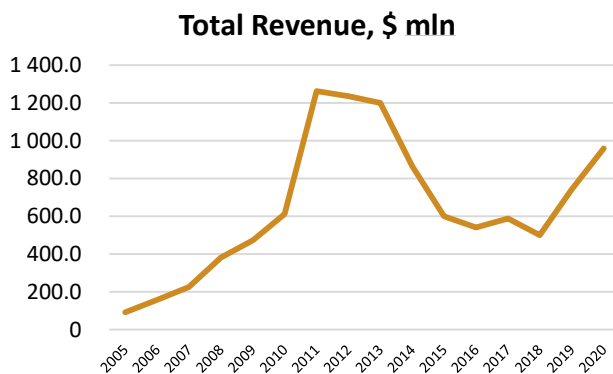


The graphs show that after 2008 revenue and PPE started growing. Presumably, this phenomenon is related to an active exploration of gold mines after 2008.

Based on capital expenditures data given in the graphs above, it is clear that after the purchase of the mines, the company invested heavily in new equipment and technologies in order to explore the mines and gain profit. After 2011, the profit and PPE started falling, whereas CapEx experienced an increase. The reason for that may consist in a gold prices fall at the same period, and the company cut its expenditures on the mines. Furthermore, main actions toward developing the mine have already been made.

## Total assets and liabilities, $ mln
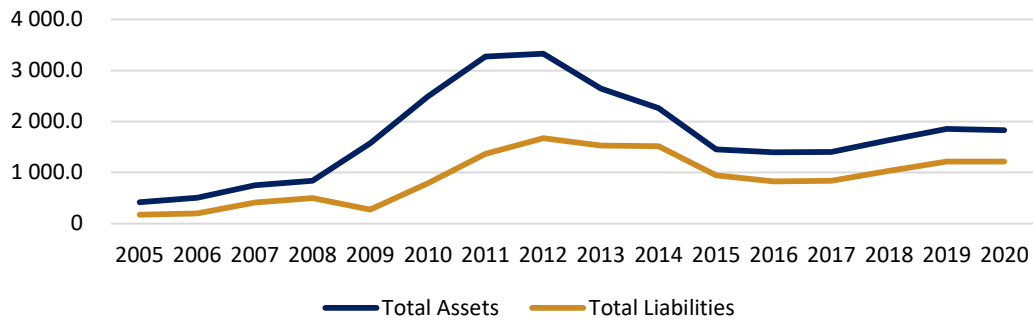


Assets and liabilities went along together with only one peak in 2012. It can be explained also by buying gold mines in 2008 and 2010, which increased the company's assets. After 2012, there was a decline, both in profit and PPE for the same reasons.

## Return on Assets, %
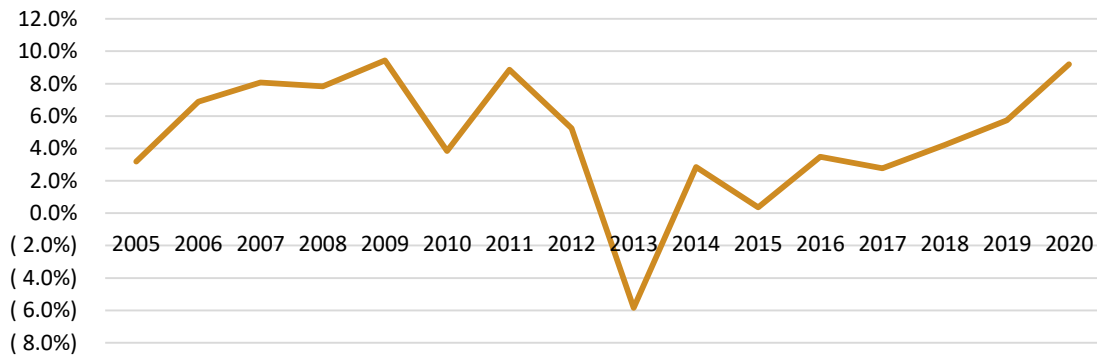


ROA is an indicator that is calculated by net profit divided on assets. Since the company explored the mines intensively in the period from 2009 to 2015, it incurred large costs, which resulted in such a high volatility [8].

## Total Equity, $ mln
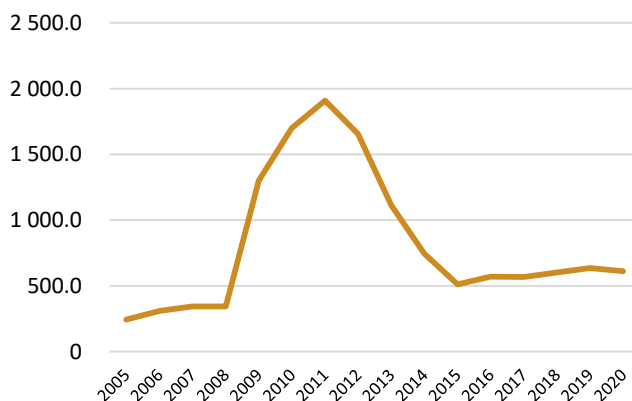


## Return on Equity, %
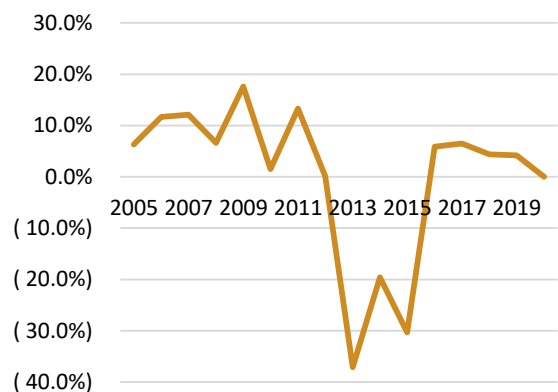


As is expected, the same trend can be observed in equity changes: the more mines and infrastructure, the larger PPE. Petropavlovsk's revenue increased, the company could pay its shareholders, whom it has attracted (equity can be found in the balance sheet). Then, the company probably needed the money back to keep up with sustainable development. ROE fluctuated a lot for the same reason as ROA. Equity looks relatively the same as assets; as a

result, it is a profit that made ROE negative for some time. Petropavlovsk can hardly be called attractive for long-term investment, as its ROE has been no higher than 20% for 15 years and is generally insignificant in the industry.

**D/E, %**
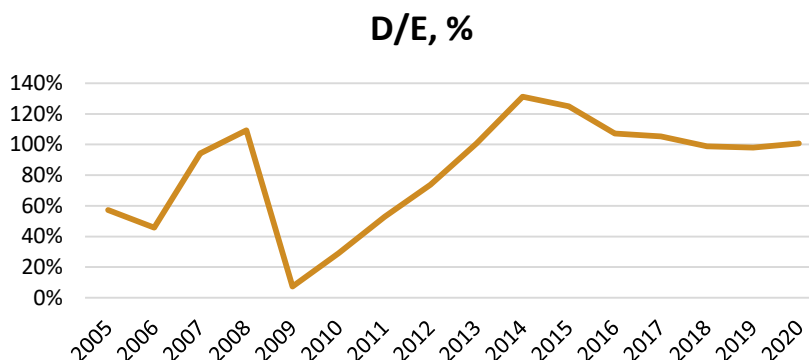


Finally, we can move on to D/E that changed in a curious way. In 2009, it fell and almost reached 0% because of an incredible rise in equity, which is somewhat sensible. However, afterwards it started rising again, even though equity kept increasing too. Supposedly, until 2011 the company needed extra money to finance the mines, and after 2011, as equity began to drop, the rise in D/E was inevitable.

Thus, it can be stated that Petropavlovsk invests in its own development. Even though it experiences hardships with managing its assets properly, it has potential to become larger and succeed in the future. Petropavlovsk is small-size compared to Polyus, because of which it does not have sufficient funds for development. Simultaneously, Petropavlovsk does not take loans to expand production. Perhaps, it should have taken a small risk in order to obtain funds for development. However, due to the fact that the gold mining industry requires a huge amount of money for gold mining, the company failed to cope with its obligations and go bankrupt. For this reason, it can be inferred that they behave expediently in accordance with their position and available opportunities.

In conclusion, the purchase of gold mines influences a company's balance sheet significantly. Its revenue, assets, equity depend greatly on the fact whether the company acquired the mines and how intensively in explores them. If there is not enough money, the company may decrease equity and such indicators as D/E and ROE change accordingly. Shareholders and stakeholders always pay much attention to the dynamics of these indicators, which means that companies must supervise them and provide an explanation for unpredictable and outstanding shifts.

Overall, Polyus is a stable successful company that has generated profit and uses its assets properly, which is not the same about Petropavlovsk due to relatively volatile ROA and ROE. Probably, both companies will proceed their growth in the future and learn to operate more efficiently.

In our opinion, companies need to continue to develop high-tech, less energy-intensive and costly ways to mine gold in order to remain globally competitive. Additionally, in order to avoid monopolization and the development of an oligopoly, it is necessary to support smaller companies that are pointwise engaged in gold mining in small mines. We tend to be optimistic and believe that the Russian gold mining industry will continue to develop and possibly catch up with China, which is a world leader in this area.

In 2020, in the form of an epidemic, investment demand for gold has grown markedly, as people consider this precious metal a reliable investment and an asset that will help escape financial instability in the world. The PwC partner believes that this situation can serve as an incentive for more active development of the gold mining industry. He also points to the stability of the TOP-10 gold mining companies in Russia, which account for 67% of the market, and their increase in production. The Bullitt CEO emphasizes the dependence of the gold mining industry in Russia on foreign equipment, the supply of which may be reduced

due to the pandemic. In this regard, it is necessary to develop domestic equipment for mining and metallurgical enterprises.

Thus, experts identify a number of restrictions for the gold mining industry and indicate a vector of development in which companies should move. At the same time, they state the growth of indicators and general development of the gold mining industry in Russia.

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**Blockchain technology and digital collectibles**

**ABSTRACT.**
The current report discusses the blockchain technology as a way of storing information electronically in a digital format. Blockchain technology is often associated with the concept of cryptocurrencies, especially the bitcoin, although today blockchain-based platforms are becoming increasingly popular in such government sectors as healthcare and even art. Blockchain is an underlying technology of non-fungible tokens (NFTs), which used to store and secure them as unique digital identifiers used to verify authenticity of a digital collectible. The study seeks to explore opportunities and limitations of blockchain technology as a whole and discusses the influence it exerts on the functioning of the digital collectible market and determines whether NFTs are a good investment. An experimental approach is applied to address the above research questions. Individual experience of purchasing digital collectibles is described in the study.

**Keywords:** *blockchain; cryptocurrency; non-fungible token (NFT).*

For the last few years the Internet has been buzzing about crypto and blockchain. Currently, some online processes occur, which are regarded as extremely bizarre, from public standpoint. Particularly, Francis Suarez, the mayor of Miami, Florida, has posted a tweet to declare his next paycheck in bitcoin (100 per cent). In reply to it, Eric Adams, another prominent politician, intends to take his first three paychecks as a New York city mayor in bitcoin. Social media chatter and discussion forums have hyped up crypto and enabled its astronomical popularity and prices. That includes public statements by influencers, celebrities and CEOs of big tech companies. However, with all the representation that cryptocurrencies received, their core concepts and underlying technologies remain a mystery for most people, as this space is extremely hard to navigate, because the predominant part of commentaries around crypto belongs to the owners of a direct financial stake, interested in getting more people to buy their coin of choice. The cryptocurrency market has been a revolution within the past decade, whereas today it is one of the most dynamic markets in the world that fascinates both crypto experts and inquisitive people who have never been interested in finance before. However, is it possible for ordinary people without technical background to understand what blockchain is and what sort of things it can store?

The purpose of this study is to familiarize a broader audience with the concept of blockchain and raise awareness of its practical applicability in the world of digital art and digital collectibles.

**Professional Significance.** The discussed technology of blockchain can be applied to a wide spectrum of industries. It is crucial to understand that this concept prompts and furthers financial prosperity. Additionally, it is especially important to find an application in a variety of spheres where its transparency and security may come in handy. This fascinating technology can be beneficial to many businesses or investors if they can wisely utilize it.

**Delimitations of the study.** Ever since the dawn of humankind, we have been tirelessly improving our ability to own goods. At present, owing to blockchain, we have the most powerful ownership tool, called an NFT. This ultimate form of ownership proves that we strive to approach a widespread adoption of decentralized blockchain technologies and intend to refuse various expensive and restrictive intermediary services.

**Definitions of key terms**

● A blockchain is a distributed database that is shared among the nodes of a computer network. A blockchain stores information electronically in digital format [3].

● A decentralized network is a type of architecture that distributes workloads among several machines, instead of relying on a single central server [5].

● A cryptocurrency is a digital or virtual currency that is secured by cryptography, which makes it nearly impossible to counterfeit or double-spend [2].

● A non-fungible token (NFT) is a unique digital identifier that's secured and stored on a public blockchain [6].

**Literature review**

Arthur C. Clarke once wrote, "Any sufficiently advanced technology is indistinguishable from magic" [1, p. 181]. Clarke's statement is a perfect representation for the emerging applications of blockchain technology.

An idea behind the blockchain was first introduced in 1991, when Stuart Haber and W. Scott Stornetta implemented a system where document timestamps could not be backdated and tampered with. Its core concepts were applied to electronic cash and described by a mysterious person or a group of people named Satoshi Nakamoto in a paper called Bitcoin: A Peer to Peer Electronic Cash System, which was published in 2008. Most modern cryptocurrency schemes follow the blueprint that was described in Nokomoto's paper [4, p. 2-6]. Bitcoin was just the first of many blockchain applications.

Blockchain can be understood as a structure similar to a database that stores data in bundles called "blocks". Blocks in a blockchain are connected to each other. To refer to interaction between parties in a blockchain, a word transaction is used. For example, in terms of cryptocurrencies, a transaction represents a transfer of digital money between users. A collection of transactions is called a ledger. In modern times, people do not use pen and paper to keep track of the exchange of goods, and most ledgers are stored digitally, often owned and operated by a centralized trusted third party. While this approach is widely used, there are possible trust, security, and reliability concerns related to it. Centrally owned, ledgers may be lost or destroyed if the owner is not backing up the system properly, the transactions are not transparent, they may not be valid or complete, on a centrally owned ledger transaction data may have been altered by a central authority.

Is it possible to create a system that allows creation, verification and updates without a central supervision, so that the mentioned problems are solved? Firstly, to make all data regarding transactions public, a peer-to-peer network of servers, usually smaller ones (e.g., desktop computers) also known as nodes is required, where they are equally privileged and can be accessed by anyone. Secondly, to enable secure communication, cryptographic algorithms are applied. Cryptography is a practice of techniques that allow only a sender and a recipient of a certain message to get access to its content. To implement this approach, blockchains use cryptographic hash functions that make it possible for nodes to validate the legitimacy of transactions. By applying a hash function to an input data of nearly any kind (e.g., a file, text, or image), a relatively unique output called digest is created. In terms of security, it is important to note that cryptographic hash functions are preimage resistant, which means it is impossible to calculate an input value based on a given output. Moreover, they are second preimage resistant, with an input being computationally infeasible to find another input that provides the same digest. Lastly, they are collision resistant: it is impossible to find 2 inputs that produce the same digest. Each block (except the first one) contains the hash digest of the previous block, thus forming a blockchain. Each block of blockchain contains a block header and block data. How data fields are defined, depends on the blockchain implementation, but most blockchains utilize data fields like the following: a block header consists of a block number, a hash value of previous block's header, a hash representation of block data, a size of the block, a timestamp. Block data contains a list of transactions and ledger events included within the block, but other information may be present. Thirdly, to build a blockchain, a consensus algorithm is needed. In other words, there has to be a rule, which everyone agrees with, on how to update the ledger and how to add new blocks to the blockchain. Many types of consensus rules exist, namely in case of Bitcoin the consensus algorithm known as Proof-of-Work (PoW) is used, which states that in order for someone to add a new block to the blockchain, they need to find a solution to a complex mathematical equation (more like a puzzle), which requires computational power

to solve. Computers around the network run calculations to solve a math problem; in doing so, they consume much energy and do much work. When one of them finds a solution and displays it to the network, they basically display a "proof of work". Now that the publishing node has spent time and energy solving this problem first, it is entitled to add a new block to the network. A new block is sent to the full node that stores an entire blockchain, which verifies that the block fulfills the puzzle requirement, adds a new block to its copy of the blockchain and resends the block to all peer nodes.

Since blockchain technology is still relatively new, many companies are looking at ways to incorporate it into their businesses. Blockchain technology solutions may be suitable for activities and services that require features like a vast number of participants, distributed participation, wants or needs for absence of a third party, transactional nature of workflow (e.g., transfer of data/digital assets), a need for a digital identifier (i.e., digital art, digital land, digital property). Blockchain is usually associated with cryptocurrencies; however, lately blockchain has been changing the art industry, supposedly being distant from the world of constantly changing technologies.

Prior to all other notions, it is pivotal to investigate an NFT. This abbreviation stands for a non-fungible token, as is mentioned above. (In this term, the word *fungible* is used instead of its synonym *replaceable* to avoid confusion). Remarkably, one dollar bill is fungible, because a banknote can be swapped for another equivalent banknote, and this action will not change its value, you will still have one dollar. The dollar in your possession that will remain functionally identical. In contrast, a non-fungible asset is something unique or extremely rare, something that has specific attributes that distinguish it from the rest. For example, a dollar bill with a binary serial number or the Mona Lisa painting. Everything in our economy is one or another. Unsurprisingly, non-fungible things are far more valuable. NFTs are basically unique coins, but what are they used for? With their uniqueness in the digital world, NFTs are used to prove ownership of a certain digital file.

In real life, the original piece of art, for example a painting, is much more valuable than its copies. Some methods are employed to validate the authenticity of that painting, in particular receiving a certificate of authenticity. However, digital media is something that can be easily reproduced by simply downloading and saving it. How can you have anything unique if anyone can create an identically functioning copy of it? This is the situation where NFTs come in handy. It can be thought of as a digital signature linked to the digital good, which proves that someone is a rightful owner of it. Those certificates or tokens are stored on blockchains that support smart contracts, similar to those in the real world, and contain information about digital goods for sale. What needs to be kept in mind is that not digital goods themselves are stored inside the token, but attributes relating to them. Unlike buying a real life painting and taking it home, with an NFT you do not have any power over the goods that you are buying. Consequently, many questions arise about the value of NFTs. After all, they are only worth as much as the next person is willing to pay to brag about owning it.

To sum it up, an NFT is a token on a blockchain that acts as a digital certificate of authenticity. It can be verified instantly by the blockchain and shows the history of its previous owners. To a certain extent, any digital content can benefit from the technology by providing certificates of authenticity for the user willing to have it at their disposal.

**Methods**

To achieve the objectives of the research, we proceed from the assumption that NFTs can be effectively utilized in the world of digital goods and investigate whether they are a good investment. A practical approach enables to discover one of the fastest growing NFT platforms.

One of the significant characteristics of the digital era is that information can be endlessly replicated and shared. Pirated information is easily accessible, and it is difficult to regulate or address scarcity information on the Internet. However, the blockchain

technology enables to create digital scarcity and authenticity at a reasonable cost and many industries can reinvent themselves in the digital world.

The NFT is a huge economic invention — it allows businesses anywhere in the world to share their creations while collecting payment for their hard work. In 2019, the NBA partnered with Dapperlabs to create the Top Shot marketplace (https://nbatopshot.com). The platform has created a space where individuals interested in NFTs, digital collectibles and most importantly basketball come together and get excited about owning a piece of sports history. Top Shot is an officially licensed product of the NBA, so almost every player is eligible to have their own moment sold on the marketplace. It also effectively utilizes the feeling of nostalgia, because buying and selling NFTs resembles the process of trading real life NBA player cards.

The idea behind the experiment consists in the investment of a relatively negligible sum of money into digital collectibles and determine whether it is possible to make profit for someone who is new to the concept of NFTs but enthusiastic to do a fair amount of research on the topic. It is difficult to estimate a "negligible sum", but I thought utilizing my HSE scholarship would make the experiment a great fun and amusement. In total, 28$ American has been spent, taking into account the price of the dollar in early February 2022. Overall, the converted sum approximated 2100 rubles, thereby slightly exceeding the budget.

**Results achieved**

Top Shot allows users to buy, sell and collect influential NBA scoring Moments. Each moment is an individual NFT minted (recorded to a blockchain in digital form) on a blockchain called Flow and displays a single highlight from a major play in NBA history. Moments come in Packs – extremely similar to physical trading cards: you buy a pack, open it up and see what you get. Packs come in sets and they are not in free access; therefore, all users need to wait for them to be dropped at a specific time and get into an online queue to get a chance to buy them.

There are many factors that determine a moment's price, but the rarity and a serial number are most important. The first pack, which I purchased, was dedicated to Kevin Durant - a Brooklyn Nets player. It contained 4 moments that I managed to sell for 20$ almost immediately by pricing them lower than other marketplace users as none of them had an outstanding serial number (e.g., when the moment's serial number matches the jersey number of the player whose shot it depicts, it can be sold for thousands of dollars). In addition, all 4 moments were Circulating Count, meaning that they can be minted over and over again and flood the marketplace with comparatively much supply, so there is no reason to hold them if the goal is to generate profit.

The second pack that I purchased was dropped on February 17, 2022 and cost 19$. It contained 3 Circulating Count cards of not a significant value and 1 Limited edition Jalen Green's card, meaning the number of them are finite and no more moments like this are going to be minted. Moreover, the card was minted during a player's rookie season and in case he performs well in upcoming matches or becomes a successful NBA player in the future, its value will potentially increase. Therefore, I concluded that holding that card in my collection will benefit me in the long run, possibly generating a higher revenue. Overall, 7 out of 8 moments were sold for 41$ and the surplus summed up to 13$.

The current study seeks to familiarize a broader audience with concepts of blockchain and NFT. Ways of storing information electronically in digital format constitute the main points of consideration. The most powerful digital ownership tool, an NFT, and its core concepts were introduced. Practical applicability of NFTs in the world of art and digital collectibles was considered. An experimental approach introduced a popular marketplace for purchasing digital collectibles. By investing small sums of money into NFTs, this study manifests that it is indeed possible to generate profit even in a short term. The findings of the present study can help in determining whether investing insignificant sums of money

into NFTs can pay off. In addition, the results of our detailed discussion of blockchain's underlying technologies may be used for future research into specific areas where the concept can be applied. Finally, the research highlighted successful applications of NFTs in existing businesses. It is crucial to understand that blockchain is not magical and cannot solve all problems. Simultaneously, it must be regarded as one of many other available technological solutions. It makes sense to investigate blockchain with the mindset of "how could it potentially benefit us?" rather than "how can we make our problem fit into the paradigm of blockchain technology"?

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**Rescue of Orphan Bears: Legal Aspect**

**ABSTRACT.**
The article is devoted to the issue of orphaned bear cubs protection in Russia. Although bears, associated with strength and power, do not usually seem to be animals that need protection, the real situation differs. There is the only center for the rescue of orphaned bear cubs in Russia, located in the Tver region. They developed their unique methodology of care for young bears, which allows them to rapidly adapt to the wildlife and continue living without interference from humans. However, the legislation does not provide legal guarantees that contribute to the implementation of the activities of such organizations. On the contrary, bureaucratic regimes function in the way to complicate the activities of organizations engaged in animal rescue. For example, the recently issued acts regulating domestic keeping of wild animals, are mainly aimed at prohibition of keeping by individuals,

but at the same time impose various restrictions on organizations like this one. This problem requires the transformation of the legal regulation of this activity in the Russian Federation in order to prevent the disappearance of populations in the wild.

In most cases, when we hear about animal rescue, we imagine pets or those who are on the verge of extinction. The powerful image of the bear does not correlate at all with the fact that they also need human help. However, cubs left without their mothers are just as helpless as babies. They need timely and qualified professional help. According to statistics presented at the international seminar on the migration of wild predators, the population of the brown bear has practically doubled within 19 years [5]. These figures allow us to conclude that it is necessary to continue these positive dynamics, which was formed with the help of specialized centers for the rescue of wildlife. To improve the work of such organizations, it is necessary not only to provide sufficient funding, but also, of course, to work on legislative consolidation of rules for effective activity, as well as to ensure accurate regulation of the activities of other enterprises directly affecting the bear population. Thus, the bear population is affected by the development of industry, road construction, deforestation, which destroy the habitat of bears, resulting in a decrease in their numbers. Cubs left without mothers cannot integrate into their natural habitat. Since such babies are the most vulnerable in the wild, by saving them it is possible to save and replenish the population of the brown bear.

The only center in Russia that provides such professional assistance is the Orphan Bear Rescue Center, located in the Tver region. It has been caring for cubs delivered to the center from many regions of Russia such as the Komi Republic, the Vladimir and Vologda regions for more than 20 years and preparing them for adulthood in the wild.

The specialists of the center raise cubs using a special methodology developed by Valentin Pazhetnov, a founder of the center and honored ecologist of Russia. Mr. Pazhetnov devoted his whole life to the study of bears: first, he studied the entire life cycle, from growing up to gaining independence, and subsequently transformed the results into a special technique that allows bears to achieve maximum independence from humans that, in turn, will allow them to survive in the wild and even have offspring. The main thing in this work is to delicately help the cub to gain independence, leaving the wild nature in it. As Mr. Pazhetnov himself explained: at the very beginning, the bear performs a protective function over her offspring, but she does not teach them to hunt or build a den – the cubs do not need their mother's help in this, since these animals are inherent in them by nature itself, which makes it possible for them to be rehabilitated at the center and released into the wild [1]. These recommendations are used to save not only brown bears but also other types of bears and allow other specialists to save animals in Russia, Korea, India.

The history of the center began in 1985, when the Pazhetnov family organized a unique biological station called "Clean Forest" in the Tver region. The main purpose of it was the rehabilitation of orphaned cubs and the study of large predatory mammals [11]. The specialists of the center are representatives of the scientific dynasty and continue the work of Valentin Pazhetnov. In this regard, another feature of this center is notable: volunteers do not take part in its activities, so the center's specialists strive to minimize the contact of cubs with humans. They do a lot of work in addition to the rehabilitation of bears. During the entire period of operation of the center more than 230 cubs were rescued and their activity is tracked through chips and installed cameras in their habitats, which takes a lot of time and effort. They also monitor the bear population in various regions of the country, exchange experience with leading veterinarians and consult them, and also publish various scientific studies, for example, methodological manuals.

Table 1 Statistics on the admission of cubs to the center for 5 years (2018-2022)

| Year | Number of bears | The region of the Russian Federation where the bears came from |
|---|---|---|
| 2018 | 10 bears (7 males, 3 females) | Tver Region, Leningrad Region, Troitsk, Novgorod Region |
| 2019 | 15 bears (9 males, 6 females) | Vologda Region, Pskov region, Smolensk Region, Arkhangelsk Region |
| 2020 | 18 bears (11 males, 7 females) | The Karelia Republic, Vologda Region, Novgorod Region, Leningrad Region, Pskov Region, Kirov Region, The Komi Republic |
| 2021 | 13 bears (6 males, 7 females) | The Karelia Republic, Kirov Region, Kostroma Region, Pskov region, Smolensk Region, Tver Region, Arkhangelsk Region, The Komi Republic |
| 2022 (till April) | 13 bears (11 males, 2 females) | Vologda Region, Novgorod Region, Tver Region, Leningrad Region, Kirov Region |

Based on the analysis of the table, we can conclude that most of the regions where the cubs came from have large logging enterprises whose activities scare off the bears, which is why the cubs are left alone in the dens. The other interesting fact is the sexual differentiation of cubs in recent years. The male sex was predominant, but in 2021, the female was in the first place. Despite the actions of the center's employees, the number of cubs entering the center for rehabilitation remains at the same level. This tells us about the importance of continuing to popularize environmental protection and raising the level of legal awareness of citizens.

Despite the difficulties faced by the specialists of the center during the direct work with the cubs, there are also problems in the legal regulation of the center's activities, especially in regards to the moment of transfer of an animal to the center, its transportation, financing of the center and, of course, the protection of animals.

Previously, the center was under the care of the international fund for animal Welfare (IFAW), but the cooperation was suspended, as the international center began to pay more attention to animal protection in Africa. The current legal status of the center is an autonomous non-profit organization for the conservation of Wildlife "Center for the Rescue of Orphaned Cubs". The fundamentals of the activities of such organizations are established by the Federal Law "On the Non-Profit Organizations" [8]. Thus, all the activities of the center can be divided into several main groups: 1) educational and scientific activities: organization of educational events, various seminars, conferences and participation in them, organization of excursions, that is, activities aimed at popularization and education of the population in environmental conservation; 2) direct rehabilitation of cubs: maintaining of infrastructure, construction of aviaries, purchase of medicines, providing of consultations; 3) communication with the media, various organizations for the protection of wildlife. From

this standpoint, we can conclude that the center carries out various types of activities, the main of which, of course, remains the rehabilitation of cubs. However, the center's specialists strive to popularize the topic of environmental protection and inform people about their work through the media.

Taking into account the status of the organization, its subject of activity, the state also establishes requirements for organizations engaged in keeping live animals in semi-free conditions in the Federal Law "On the Animal World" [7]. These include, of course, control of such organizations by state organizations, state registration, as well as compliance with the basic principles of humanism, sanitary and zoological requirements. The establishment of administrative, as well as criminal liability for non-compliance with these norms shows us the willingness of the state to preserve animal populations, to prevent inhumane treatment of them.
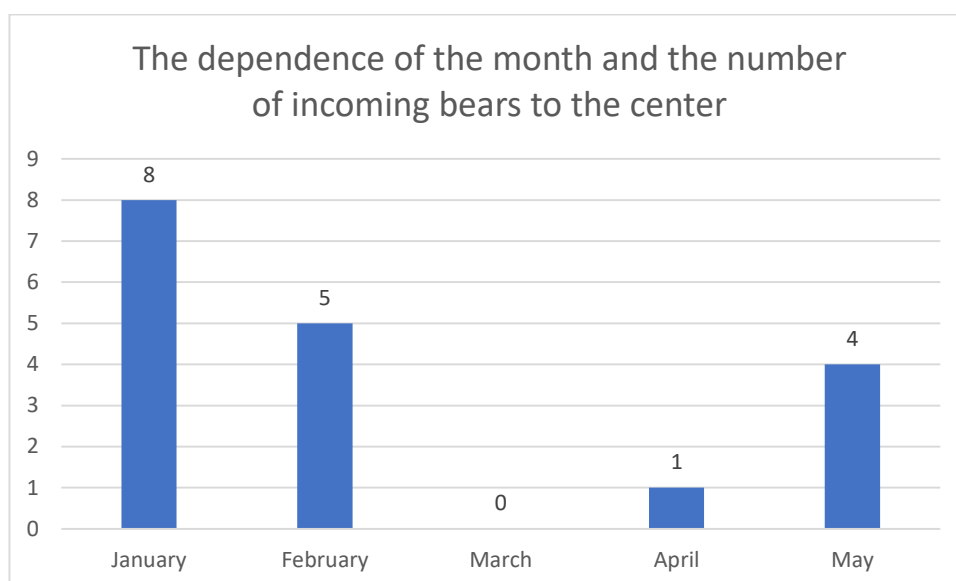
Nevertheless, the state is also ready to enter into a dialogue with these organizations for more precise regulation of their activities. However, such control should not be excessive and in any way interfere with the legitimate activities of the organization. Too strong regulation diminishes the rights of the organization in carrying out its activities, increases the time necessary for preparing documents, which leads to a negative influence on direct animal rescue, since there is very little time for rehabilitation or emergency assistance. Bureaucratic procedures established by the legislator prevent from starting work immediately.

The legislation of the Russian Federation seeks not only to consolidate the legal status of animal protection organizations, but also to regulate the maintenance of wild animals in specialized centers, which makes it progress in this branch of legislation. The Federal Law "On responsible treatment of animals", among other things, provides the government of the Russian Federation with a possibility of adopting a list of animals prohibited for domestic keeping, as well as a list of exceptions in such cases (paragraph 1.2 of Part 1 of Article 5, paragraph 1 of Part 1 of Article 10) [9]. According to the Decree of the government of the Russian Federation №795 dated 22.06.2019, bears are included in the List of animals prohibited from domestic keeping (item 10 of the List). Nevertheless, the Decree of the government of the Russian Federation №819 dated 27.06. 2019 establishes cases when such animals can be kept. According to legislation, bears can be kept: 1) if it is overexposure/assistance to injured animals; 2) treatment of animals or feeding of their cubs by shelters, zoos, etc.; 3) maintenance by organizations whose purpose is to breed animals to preserve the genetic fund objects of the animal world. That is, the Orphan Bear Rescue Center is engaged in all three points in its activities and therefore has the right to keep bears. Thus, the number of animals allowed being kept in specialized centers under special conditions is limited, and strict requirements are imposed on the centers for infrastructure and direct activities that can be carried out with these animals. However, the activity of animal rescue organizations related to the rehabilitation and reintroduction of animals into the wild has serious legislative gaps.

According to article 31.4 of the Federal Law "On Non-Profit Organizations" [8], state authorities and local governments provide support to non-profit organizations: they provide benefits for the payment of taxes and fees in accordance with the legislation on taxes and fees. Non-profit organizations, if recognized as performing socially useful services, can also apply for grants from the President of the Russian Federation for the development of civil society. This shows us that the state is interested in the activities of such organizations, since they bring enormous benefits in various spheres of public life and, therefore, seeks to provide all possible assistance in the activities of such organizations. However, tax benefits cannot solve other financial issues.

Currently, the rescue center has no official sponsors, and conducts its activities thanks to the support of compassionate people from all over the world. This shows us that there are

legislative problems in financing such centers. In order to overcome legal gaps, we propose to provide financial support to animal protection centers within the framework of social responsibility of large Russian companies. In return, companies will receive a reduction in the tax base for the amount they donate. Undoubtedly, this will be a mutually beneficial cooperation for each of the parties.

## The dependence of the month and the number of incoming bears to the center

| Month | Number |
|---|---|
| January | 8 |
| February | 5 |
| March | 0 |
| April | 1 |
| May | 4 |

This diagram shows us that the largest number of bears (8) arrive at the very beginning of winter, when the logging season begins and bears leave their dens. In addition, an increase in the number of bears is visible in the middle of spring – when hunting for bears is allowed and poachers intensify their activities.

However, the cooperation with Russian companies is not always productive and may exert a negative effect. A striking example is deforestation, which is the main activity of many large commodity companies. According to the World Wildlife Fund, about 1 million hectares of forest are cut down legally and another 40% are cut illegally every year [4]. What does it have in common with bears? Deforestation occurs in winter, when bears have offspring, and the noisy process of deforestation scares them. Therefore, they have to leave the den, leaving the newborn cubs alone. Woodcutters often notice the tracks of bears and immediately report to the Orphan Bear Rescue center, which promptly comes to the rescue. It is important to note the established connection between ordinary citizens, regional ministries and the Center for the Rescue of Orphaned cubs, since fast communication between subjects is important for the rapid transport of cubs to the center. However, the close connection between the center and the state authorities does not guarantee the same connection between the direct participants in logging activities. In such a situation, it is necessary to provide for closer cooperation with foresters who know the approximate location of wild animal populations, and the leaders of the deforestation process. It is necessary to fix this as mandatory at the legislative level in order to reduce the negative effect on the environment and reduce the number of cases when cubs lose their mothers.

When such negative situations occur and the cubs are left without a mother, the most important thing is to quickly deliver them to a specialized center, because the cubs left in the den alone are most vulnerable for several reasons. Firstly, they can be attacked by other predatory animals, and secondly, the cubs can freeze to death without their mother's warmth. Of course, they can be warmed by compassionate people, but if the cubs stay with people for a long time, they will be dependent on humans and will not be able to return to their natural habitat. Consequently, the Orphan Bear Rescue center stands for the rapid transfer of cubs.

In accordance with the amendments to article 13 of the Federal Law "On veterinary medicine", the transportation of animals must be carried out in coordination with the bodies carrying out federal state veterinary supervision, as well as in compliance with the requirements for the prevention of the occurrence and spread of animal diseases [6]. The document of the regional ministry of Agriculture specifies only the minimum time necessary to send an application for approval of the route of animal transportation across the territory of Russia to the center. However, it does not determine the time necessary for the ministry to consider these applications and approve this route. Of course, the ministries of some Russian regions understand the situation and try to transfer documents rapidly, but this is not always possible. Thus, the legal gap in this situation is as follows: despite the fact that the state strives to take care of the safety of animals and introduces the obligation to approve documents, regulatory legal acts establish only a unilateral obligation of the entity transporting the animal to submit necessary documents within a certain period. However, the responsibility of Ministries to review these documents does not have a clear regulation. Thus, a more optimal solution would be to reduce bureaucratic procedures in such emergency situations. It is necessary to specify the deadline for consideration of applications received for approval of the animals' transportation route, as well as to add exceptions to those animals whose health condition requires immediate medical care, such as cubs that cannot be left unattended for a long time without specialists. Of course, this overcoming of the legal gap will allow the centers to reduce the waiting time for documents and get to work faster.

However, the legislation sets out requirements not only for regional ministries to coordinate the route of animal transportation but also for the centers themselves. In accordance with the List of Exceptions from the ban for the keeping and use of animals prohibited for domestic keeping [3], the heads of organizations must send information to the territorial bodies of the Federal Service for supervision in the Field of environmental management within 3 days from the date of acceptance of animals for maintenance. This demonstrates that the specialists of the center, when an animal is admitted to them (in most cases in a hard condition), cannot immediately help them, but are obliged to draw up an appropriate document and send it to the authority. This undoubtedly complicates the activities of such organizations and increases bureaucratic procedures. We believe that the period of three days is too short for the preparation of the document, given the frequent serious condition of the cubs upon admission to the center, as well as the necessary courtship regime – feeding every two hours. Therefore, it would be more appropriate to make an exception in the legislation to animals in serious condition and to extend the deadline for sending documents up to one week. Thus, the specialists of the center will be able to carry out all the necessary examinations in the first days, and then prepare documents.

After receiving necessary documents and transferring the cubs to the center, long and hard work begins. Based on the developed technique, the center's specialists keep a special observation log for each of the cubs, following some rules of behavior, namely they do not talk to each other near the cubs, always wear gloves, use no perfume in order to protect the cubs' sense of smell. These actions are performed so that the cubs do not get attached to people, do not feel empathy for them and integrate into the natural environment faster. Grown up and stronger bears are ready to go back to their natural habitat in the middle of autumn. The bears are released in the same area from where they came to the center: this is how the center's specialists try to preserve a single population throughout our country. Thanks to the activities of the center, the bear population has been restored in the Tver Region, the Komi Republic and other regions of the Russian Federation. It is also important not to turn such a procedure into a vicious circle. Bears that are released into the wild very often have offspring integrated into that habitat area, but they do not always manage to exist peacefully.

Poachers are another factor that affects the need to protect orphan bears and all the animals in general. For them, the opportunity to hunt bears is an important event in their lives, for which they are ready to break the law and sacrifice moral norms. Disputes about the possibility of hunting a bear in winter constantly arise between hunters and animal defenders. In addition to direct hunting and enjoying this process, poachers are also driven by material benefits – valuable skin, meat and bear fat. In Russia, many people from this sphere are willing to pay huge sums to receive a trophy. Of course, article 258 of the Criminal Code of Russia stipulates criminal liability for illegal hunting [2], but such a regulation is not enough. Bears are allowed to hunt from March 21 to June 10 and from August 1 to December 31 [10]. Since the bear goes into hibernation in November-December, in fact, this makes it possible to hunt a bear in a den, and this is when poachers begin their hunt. The sphere of activity of the center's specialists does not include the obligation to search for poachers and apply criminal law measures to them. Their main task is to raise cubs in favorable conditions. Therefore, I think it is important not only to regulate the activities of illegal hunters by applying punishment to them but it is also necessary to increase the number of foresters who could closely monitor hunting over the controlled sites. Of course, in addition to increasing the number of foresters, it is also necessary to raise the level of legal awareness among the younger generation, explaining to them the negative side of hunting and the consequences of the activities of poachers. These actions will help to reduce the number of new poachers, and subsequently reduce the number of hunting tickets purchased. Such measures will allow minimizing the cases when the cubs are left alone because of poachers.

Thus, as a result of the conducted research, legislative gaps have been identified in the framework of regulating the activities of the center, as well as problems related to the financing of such organizations. The Russian legislation is often amended in regard to the scope of non-profit organizations regulation, and issues related to the protection of wildlife are not an exception. Various organizations of the related area have to adapt quickly to the newly established standards and rules for the organizations of their activities. At the same time, after analyzing the activities of the "Center for the Rescue of Orphaned Bears", we can state that this organization successfully solves its goals and objectives in accordance with the requirements of legislation. As part of the study, we propose to provide additional support measures in the Russian legislation, such as: to release these centers from land tax, to provide them with food, medicines and other equipment at the expense of regional and local budgets, to allocate grants for the construction of such institutions and the appropriate infrastructure. The center continues to provide assistance to cubs, which is exceedingly significant for wildlife. Specialists of the center constantly travel to rescue cubs in different regions of Russia, cover their activities in the media and strive to preserve the bear population.

It is not a coincidence that the bear is a symbol of Russia. Each of us can participate and help the activities of this center: firstly, the legal community can develop and propose amendments to the current legislation, reducing bureaucratic procedures, and provide tax benefits for such organizations. In addition, each of us is able not only to provide all possible financial assistance but also take active participation in public discussions of regulatory initiatives encouraging our social activism. Thus, each of us will be able to contribute to environmental protection, become interested in this area and subsequently take more significant steps in regulating this area.

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**Costs and Benefits of Financial Technology (FinTech) Development for Technological Ecosystems**

**ABSTRACT.**
The article provides insights into previous research and gives definitions of FinTech and tech ecosystems that best fit the topic. It contains hypotheses connected with the feasibility of developing financial technologies in big technology companies. The paper seeks to analyse the current situation in the world of financial innovation, to describe the pros and cons for tech giants, to introduce and develop FinTech services, and to outline the prospects

for the development of FinTech within tech giants. The article studies the experience of Russian, American and Chinese technological companies in the financial sphere. It is revealed that tech giants can rather benefit from the use of FinTech than encounter problems. The findings suggest that both companies and customers take advantage of it. Tech giants receive a larger user base and volume of transactions, increasing demand for ecosystem products and services, better financial inclusion, growing profitability and competitiveness. However, it is necessary to be aware of regulations and rely on the bank's support. The countries' legislations and the principle of regulating financial transactions are not relevant for modern financial technologies. Therefore, there are gaps due to which the introduction of FinTech to technological companies may have an unpredictable effect.

The financial area is becoming different, and it affects almost all parts of markets and people's lives. The traditional banking sector and other organisations start to lose if they do not keep up with new financial technologies. Global adoption of FinTech services has rapidly grown, from 16% in 2015 to 64% in 2020 [18]. Every year the volume of investments in FinTech increases and becomes an essential part of developing companies' business and competing with other market participants [57]. FinTech transforms the majority of sectors giving companies many advantages, which are described in this paper. Financial technology introduction concerns the majority of technology ecosystems and other institutes as they realize that FinTech represents a new stage in the development and promotion of organisations, in any way related to technology and finance. The problem of rapid development of FinTech in recent years leads to the necessity to cover the advantages and disadvantages of it for technology organisations. The majority of studies just describe FinTech or financial ecosystems or examine the effect of financial technologies on banks and people [3, 37, 67], while this paper concentrates on the influence of FinTech on tech giants. An appropriate decision of investigating FinTech's impact on technology ecosystems is needed if new financial technologies influence activities of tech giants positively or negatively. This is a research question to be answered in the paper. As a result, this study seeks to supplement and structure data about financial technologies with a focus on tech ecosystems in the most appealing markets. It should result in the solution if there are more benefits or costs, if these ecosystems should undergo changes and come to the financial sphere or not.

Furthermore, this study is unique because it does not only aggregate the information about the interaction of FinTech and tech giants but also compares the most popular and widely known organisations. Therefore, the paper includes an analysis of Russian, American and Chinese tech corporations with FinTech that may be useful for start-ups to take a firm place in the market, for traditional organisations to recover and go further and for all b2b or b2c consumers to understand FinTech market conditions. This study contributes to academic literature on the topic of financial technologies for non-banking companies [45, 4, 65], which means that the work can become an intermediate link to a more global study.

The methodological basis of this work includes a cost-benefit analysis and recapitulation of open sources of literature and statistical data, and a comparative analysis of Tencent and Alibaba Group (China), Apple and Amazon (the USA), Sberbank and Yandex (Russia). The comparison of tech companies from different countries that have their own rules, values and trends allows us to look at the impact of FinTech on these ecosystems from various angles.

First of all, for better understanding, the key terms such as FinTech, tech giants, ecosystems should be explained as they have various meanings. The World Economic Forum characterises FinTech as 'new entrants that promised to rapidly reshape how

financial products were structured, provisioned and consumed.' [10]. This interpretation of the word only applies to early companies, start-ups. However, this is not exactly right and the term should cover all "organizations combining innovative business models and technology to enable, enhance and disrupt financial services" [17]. McKinsey & Company and KPMG use a similar definition of financial technology, and the main point of this term is transformation connected with new technologies in finance operations [10]. It should be noticed that FinTech often means not a company but a technology that an organization introduces in its activity for different aims. Moreover, this term applies to both financial and non-financial organisations, and the integration of finance and high-tech (high/advanced technology) gives enormous results to them. For the investigational purposes of the paper, the definition of FinTech, after all the meanings of it have been collected and analysed, will be taken to imply a new technology that seeks to improve and automate the delivery and use of financial services [31]. Thus, FinTech is supposed to help people in various ways (which are discussed below in this work), and the consequences of using new financial services are supposed to be investigated in this study. All the operations, which are influenced by FinTech or somehow connected with it, are divided into risk management, marketing, insurance, regulation, savings, security, lending, capital raising, digital payments, financial software.

As regards tech ecosystems, they have appeared from tech companies or even banks. Technology companies may be defined as a business whose activity relates to producing technological products (such as software, gadgets) and various internet-related services. Several organisations turn into ecosystems. Cavallo et al. present debates and future directions have considered various approaches in defining the concept of a business ecosystem [8]. The main idea of the definitions implies creating a complex system of organisations that gather around one firm. It includes relationships with different elements, creating new products. However, an ecosystem can be defined not only as a community of firms. More applied to tech ecosystems, it means a group of devices with software to create one collaborative network, a 'family' of products [41]. In this work, we use both definitions as, for example, Sberbank needs more the former, while Apple fits more the latter. Combining the concepts of tech companies and ecosystems, we form a definition of a tech ecosystem for the purposes of this paper. A technological ecosystem is an amalgamation of organizations, people, united for a more successful competition with other market players and for more revenue, producing new technologies or providing services based on high-tech; or it is a system of technical products that are interconnected and penetrate into several spheres of consumers' lives. Big Tech and banks have been transformed into technology ecosystems will be considered.

Explicit understanding of FinTech and the tech ecosystem enhances our awareness of the role of modern finance services in the development of the tech ecosystem. During our research into various sources dedicated to FinTech, some of their opportunities, beneficial for both companies and their clients, have been found.

It is more reasonable to begin with payments as they are the most popular finance service. Currently, almost all banks try to modernize money operations creating special platforms, apps and producing credit cards, and the majority of tech giants try to compete with each other and the finance sector by introducing their own digital payment system. However, many of tech companies understand that the collaboration with banks is an easier way to enter the financial services market than to become banks themselves because, otherwise, it demands complex regulation and needless licensing, red-tape activity [14].

According to El-Assi [14], digital payment gives a lot to tech ecosystems. First of all, it is *the growth of revenue reached by payment fees*. These fees are paid to tech giants by banks that are interested in this because the volume of money transactions increases. Secondly, tech ecosystems get an opportunity to collect more *data about their users*' behaviour and build a more accurate user profile. In addition, tech companies can use this information for

different business purposes. For example, collected data enables tech giants *to better target people with advertisement* when they use companies' services. Obviously, it leads to *higher demand for ecosystem products and services* and thus to a more considerable income. Other BigTech firms can also leverage this data to *up-sell or cross-sell their user base* as they see it fits [14]. In addition, technology ecosystems aim to *enter many markets*, including the finance sector. This lets them lock users in their systems. This means that people get used to the company and usually choose it in all areas of their lives. All of this brings benefits to the ecosystem directly. Besides, a large number of people use online payments on various sites; therefore, new payment services, such as Apple Pay, AliPay and others, make purchases on web platforms simpler and faster, since there is no need to enter personal data every time. Thus convenience of the payment process pushes consumers into constant shopping. The consequence of this is *a growing volume of money transactions and income.*

BigTech companies should go into finance also because throughout the world there are many places without access to banks. That is why all banking services are unavailable for such residents. Kaplan gives an example that illustrates the importance of tech ecosystems' involvement in finance services: "Amazon Cash program allows consumers to shop on Amazon after depositing cash at partnering retailers and kiosks". This means that tech giants contribute to *financial inclusion*, especially in emerging markets and developing economies [16]. In turn, tech companies find *new markets for the distribution of their services and products.* In addition, these markets with new customers are highly appealing because there are *few competitors*.

Another service that should be described is lending. As is known, to get a loan, a person needs to have a good credit history. For example, in Russia in 2021 66% of people were denied a credit by banks (RUSBANKROT), while in the USA only 20% of Americans with high credit scores (FICO) can borrow money on good terms [46, 64]. Simultaneously, BigTech companies with FinTech provide loans to more people and firms, and they expand their banking services globally. Tech ecosystems have more advantages to do this, which will be demonstrated further.

First of all, they use a huge database about their clients, the information, collected during users' activity in digital payment and apps, helps companies to *assess risks more accurately* and, thus, offer more loans to clients. According to the World Bank, 1.7 billion adults still lack a bank or mobile money account. Many of these unbanked citizens lack a credit history or proximity to a brick-and-mortar bank branch, but they have access to the internet within their phones (or other devices) [43]. This is the reason to allow BigTech firms to develop their financial sectors. As a result, not only users benefit from this but also companies take gains from lending. There are several factors that drive the supply of modern FinTech credit providers and products, according to Reiners [34]. The most important factor is that lenders can use new digital innovations more intensively and efficiently in consequence of FinTech. They can automate the entire lending process, while offering the highest level of convenience and speed of services; in addition, tech giants can use new non-traditional data sources. To assess a borrower's credit risk, banking organisations have relied on traditional metrics like credit scores, debt and income levels. However, FinTech lenders can *incorporate additional data*, for example a business' sales volume on e-commerce websites, or customer reviews from platforms [28]. For assessment of individuals' credit risk, tech companies may search data in social media accounts with the help of artificial intelligence. Combined with traditional parameters, this additional piece of information may provide technology ecosystems with a more complete credit risk profile for each potential borrower [28]. Remarkably, technology companies can observe their clients' revenue flows in real time and can keep track of any network changes in the financial condition of a firm; accordingly, they know when default rates are low [29] and enable higher profits.

Additionally, tech giants with FinTech do not have brick and mortar branches to pay for, all working process becomes online.

Another benefit for tech ecosystems to introduce FinTech services consists in no supervision by federal banking agencies that do not need to hold much capital and liquidity as banks do or get a license, so the rates of credits are lower and more appealing, but income from all financial operations is still higher than banks have [34]. However, this point has become different lately. In many countries, regulatory agencies and the government become awakened and start to pass laws restricting the financial activities of the companies. In the part of tech ecosystems' comparison, we give examples of such negative phenomena.

The last point about lending tech giants will be always *in great request*, even during the financial crisis, because in bad situations banks suffer and have to offer unfavourable terms to their clients [34], which leads to outflow of consumers.

Finally, the process is automated, which implies an individual approach to each client, with more convenient, fast and less costly services. As a result, people and SMEs are supposed to *choose BigTech firms*, and this is the reason why companies with FinTech become more popular and competitive [34].

There is much research into whether tech giants can beat banks [35, 36, 23, 1]. We suppose that at least during the next few years, this will not happen because everything depends on governments and regulatory agencies' behaviour. They seem not to allow tech companies to take over the financial sector for many reasons. In addition, there are many adults whose consciousness is not used to a new reality with no banks, and technology ecosystems provide financial online services. Governor Mishkin presented remarks at the Econometric Society in 2007: 'Microfinance is a positive development; it has clearly helped substantial numbers of poor people escape poverty [...] However, microfinance is not a substitute for institution building [...]' [62]. Nevertheless, technology companies are seen to gain momentum in the financial sphere.

One more point in advantages derives from all above-mentioned benefits. BigTech companies become more attractive for investors because they introduce FinTech, while FinTech is known to be invested greatly from year to year.
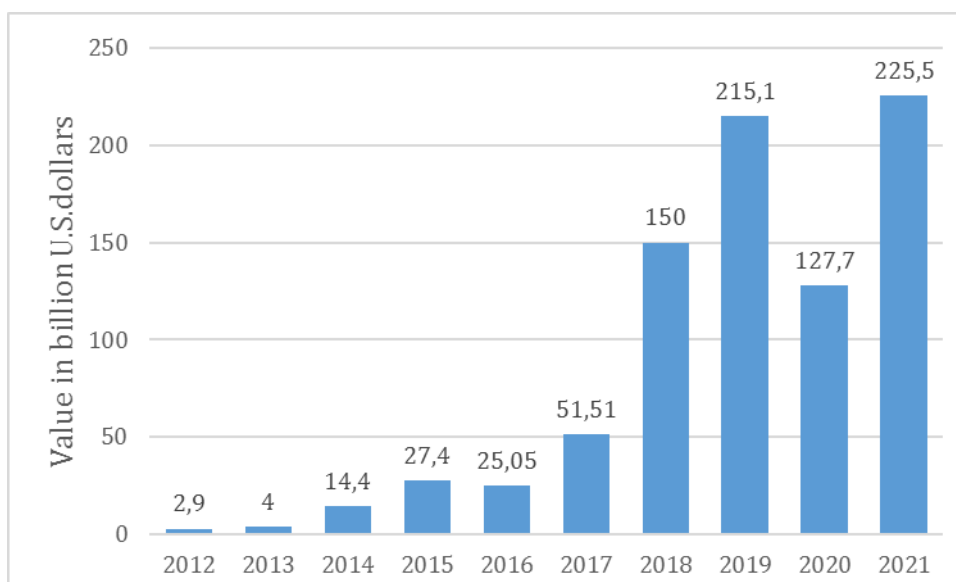


*Figure 1. Value of investment in Fintech sector worldwide from 2011 to 2021 (in billion U.S. dollars), Statista [57].*

In the process of discussing the impact of financial technology on companies, FinTech was found out to bring not only advantages, but also disadvantages, as is mentioned, for example, regulatory challenges. Additionally, Statista proves that many people do not want

to use financial services provided by tech ecosystems due to many factors: privacy concerns, lack of trust, bad experience in the past and others [54]. The second point may be deleted if tech giants begin to cooperate with well-known banks, while the first point is actually a problem for customers. Security also concerns government, so state regulation in this industry is more active now. We suppose that troubles connected with restrictions can turn into possibilities to build confidence and attract more users.

In sum, all the benefits and issues should be checked on tech companies, and the main hypotheses that need to be supported or disproved in this paper are presented below.

1. Financial technology brings mostly benefits to technology ecosystems and all of them are better to introduce this innovation.
2. Tech companies should cooperate with SMEs and banks.
3. There are important restrictions to develop FinTech within the technology entity.

In order to test the hypotheses, we seek to analyse the largest technological ecosystems from three dissimilar countries: China, the United States and Russia. China is a developing market but its financial sector makes the greatest progress. China surpasses other countries in FinTech value, and Alibaba (with Ant Group), Baidu and Tencent play the main role in it [44].

Chinese giants rapidly develop and extremely influence financial inclusion, which is important for economic growth and people's well-being. As is stated before, FinTech is divided into several parts, and in China the most demanded ones are payments (online, mobile and QR code), wealth management and micro loans. Additionally, there is an interest in cloud computing, AI, internet insurance, internet banking, P2P and crowdfunding, and Internet of things.

By adoption index and transaction value, payments are the world's most popular segment. The Asian region dominates in digital payments, and its CAGR is the highest [7]. The reasons for China's dominance over other countries in financial technologies are interesting. Until 2015 there was a lack of regulation, more precisely, those regulations were inappropriate for modern non-financial organisations. The rules before had been proven ineffective to control risks by the high and increasing default rates in P2P lending in 2011 – 2014 [68]. Speaking about Chinese standards of AML (anti-money laundering), which focus on the protection of financial integrity, anti-corruption and harmonisation with international standards [68], they were inefficient. For example, the definition of non-financial companies was inaccurate; therefore, it was difficult to apply laws to tech ecosystems. All regulation weaknesses helped technology companies to experience a rapid growth. Certainly, it is not the only reason for such a development. Other causes are a large base of users, financial exclusion of many Chinese (before the FinTech distribution campaign) and others. China has moved to a cashless economy extremely quickly, and these days the majority of Chinese people use modern payment services. Compared to the origin of RegTech (regulation technologies), for example the UK and the USA, regulation in China is still at an early stage [39]. Initially, regulation has helped Chinese technology ecosystems, but in recent years the country has tried to concentrate on restrictions and rules, which are disclosed in this work as the disadvantage of implementing FinTech in the company.

China is appealing within the framework of the project as its tech ecosystems are widely known and make a breakthrough in FinTech. The largest companies - Tencent and Alibaba – will be discussed. The first Chinese tech ecosystem to be examined is Tencent. On the website of Tencent there is the following citation: 'From connecting people, services and devices, to connecting enterprises and future technologies, fostering win-win ecosystems for everyone,' - that describes the essence of the company [61]. Thus, Tencent aims to have some big and small partners. Tencent's technological ecosystem can be divided into 4 parts: communication and social, digital content, tools and FinTech services [61].

Tencent was a messaging and gaming company, and it began to develop FinTech in its ecosystem starting with the payment system launched in 2013 - WeChat Pay. WeChat Pay included approximately 800 million users in the 4th quarter of 2019 [51]. The application accounts for a large market share - 38.8% [5]. Initially, social networking and games were a big part of the tech firm's revenue. Nowadays, in the report Tencent claims that FinTech and Business services cost 128.1 billion RMB in 2020, which constituted 27% of the total company's revenues in 2020 [61]. Annual revenue of Tencent holdings from 2007 to 2020 in billion yuan grew [2], and the segment related to FinTech expanded significantly [59].

One of important Tencent's services is represented by WeChat; moreover, different options such as stickers, public accounts and gaming, advertising, which leads to making money through app by payments. The fee amounts to 0.01% to transfer a sum exceeding 1000 yuan outside the app ecosystem [11]. One speciality of Tencent and Alibaba is that sellers and consumers in China usually use QR codes as it is much easier, especially for the former because they do not need to buy special technologies to receive payments. We suppose such a payment system could be conducive to other countries' commercial success, in particular, an increase in the frequency of money transfers.

Apart from digital payments, Chinese technology ecosystems try to develop financial services in other spheres. For example, Tencent's insurance segment includes the in-house platform WeSure – a middleman between insurance agencies and consumers [40]. FinTech allows Tencent to build an insurance platform, able to satisfy all customers' demands.

Tencent focuses on the partnership with financial organisations rather than competition [21]. To develop financial services, Tencent began to cooperate with Hank Seng Bank (in 2018), joining an extensive service network and advanced technologies [24]. This union helped Tencent to get more clients and promote itself in Hong Kong. Hang Seng provided a merchant-acquiring service for Weixin Pay and WeChat Pay HK that enabled customers to use Weixin Pay or WeChat Pay HK to make mobile payments at designated merchants in Hong Kong and mainland China [24]. Along with it, Tencent and State-owned China Construction Bank (CCB) announced in 2019 that they were going to build a lab for FinTech innovation [38]. Moreover, Tencent cooperates with the University of Hong Kong for FinTech research and development projects, and with FinTech and blockchain lab within the university department [30]. This can help the company to carry out a better analysis of the financial technology market. As regards cooperation, the strategic focus on FinTech business, according to Tencent's report, consists in considerable cooperation of regulators and their collaboration with industrial partners in order to deliver compliant and inclusive FinTech products, thereby prioritising risk management over scale [60]. Thus, the company is expected to increase the number of business partners in the financial technology segment.

Coupled with partnership, the company conducts many FinTech services through its own payment platform and its WeBank, with Tencent's 30% share. We suppose that WeBank renders Tencent a feasible help to avoid risks connected with regulation as it has a license.

Bloomberg provides a small table that shows the impact of government actions on tech giants [25]. The table demonstrates that officials in China strive for fair competition, more transparency of tech giants and seek to protect consumers' rights. With reference to it, there might be stronger rules connected with privacy and data security and control of loan funds [26]. All these demands refer to antitrust law and increased activity in FinTech. Bloomberg and Fortune (an American widely-known magazine) confirms that some changes will be required in companies, what possibly lead to higher costs connected with license, capital restrictions [6]. However, Tencent's president argues that the company was determined to collaborate with regulators as the tech giant tried to control the risks, and in which case it would be only necessary to restructure a financial holding group of Tencent [12]. These new rules are current problems for Chinese companies because they could spend this money on development and expansion. However, the regulations do not threaten companies' existence

and do not entail extremely large losses. It remains only to assume that the Chinese technology ecosystems will be able to quickly rebuild to new conditions and restructure so as not to suffer due to falling stock prices or fines.

To conclude, FinTech has given a lot of advantages to Tencent: new profits, a larger number of users, information about customers' preferences and private data, more targeted advertising, but the technology ecosystem still incurs high costs connected with FinTech services and has one more problem: it needs to approach financial services' development carefully nowadays due to new regulation processes. Nevertheless, analysts are positive about Tencent's future development. Analysing the forecasts and recommendations from the CNN, it can be assumed that the company will be invested in and stock quotes will rise [58].

The next Chinese tech company that is studied in this paper is Alibaba. In some ways, it is very similar to Tencent. It is known that Ant Group is a subsidiary of Alibaba and this company is responsible for Alibaba's financial services. The AliPay system was initially created to secure online payments for Alibaba platform users [63]. Currently, Alibaba includes not only its own payment system, which accounted for 43% of total revenue in 2019; simultaneously, it is positioned as wealth management (14%), micro lending (34,7%), insurance and mutual aid [40]. In addition, Alibaba's ecosystem contains the Yu'e Bao fund – an investment platform. The Yu'e Bao fund constituted 972 billion RMB of assets under management and a market share - 11% in March 2021 [20]. This platform helps not only users to earn money but also tech giants to accumulate people's money and increase investment income.

However, as is mentioned, an active restriction campaign has begun recently, and regulators have demanded a reduction in the size of the fund. Apart from this, Alibaba drew attention to its financial activity and was fined 18.2 billion RMB for breaking antitrust law, according to FitchRatings [20]. Alibaba is accused of a disorderly expansion of capital (the largest issue of shares was planned) [13]. Moreover, the new rules require companies like Ant Group to fund at least 30% of the loan and restrict them from lending more than one third of individual borrowers' annual salary [48]. Another tech giants' activity which catches state regulators' interest is data. In contrast to Western Wallets, WeChat and AliPay know how much, when, how and on what their users spend their money and both companies have been accused of enabling to share this information with third parties and even with the Chinese government [42]. Spreading the information about users can be profitable for tech giants as they get money from the data about each user but, in addition, may be dangerous for people. The new rules make tech ecosystems save the information that may hit companies' revenues. A difficult period of restructuring and losses of income has begun.

To sum up, from time to time, there are several barriers to develop FinTech within a technology entity, which both stop financial services' extension and hinder the progress of other ecosystems' parts. However, as is noted, financial technologies are not the main reason why Alibaba has attracted regulators, thus FinTech should be developed further.

According to Statista [52], the USA is the world's second developed country in terms of FinTech, adopted by organisations. In this country, there are five Big Tech companies – Amazon, Apple, Facebook, Microsoft and Google. We aim to consider the first two companies.

Apple is popular and known all over the world as an ecosystem that produces different types of the most modern technologies. Since 2014, the BigTech firm has expanded into the financial sector, organising a payment system, first, and creating a credit card, second. To begin with, Apple Pay is used by people in 20 countries and in many markets it is a leader in terms of frequency of use. Apple does not show statistics about Apple Pay or its credit card, but Statista provides estimated information about Apple financial sector's users [55]. The number of Apple Pay users worldwide increases every year. From each transaction Apple gets fees. Conceivably, the reason for FinTech development is that many people buy Apple devices, especially an iPhone, every year. Consequently, for people it is easier to have a

payment system from the same brand, and for Apple it is an additional source of income. The Times has published information that Apple earns a 0.15% charge for each customer's purchase [22]. Forbes has also announced the result of the financial report by research firm Bernstein: Apple Pay reaches 5% of all global credit card purchase volume [33]. Although fees for money transactions are not high, in aggregate, considerable revenue is yielded.

Beyond that, in 2019 Apple launched an Apple card in partnership with Goldman Sachs and MasterCard. Through this card, Apple offers profitable features for consumers, for example, no annual fees and cash back. The question is how Apple and its partners earn money. In real conditions, Apple gets much money from credit operations. Forbes has collected some information about the Apple card: some researchers assert that global non-cash transaction volumes approximated 539 billion dollars in 2017, and annual growth approached 12%, others now estimate global payments volume of Apple at about a trillion dollars [33]. Anyway, this credit card offers an APR between 11% and 24%. It exceeds 100 billion dollars, and Apple has a share of this income. Moreover, as Apple cooperates with a leading global investment bank, regulatory problems do not bother it, at least for now.

Bak-Mikkelsen points out that 'Apple Financial Services gives our business flexibility — now we can add the right devices at exactly the right time, in line with our company growth.' Supposedly, this quote is about analytical part thanks to FinTech, which means one more advantage in competing with other tech giants [15]. Analysing the financial sector of Apple, it becomes clear that the partnership with banks allows tech companies to develop profitable FinTech services without barriers.

Amazon is an American multinational technology company. It concentrates on e-commerce, cloud services, digital streaming, and AI. Its ecosystem includes financial services which are divided into four parts [19]: banking, payments, capital markets, insurance. As many other tech giants, the company develops its financial services through a payment system. Amazon Pay, as an online payment platform, is comparatively popular in the USA, with its 18 % share [56]. The company constantly develops its payment system. Since 2019 Amazon has collaborated with bank Worldpay – an intermediary between banks and credit card companies [9]. Amazon Pay is in great demand by the tech giant itself because Amazon has a trading platform. So the company brings at least two benefits to itself with one service at once: income, speed and strong security of transactions. Interestingly, Amazon started earlier to create a P2P platform, but it failed because of lack of people's readiness.

As is stated above, another financial program is Amazon Cash. This service allows unbanked customers to shop on Amazon after depositing cash at partnering retailers and kiosks. In this way, Amazon develops FinTech to gain ground in big cities and remote areas with poor banking infrastructure. With respect to the company, its user base has been expanded, and the cooperation with local merchants helps Amazon to encourage consumers to spend more on its e-commerce platform. In the matter of lending, Amazon launched its service for small loans in 2011 and then became a partner of Bank of America Merrill Lynch [9]. The goal has remained the same: offering more loans to sellers for further intensive purchasing on the Amazon platform. Moreover, the tech giant takes gains from interests.

Overall, Amazon focuses on building FinTech products to increase people's participation in the Amazon ecosystem. This is the greatest benefit, besides monetary profit, for the tech giant. Due to financial technologies, many more consumers and merchants are attracted to make them start to buy or sell more things in the Amazon ecosystem. Due to a variety of products, people stay in the Amazon ecosystem for a long time. In addition, the aim of the tech ecosystem is to modernise systems, optimise banking operations, build a secure cloud and create more elegant customer experiences. It results in improving agility and scale, in bringing new ideas to market, in being at the forefront, and in lowering costs.

It should be added that Amazon collaborates with financial institutes, and the company is launching a deposit-holding bank [9]. As is known, Amazon does not face regulatory

challenges. However, the lending business growth is not high enough due to capital limitations and a strategic decision to keep a cap on growth to avoid regulatory pushback [9]. Finally, Amazon has all favourable conditions for FinTech development and has a positive effect of financial technologies on its entities.

Compared to China and America, Russia does not have firms, similar to BigTech. Just Yandex and Mail Group are big technology companies, and one of them will be discussed further. Before we have considered only tech ecosystems that initially involved something connected with technology. Regarding Russia, we will describe a bank that is considered to be a tech ecosystem.

Although the situation with tech ecosystems with FinTech is far from ideal, Russian FinTech adoption (by consumers) has the highest level in Europe and top-3 in the world (EY Global Fintech Adoption Index 2019) [49]. Many FinTech transactions are made annually, and the majority of operations connected with finances belong to digital payments and personal finance [50]. The question is what influences this percentage of adoption. Presumably, apart from foreign companies, Sberbank plays a great role in FinTech adoption.

Sberbank is a financial organization, Russia's largest bank that also expands in non-financial spheres. The bank is a leader in FinTech in Russia. It has an online platform, though which people and entities can transfer money, pay for some services, analyse their budgets, and invest in stocks. In addition, there is an insurance sector in Sber App and many other services. All of these factors have made Sberbank popular among people [53].

Sberbank's strategy to compete with tech companies has been implemented. The company's presentation from 2020 manifests that a new IT platform has been developed, AI platforms that optimize costs and give more revenue have been launched [47]. Thus Sberbank may be called a tech ecosystem with a financial centre. Here are also goals for 2023, Sberbank intends to launch SberPay, QR codes for payments and use biometrics not only for Online Sberbank. Obviously, the company becomes similar to Chinese and American companies. Sberbank plans to introduce a personal financial manager, cloud service and lending based on AI. The bank aims to become an enormous tech ecosystem with a strong financial foundation. Supposedly, the bank has well-founded reasons for development and an increased share in the Russian financial market.

Unlike foreign tech ecosystems, Sberbank now works for future income and considerable results as it is at the stage of development of FinTech and other technologies. At the same time, Sberbank does not actively cooperate with other tech companies or banks like American and Chinese companies. Supposedly, the bank even does not need other organisations to become strong. It chooses its own trajectory of evolution and follows it in collaboration with small companies. It used to be a traditional bank, and now it has been adjusted to new global banking conditions. This organisation has at its disposal appropriate environment for FinTech development and does not suffer from regulation now.

The development of FinTech represents a key direction for Yandex. Currently, it is a tech ecosystem with various services [66]; however, the financial sector is a problem for Yandex because for creating really important FinTech services, the company needs much time and a huge number of investments, or it should cooperate with a bank. Unfortunately, Yandex failed to become a partner of Sberbank and Tinkoff Bank. It is known that Yandex and Sberbank have had their common product called Yandex Money before, but this service became Sberbank's platform after the organisations' severance [27].

Yandex, in its turn, strategically needs FinTech as the tech ecosystem includes many services whose number of transactions is considerable; however, it has neither a license nor special resources. Consequently, the potential benefit of FinTech development for Yandex is more revenue from transactions, simplicity and convenience of services that contain payments for users and the company. Without banking, Yandex can become less competitive, which may result in a liquidation of this company as Sberbank has developed into Yandex's

main rival. Thus the main barrier of Yandex ecosystem evolution is lack of support of financial organisations. However, according to the latest news, Yandex has acquired "Acropolis" – a small bank, and it is expected to develop financial technology in the near future [35]. Therefore, in future reports it would be useful to consider the promotion of a company in financial technology.

This paper examines the effect of FinTech on tech ecosystems. The hypotheses about advantages and barriers of FinTech have almost come true. We consider six most popular and appealing technology companies, analyse their activity and decide if there are many benefits for technology companies. Firstly, it is an increase in revenue for many different reasons discussed before, namely an immense source of information about consumers and merchants, a high level of security and users' convenience. Secondly, FinTech development results in entering new uncompetitive markets, attracting and locking people in the ecosystem. Thus it is a higher demand for companies' goods and services. Finally, FinTech gives a tech ecosystem a chance to overtake competitors and attract investors' money for further development.

Regulatory problems are considered a barrier; however, they are almost fully solved by a partnership with financial organisations. This also confirms the hypothesis that it is essential to cooperate with banks. At least currently, it is the only fast and cost-effective option for a technology ecosystem to develop FinTech services in the company. Notably, this rule applies less to organisations which have initially been bank-related. For a particular company and others, it is not a competition but cooperation with SMEs that may be effective for building an ecosystem and developing FinTech, which may be conducive to overall welfare.

In conclusion, all probable pros and cons of FinTech development for tech ecosystems have been formulated. Notwithstanding, sometimes there are limitations as is hard to get information about companies' services transactions because they do not publish all required data. For this reason, some of the diagrams and tables in the links are based on estimated records. In perspective, as the regulation sector develops, it will be useful to supplement and correlate this work with actual legislative documents in order to more objectively reflect the advantages and disadvantages of FinTech development for tech organizations.

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**Applications of Game Engine technologies: Unreal Engine 5**

**ABSTRACT.**
The key objective of the study is to investigate implementations of game engine technologies both in non-gaming fields and in the information technology (IT) sector. The preeminence of using game engines in other areas and potential development of such software technologies is of particular interest. The study describes the technological significance of game engines as a software that is extensible and can be used as a cross-

industrial tool and a foundation for various games, business and technical solutions without any major modification. This research is primarily based on a data collection and an analysis of Unreal Engine 5.0-5.1 and Unreal Engine 4.0-4.27 Documentation, a collection of articles "Ray Tracing Gems" by Nvidia coupled with Nanite and MetaHuman Documentations by Epic Games to generate usage patterns of game engine technologies in different professional fields. The anticipated results of the research include new prospective applications of game engine technologies in automotive, formal sciences, architecture, and urban planning as well as within the game development.

**Keywords:** *Game Engine; Lumen; Digital twins; Real-time pipeline; Unreal Engine 5; MetaHuman.*

**BACKGROUND**

The gaming industry is an auspicious sphere that expands by approximately 10% per year. Game engine technologies increasingly transcend the traditional boundaries of their medium, as evidenced by their extensive use in software engineering, graphic design, and IT in the aggregate. Thus, they are not only remunerative for a business but they also have an immense potential in non-gaming fields including non-Euclidean geometry, real estate and urban maintenance, filmmaking, broadcasting, architecture, and car manufacturing. Particular game engine "families" such as Unreal Engine (UE) and Unity made the next evolutionary step, boasting some of the best tools and the richest engine feature sets in the industry. Since 2014, when Epic Games released UE 4 at the Game Developers Conference, the game industry has experienced serious changes with the release of UE 5 Early Access in 2020, which uses advanced technologies such as Nanite, a virtual micropolygon geometry system, Lumen, a fully dynamic global illumination solution, MetaSounds, a high-performance audio rendering system, together with MetaHuman, a tool for creating extremely detailed and hyper-realistic 3D human characters.

**PROBLEM STATEMENT**

With the current state of the game development industry, working with game engines is generally limited to the documentation of engines, the practical experience and skills of specialists in the gaming sphere, primarily engine developers, level designers and DevOps engineers. This fact from the reality of the game development field might be explained by the applied nature of the industry, but it is reasonable to assume that it is a theoretical base that becomes a basis for subsequent innovations in the consecutive development of game engines, the further development of their functional features, as well as the expansion of horizons for game developers. The study opens a door to a further development of next-gen game software features and enhancements. Relevant data presented in the UE 5.0/UE 4.27 Documentation appears to have some visible gaps in the current scientific investigation regarding the preeminence of such software engineering products. Therefore, insights into this promising area define importance of the paper for future studies on implementations of game engine technologies.

Digital distribution game platforms such as Steam and PlayStation Network are becoming increasingly problematic, thereby strongly influencing modern gaming products consumers' approaches to their purchase preferences. Therefore, the meticulousness of the developers and, in general, the specialists involved in the process of game production, the thoroughness and the desire to give gamers new mechanics, animation systems, improved optimization of the graphics of the final product is relatively explicable by high competition. With an increasing level of demand, the novelty of the theoretical description of the technologies in game engines is relevant and gives impetus to the development of systems that expand the current understanding of traditional mechanics used in the development of a game product.

**PROFESSIONAL SIGNIFICANCE**

The increasing power of interactive visualization systems has made it possible for scientific and business communities to gain new insights into their fields. By developing and maintaining shared infrastructures for game development, game engine companies have contributed to the immense trade success of their industry. However, with the most resent advent of UE 5, game engines have been introduced to some areas outside the gaming industry, namely architecture, artificial intelligence, manufacturing, public planning, physics, animation and film production. This paper investigates a variety of fields where game engine technologies can substantially improve productivity, efficiency levels, performance, and reduce labor costs; in addition, it categorizes features and enhancements used in the software of a video game. The study considers software technologies, which include world building, rendering, animation as well as geometric solutions and can be therefore classified mainly by a corresponding type of features.

**WHERE THE GAME INDUSTRY IS TODAY**

Since the rise of open-source game engines, many companies within this field have chosen such programming and design solutions as Unreal Engine or Unity, the underlying reason for which consists in many resources to develop one's own AAA-level software. In this case, AAA-level should be understood as a class of high-budget computer games content solutions. Most of the engines (Fig. 1) have been developed over a significant number of years, some of which represent several (either partially or completely rewritten from scratch) versions with subsequent name changes. It should also be noted that most of these engines use all sorts of middleware to implement certain functionality including platform compatibility, physics, network, user interface (UI), rendering and sound.

Arguably, a data-driven architecture is what differentiates a game engine from an application that is considered a game, not an engine [6, p. 13]. Consequently, when a game employs one case code to render specific objects or scenes, it becomes extremely challenging to reuse that software in order to create a new game. Most engines are designed for a particular genre or a particular appropriate set of hardware parameters. As a matter of fact, even the most-general purpose game engines are really only suitable for creating games in one category, such as third-person shooters or survival horror, since these subgenres belong to the action games' group.
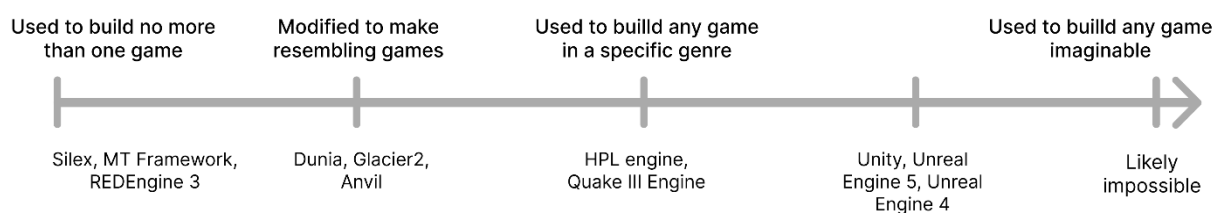


Figure 1. Game Engine Timeline

The emergence of self-sufficient rendering algorithms and data structures gradually blurs and softens the line between different genres of games. It is safe to conclude that all 3D games, regardless of the subgenre they correspond to, require the same standard attributes – third dimensional mesh rendering, tone mapping and ray tracing to achieve hyperrealism or, in a relatively small number of cases, non-photo realism (NPR), some form of heads-up display, low-level user input from the keyboard and/or mouse. With similar technological requirements, it becomes possible to design games on the same platform provided that they meet the same cross-genre requirements.

However, an optimal compromise enables programmers and designers to create independent game engines and an informed choice in favor of one or another software used to make an impressive application [3, p. 21].

The decision to write a company's own game engine often occurs due to the need to use unique in-game mechanics that are not supported by existing technical solutions presented on the market. New product development of triple-A games lasts for approximately 4-5 years or longer, mostly because such a project passes through several successive stages: concept development, feasibility testing, product design, development process, pilot production, and final version, each of which takes months to be completed, and surely, overlapping might not work for each of them.

### ARCHITECTURE

In the recent past, most 3D architecture simulation models were developed in a conventional way, which led to issues with reusability and interoperability because of its strong individuality. Frequently, 3D artists and designers must enhance a look of a specific object and/or scene through a combined selection of properties that affect color correction, tone mapping, lens effects, and rendering features. A special type of downstream processing zones piloted in Unreal Engine 4 called a Post Process Volume can be added to a project level in order to access such features. Each Post Process Volume (PPV) is essentially a type of blend layer that can have a weight, which is conducive to merge effects. Blending is always done with a linear interpolation and only enabled volumes that are getting blended.

Setting post-processing materials within a certain volume can be especially helpful in architecture when an interior/exterior designer is required to control the settings for different rooms, floors, or buildings within one project. Basically, PPV allows enabling blend effects such as non-photorealistic rendering, eye adaptation, color grading, depth of the field, and lens flare when the camera is within the bounds of the volume in real time (Fig. 2). The viewport displays corrected attributes of a proposed architectural design with an extreme speed: a fraction of a second per frame (FPS), giving it a far more realistic look adapted for human eye perception. According to the survey conducted by Forrester Consulting on behalf of Epic Games on the future of visualization in the aforementioned field, 95% of architects would be driven to adopt real-time rendering solutions to edit designs with customers [12].
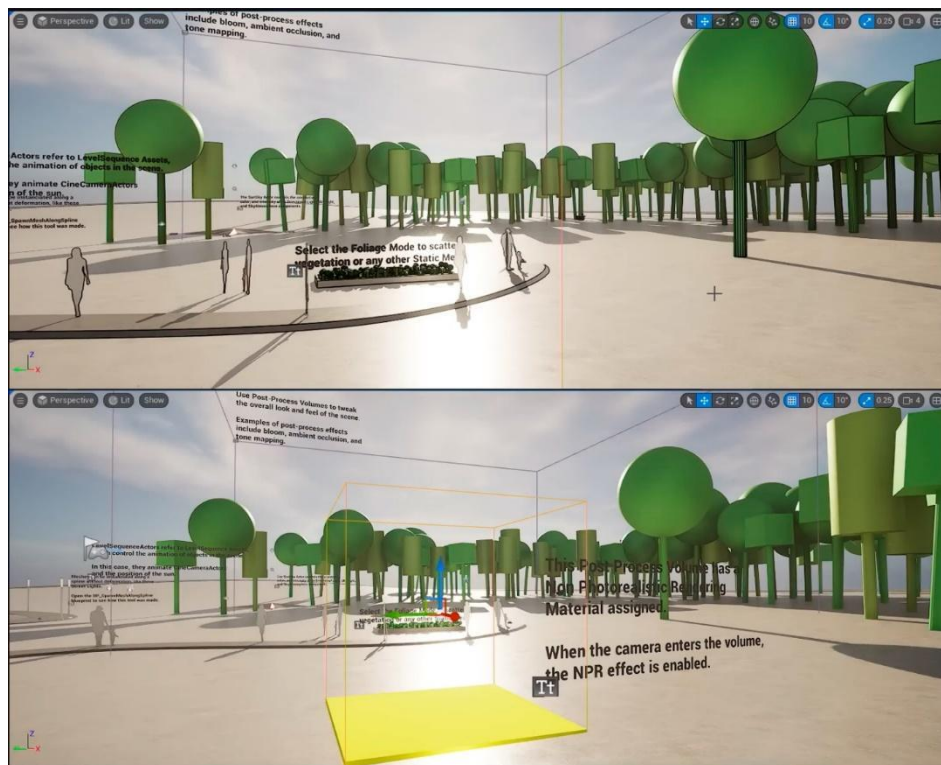


Figure 2. Post-Processing Zone in-and-out.

It is difficult to negate the influence of detailing in relation to rendering and visualization of architectural objects. The objective of the design solution in the named domain is to achieve the highest level of accuracy, realism, and precision, as well as to evoke in the viewer a differential perception of distance, otherwise known as depth perception. In particular, adjusting lighting to display the depth of field within the environment is exceptionally useful for those design layouts that use a large number of reflective, shiny, or polished objects, such as ceramic tiles and plastic (Figure 3).

Lumen, one of the key features, has emerged in Unreal Engine 5. It is a fully dynamic default global illumination and reflection method, which corresponds to indirect lighting [7, p 43]. With Lumen providing infinite diffuse bounces, it is suitable for architectural objects that may have bright diffuse materials, like white wall paint, clear glass, translucent plastics, and silk fabrics. However, the material of the object may also be non-reflective because such illumination algorithms take into account not only the light emerging from the light source but also subsequent cases. Lumen can be used for the highest fidelity, including interactive experiences and animations. In version 5.0, Lumen provides consistency between real-time rendering and offline path tracing [12]. Furthermore, an architectural designer can enable hybrid ray-traced (hardware or software)/rasterized rendering to communicating the vision for an interior or exterior design. Such ray generation projections result in extra support for lighting calculations, ambient occlusion and radiosity, in-camera area depth, reflection probes, along with light probe computation [7, p. 41]. In the case of software ray tracing, a project is required to be able to generate mesh distance fields and, for the most part, it affects walls, columns, ceiling, archways. Nonetheless, some detail is lost, not processed, or handled by mesh distance field, thus, it is not recommended to use it unless this type of tracing is an integral part of the design solution. On the contrary, hardware ray tracing is calculated based on true geometry.
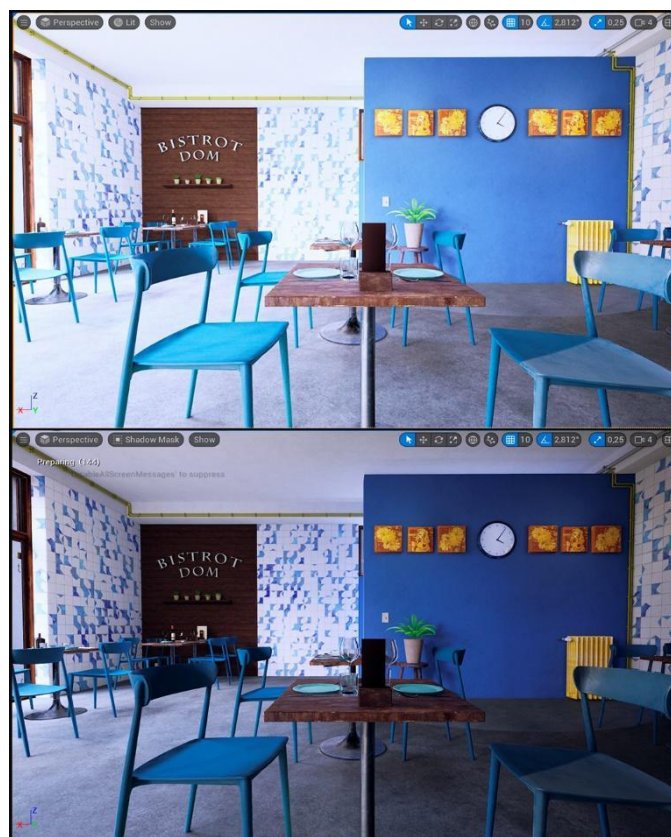


Figure 3. Adding contrasting shadows in the rendering process.

## A FUNDAMENTAL CHANGE IN OUR PERCEPTION OF URBAN PLANNING

The architectural design constitutes an integral part of the escalating domain of urban/public planning and city maintenance. Initially developed by NASA for technology roadmaps and Defense Advanced Research Projects Agency (DARPA) for numerical simulation of system failures on aerospace crafts, digital twins have outgrown their original sphere of maintenance [4, p. 267]. By definition, a digital twin is referred as a three-dimensional virtual model of a physical entity, namely in this research – an urban area or a building. An extension of the digital counterpart is an integrated data model that uses a visual analysis tool, geo-referencing, and back-end databases to improve efficiency and make informed decisions. The fundamental areas of implementation of digital twins on the game engine platforms include:

- Facility management.
- Urban planning.
- Real Estate digital property maintenance.
- Emergency and traffic governance.
- Transaction monitoring.
- Analysis of usage, traffic, workflows.

Considering a vast number of cases where virtual doppelgangers are built through the extensive use of Unreal Engine 5, it has been observed that there are great advantages that come in the form of a shorter new product development cycle, a better simulation performance, consistency between a real-world physical representation and a live data stream, with this data driving from the real-life entity to the model's animation and onscreen displays. Game engines are ideal for building composite and discrete digital twins of environmental projects, including residential, commercial, and even cultural heritage sites to address operational, infrastructure, and planning challenges.

Digital twins in a peer-to-peer composition [4, p. 271] are extensively used in case studies. At the Earth Clone Conference 2, the geo-cloning institute 51World, which focuses on smart cities and smart realty, has been elaborating a digital Unreal Engine 5-based restoration of scenarios; in particular, one of them is concerned with China's transport system modernization. [1, p. 2]. The Digital Twin is a 1:1 scale accurate model of the subway underworld, connected to the real world via sensors. Some stations, including the Wuyi Square station simulation operating platform combines the Internet of Things (IoT) and artificial intelligence (AI) technologies to actualize the integration of Wuyi Square hub station and its digital model space, making the connection between passenger traffic, equipment, and maintenance more intelligent. As a result, building architectural objects using game engines leads to the implementation of more flexible systems, suitable for a large flow of input data, coherence between the real world and the model by implementing a real-time pipeline.

## TRANSFORMING MATHEMATICS THROUGH VISUALIZATION LEARNING

Mathematical visualization is defined as a synthesis of mathematics and computer science to reify subjective pictures of impalpable objects, surfaces, and spaces in one's mind, replacing them with definite and objective visualizations. Visual math conceptualization is primarily used in the fields of geometry and analysis, which include ordinary and partial differential equations, plane or space curves, and conformal maps.

Remarkably, a mathematical approach to modeling deviates from a developer's standpoint in relation to math calculations for visual solutions. Game engines and programming specifications of mathematical equations are considered a tool for "inserting"

correct data to simulate a particular field, an abstract object and a process that arise in all branches of exact science. Viz., which should be considered paramount in regard to this approach, is mathematical accuracy. Otherwise, mathematical definite categorization of surfaces into parametric, with constant negative curvature, algebraic, minimal, pseudo-spherical, Riemann surfaces and others, becomes blurred by the notion of a surface in game engine's graphics, and standard simulation techniques might seem inadequate for creating various types of surfaces [8, p. 648].

One of the trivial yet essential uses of contemporary game engines for visual conceptualizing is as an educational tool to augment or replace gypseous models of mathematical surfaces presented at universities. Complementing standard representation of mathematical objects by game engine's digital models can push the current limits of both domains. Unlike most software for mathematical representation, whose common Achilles' heel is a lack of direct visual interaction, game engines provide an ability to create rotation, look into the rendered mathematical model, "walk" on its surface, and add domain coloring. Surely, it cannot be denied that mathematical visualization contributes to the systematization of monotonous and sometimes problematic manipulation problems.
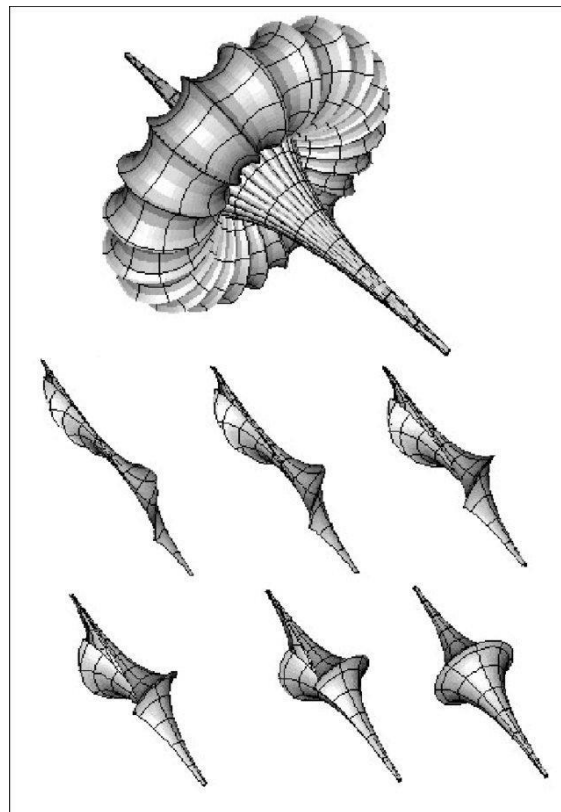


Figure 4. Pseudospherical Surfaces. Solutions of the SGE in relation to Lobachevsky geometry. Courtesy of Richard S. Palais.

In addition, scientific computing researchers who are compelled to use mathematics might find it useful to understand mathematical concepts through the prism of a given visual embodiment. Respectively, the visual component of a task is no less important than its content. The dynamic and extensive nature of modern game engines, driven in large part by the non-linear pipeline in UE 5, provides a foundation for finding solutions to highly sophisticated, comprehensive, or entangled mathematical tasks due to the fact that such pipelines allow feed-forward and feedback connections in addition to the streamline connection and can be configured to perform variable functions at different times. Real-time pipeline processing and workflow presented in Unity and Unreal Engine family contribute

to a reduction in high-priced or time-consuming experimentation. In terms of non-Euclidean geometry, the moduli space for pseudo-spherical surfaces can be identified with the space of solutions of the Sine-Gordon partial differential equation (Figure 4). The latter contains certain n-parameter families that correspond to particularly fascinating surfaces [8, p. 652]. Accordingly, there is a close relationship between the solutions of Sine-Gordon Equation (SGE) and surfaces in $R^3$ that model Lobachevsky space (hyperbolic geometry) [5, p. 272].

## A BIRD'S-EYE VIEW OF INTERACTIVE TECHNOLOGY FOR THE AUTOMOTIVE INDUSTRY

Computerized informational technologies are already driving efficiency gains in the automotive domain. The automotive industry can benefit from real-time game engines because they undertake the key role in Industry 4.0 (Fourth Industrial Revolution) [10, p. 133] as open data platforms. Engineers collaborate using real-time technologies in conjunction with virtual reality to create and validate new designs. In addition, ongoing research includes autonomous driving experimentation in game engine-driven simulators, while clients use real-time configurators to make informed purchasing decisions. Human-Machine Interfaces (HMI) paradigm is one of the reasons why automotive companies tend to invest in digital infrastructure, namely real-time technology, streamlined manufacturing workflows, configured digital twins for their manufacturing facilities [11]. Game engines provide abstractions for a wealth of complex functionalities in the following subcategories:

- Materials testing.
- Augmented reality (AR) tracking.
- Robotics simulation.
- HMI development.
- Automotive advanced traffic management.

In real-time mode, ray tracing, as is mentioned before, enables photorealistic imagery on the fly. For this reason, game engines are incredibly well-suited for materials testing. If it is necessary to experiment with a carbon fiber dashboard design, for instance, a team can utilize an engine to test whether it reflects sunlight in some or all lighting conditions. As a consequence, if the dash is angled extremely far in one or the other direction, chances are that the dashboard will reflect off the windshield and produce a massive distraction. Real-time game engine allows managing different environments, making quick adjustments, and validating them immediately [9, p. 309]. Additionally, game engine architecture allows tracking production cycles in virtual and augmented reality. If certain tasks during the production stage involve a risk of causing a physical harm to workers, the use of an augmented or virtual reality simulator would be a reasonable decision. Considering that the sensors are installed in the production environment, specific production stages can be viewed and monitored with the use of AR in the same digital space, which is considerably useful for making critical decisions about production efficiency [11].

## METAHUMANS AS A THRESHOLD FOR ENTERING GAME DEVELOPMENT

The incessant growth in the number of companies producing gaming products in view of the relative newness of this industry imposes some obligations on a clear distribution of the areas of responsibility of employees involved in the entire process of creating a game: from a game design document (often abbreviated GDD) to the final product. Surely, for young businesses and startups, the vast resources of market dominants are often unavailable, which contributes to some limited staff.

The creation and animation of any game character including non-player characters (NPCs) requires specialists of several competencies, such as concept artists, animation

developers and 2D/3D artists. Such a process takes an immense number of competent human resources with specific knowledge and professional experience. Apart from this, the whole process is time-consuming, including the period of establishing a final version of a game character; on the other hand, it should be provided with expensive technical equipment. Certainly, one of the options for accelerating the business process of creating a character may be the use of predefined or built-in engine assets and models that are distributed as a turnkey solution to reduce the production time of a new game product. Similarly, at the highest level of workload planning, there is no need for any particular skills of specialists of a similar, yet still different profile.

However, we should note that the downside of making this management choice results in a collision with several risks, which include:

- Unrecognizability of a game character.
- Loss of connection between the game narrative and the character.
- Unexpected/distorted/misinterpreted character perception by players.

Most models provided either by a game engine or a third-party service are typically not eye-catching enough to create a mental connection between the game itself and the main characters in the minds of players. Generally, it is recommended to associate the dominant visual features of a character with the game script and the place of a hero/heroine in it. With that in mind, though the short cut might be an enticing option in the short run, it ultimately leads to a decrease in gamers' interest as well as playability and the downward trend in the user statistics.

If a game is required to contain a great variety of unique leading actors and NPCs, which is exactly the case with roleplay games (RPG) and massively multiplayer online games (MMO), the work may be delayed. Epic Games has introduced MetaHuman Creator Tool, developed on the basis of the eponymous game engine, Unreal Engine 5.0. Perhaps, it would not be an exaggeration to consider MetaHuman Creator as a breakthrough in the field of real-time digital people development. It is, indeed, accessible and comparatively easy to use, therefore any standard internet user can get an opportunity to create digital people with a scalable system in a uniquely high level of graphics, up to 4,000 pixels for a horizontal display.

It is noteworthy, MetaHuman is not fully integrated with the Unreal Engine 5.0 world creation process, nor does it interpret the input data literally, but it changes facial features according to a set of predefined limited parameters. Additionally, automatic rendering and MetaHuman model import diminish the entry threshold for aspiring game developers and 3D artists. Finally, availability of more than 60-face presets is excessive, due to which it hinders the process of sculpting unique characters [2, p. 262].

Alongside the above-mentioned technology, in June 2022 a Mesh to MetaHuman was piloted as the first feature in the release note to the MetaHuman Plugin for UE 5. Mesh allows consumers to scan their own faces to create a custom facial "sculpture" and convert it into an automatically adjusted MetaHuman for further animation or model texture refinement. With the support of RealityCapture, the software that automatizes the process of MetaHuman Mesh creation by fragmenting a video with a preferred number of frames, it is possible to create an exact digital copy of individual human faces without special technological equipment, background knowledge or a great deal of talent.

**CONCLUSIONS**

The chosen multidisciplinary approach of this study reflects the versatility of the applications of the all-encompassing success of the concept, which, as is clear from the article, adheres to the Epic Games company itself.

Simultaneously, there are other various domains, not alluded to in this article, where game engine technologies have been used or which manifest a high potential for their

imminent implementation. Familiarization with the beneficial use of game engine technological advancements has occurred in such areas as medicine, physics, astronomy, biology, and their specific subject fields. Even more so, the interdisciplinary essence of the key product, the game, which is created with the help of these technologies, has an impact on finding more and more practical applications.

Specific use cases of Unreal Engine's technological achievements are intentionally not largely covered in this article so that readers can inspect businesses spin on the Epic Games' advancements themselves. Prior to all possible recommendations, a specific domain of interest should be identified as the first step to devote themselves to an investigation of pre-eminence included in the game engine.

Finally, the above-mentioned technology descriptions provide directions for future research in the field. The literature review can be extended in order to include game engines, which could also be examined.

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