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Toolkit for selecting technology as a transfer object under multi-criteria conditions

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Abstract

The article analyzes the features of the development of small and medium-sized enterprises (SMEs) in the context of the COVID-19 pandemic. There revealed the negative trends associated with the disproportionality of the sectoral structure of the business and the low enterprises' innovative activity. The key measures of state support for entrepreneurship taken by the Government of the Russian Federation in the period 2020–2021 are considered. The expediency of stimulating small and medium-sized businesses to participate in the process of technology transfer is determined, based on which the main purpose of the study is formulated, associated with the formation of economic and mathematical tools for choosing a technology for further implementation in the practice of SMEs. The research substantiates the expediency of using the fuzzy-multiple simplified method of analysis of hierarchies by Saaty for choosing technological solutions from a finite number of available alternatives, taking into account the interests of small and medium-sized businesses. The proposed approach makes it possible to increase the degree of validity of management decisions by reducing the volume of metamathematical operations and reducing the impact of subjectivism.

Keywords: small and medium business, government support, transfer, technology, multicriteria, choice, hierarchy analysis method.

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Introduction

In the context of the crisis phenomena in the economy associated with the next wave of the spread of COVID-19, the very possibility of business entities survival directly depends on their ability to adapt to dynamically changing conditions, produce and disseminate ideas aimed at offsetting the impact of the negative consequences of market changes, as well as their willingness to become recipient of new technologies in business. To a large extent, this applies to representatives of small and medium-sized enterprises (SMEs), since the negative consequences of the pandemic have affected the vast majority of companies in this sector. As a result of surveys conducted by the Commissioner for the Protection of the Rights of Entrepreneurs under the President of the Russian Federation, in 2020, a drop in demand affected 80% of SMEs, while so far demand has not recovered in 52.6% of them, and turnover, according to Rosstat for 2020 year decreased by 3.1 trillion rubles. in comparison with the previous period[1].

In the context of the recession, the state took unprecedented measures to support business: for example, 42% of entrepreneurs received state support, which made it possible to compensate for the sharp drop in demand in the second quarter of 2020. However, the demand growth trend was interrupted at the end of 2020, and already in the first quarter of 2021, this indicator fell by 13%[2], that is, with the end of state support programs, the situation of small and medium-sized businesses worsened again. It is quite obvious that in such a situation, the need to introduce innovative

[1] SME/Post-Covid. Time for system solutions: Special report of the Commissioner under the President of the Russian Federation for the Protection of the Rights of Entrepreneurs to the President of the Russian Federation. 2021. URL: http://doklad.ombudsmanbiz.ru/2021/7.pdf.
[2] Id.

technologies that can ensure the sustainable development of business entities is uncontested.

Based on previous author's research [Kravchenko, Kvilinskiy, 2016; Kravchenko, 2019; Kravchenko, Zanizdra, 2019], given the large number of studies by foreign scientists conducted in this area [Lee et al., 2012; Bozeman et al., 2015; Gunsel, 2015; Kumar et al., 2015; Hsu et al., 2017; Aleinikova et al., 2020; Leal, 2020; Becker, Becker, 2021; Estep et al., 2021], and also taking into account that in the conditions of unstable demand, as well as limited resources, the issues of increasing the degree of validity of management decisions are being updated (especially in terms of choosing the best options for further development), the purpose of this work is to propose a toolkit for choosing a technology as an object of transfer for its further implementation in the practice of SME activity based on a comparative assessment of available technological solutions (under conditions of multi-criteria).

1. Description of the research methodology

In fact, the choice of the optimal technology option for its subsequent implementation is a decision-making process in a multi-criteria environment. At the same time, there is a fairly wide range of relevant methods and approaches, which in the most general form can be reduced to three main groups (Table 1).

The proposed classification is not exhaustive and only characterizes the individual methods analyzed in the work to determine the most suitable for the purposes of choosing the optimal technology. At the same time, among the considered approaches, of particular interest is the method of analysis of hierarchies by T. Saati (hereinafter MAI) [Saati, 1989], which is designed to solve multicriteria problems with a finite set of possible alternatives and criteria for their selection. Its application is based on expert information about the relative importance of the criteria in the form of a pairwise comparison matrix.

It should be noted that T. Saaty's hierarchy analysis method has qualitative advantages over others, since it allows you to flexibly vary the number and composition of criteria, as well as take into account the characteristics of technologies that have both quantitative and verbal assessment. However, its procedure is significantly complicated by the complexity of pairwise comparisons, especially with a significant number of alternatives (as in the case of the technology selection problem), and the need to check the pairwise comparison matrices for compatibility. These shortcomings are eliminated by using the simplified AHP proposed in the work of V.D. Nogin [Nogin, 2004].

Another significant drawback of this method is a high degree of subjectivity, due to the fact that when choosing a technology, estimates are used that are given by one or more experts by prior agreement, which reduces their objectivity. This effect can be leveled by using the methodological base of the theory of fuzzy sets [Artamonov et al., 2016].

2. Theoretical and calculated parts

According to the main provisions of the national project "Small and Medium Enterprises and Support for Individual Entrepreneurial Initiative", the development of SMEs is one of the strategic goals of the Russian Federation. This

Table 1
Description of the main methods for solving multicriteria problems

Group	Name	Characteristics
Reduction to one criterion	Principal criterion method	It is assumed that from the point of view of the decision maker, one of the criteria (the main one) has a significantly higher priority than all the others, but with one important caveat: according to the other criteria, the option should not be too bad either
	Convolution method	It is supposed to introduce some generalized criterion, which is a function on a set of individual indicators (the generalized criterion allows you to sort the alternatives by value and select the best among them - additive, multiplicative, maximin convolutions)
Reaching a compromise between criteria	The method of successive concessions	All private criteria are arranged and numbered in order of their relative importance, then the criteria are gradually maximized in descending order of their importance, taking into account the established value of the allowable decrease in the value of the higher criterion (the optimal strategy is usually considered to be any strategy that is obtained when solving the problem of finding the conditional maximum of the last criterion in importance)
Ranking criteria according to their degree of significance	Hierarchy analysis method	It involves a phased solution of the following interrelated particular tasks: – construction of a hierarchical structure of indicators (features); – assessment of the significance of individual private indicators for each level of the hierarchy; – comparison of available alternatives and selection of the best one

Source: compiled by the authors based on [Saati, 1989; Nabatova, 2020; Podinovsky, 2019].

document is aimed at improving the business climate, as well as increasing the role of this kind of business in the economy (for the period 2019-2024) and provides an increase in the number of people employed in the SME sector up to 25 million people, an increase in the share of this sector of the economy up to 32.5% in GDP and up to 10% in the total volume of non-commodity exports[3]. The achievement of the set strategic targets is complicated by the negative consequences of COVID-19. Thus, according to preliminary estimates, the share of SMEs in the GDP of the Russian Federation in 2020 decreased by 1% compared to the previous period and amounted to 19.8%. At the same time, the number of people employed in the sector recovered to the level of 2018 and increased from 26% in 2019 to 27% in 2020. However, experts note the risk of a decrease in this indicator if there is no need to maintain the number of employees under the terms of support. Small and medium-sized enterprises turned out to be the most sensitive to the negative impact of the pandemic due to their high concentration in those sectors of the economy that have experienced significant changes in the volume and structure of market demand and supply (in the Russian Federation, the largest share of SMEs is involved in wholesale and retail trade, and this figure increased from 34.8% in 2018 to 41% in 2020)[4, 5]. Businesses are facing key challenges such as falling revenues, supply disruptions, communication difficulties, increasing uncertainty and, as a result, financial instability.

Taking into account the fact that small business is the basis of the population well-being, creating a significant number of jobs and smoothing the effects of social stratification in society, the state faces with an urgent need to develop effective measures to support this sector of the economy. Thus, the Government of the Russian Federation has taken a number of measures to support small and medium-sized businesses engaged in the areas of activity most affected by the deteriorating situation due to the spread of coronavirus infection. The mechanisms of financial, property, information and consulting support have been implemented. Studies of the effectiveness of state support measures for SMEs confirm the satisfactory result of the actions taken, pointing to the significant awareness of business entities about the programs being implemented and the high intensity of applications.

It is characteristic that most of the proposed measures are aimed at compensation of unavoidable losses and do not allow realizing such an indisputable advantage of small businesses as mobility and flexibility, readiness for rapid adaptation in quickly changing business conditions and reorientation of activities. It should be noted that the Concept of long-term socio-economic development of the Russian Federation by 2020 provided for a reduction in the share of small businesses employed in the trade sector and an increase in the number of SMEs in the field of information services, science, housing and communal services and, most importantly, healthcare[6]. Thus, a rational state policy in the field of small business support should stimulate structural changes in this sector and an increase in the number of SMEs employed in priority sectors.

The results of a number of Russian and international studies make it possible to single out such topical areas of activity as preventing the spread of infections, diagnosing a disease, evaluating large amounts of information, adapting to quarantine and self-isolation conditions, and high-tech developments. At the same time, research and development is being carried out in Russia and abroad in these innovative areas of activity, financed both at the expense of the state budget and private investors.

In such conditions, the issues of stimulating technology transfer are updated, which, according to GOST R 57194.1-2016, is a process of technology transfer and the corresponding rights to it from the transferring party to the receiving party for the purpose of subsequent implementation and use, and the process of technology transfer itself includes such stages as:

- identification of the need for technology, on the one hand, and the object of sale, on the other;
- assessment of the costs associated with the acquisition of technologies;
- information search;
- comparative analysis, assessment of the level of readiness and choice of technology;
- negotiations between the seller and the buyer of technology;
- conclusion of an agreement and transfer of technology (or other result of intellectual activity);
- use of technology and monitoring of results[7].

The current legislation defines the category "technology" as the result of scientific and technical activity expressed in an objective form, which includes inventions, utility models, industrial designs, computer programs or other results of intellectual activity subject to legal protection in accordance with current legislation, and can serve as a technological basis for certain practical activities in the civil or military sphere[8]. A number of works emphasize the expediency of considering technology as a commodity, which should have such properties as science intensity and the presence of competitive advantages in comparison with other available technologies [Mrykhina, 2018].

Thus, the crisis conditions for the functioning of SMEs create the preconditions for realizing the need for a constant search for new technologies, which determines the importance of ensuring free access of recipients to information about current innovative technologies, the possibility of

[3] Passport of the national project "Small and Medium Enterprises and Support for Individual Entrepreneurial Initiatives" (approved by the Presidium of the Council under the President of the Russian Federation for Strategic Development and National Projects, protocol dated December 24, 2018 No. 16). URL: https://www.economy.gov.ru/material/file/65c7e743dffadf1f3f3a8207e31a0d99/Passport_NP_MSP.pdf.
[4] Small and medium business in Russia. 2019: Statistical compendium. Moscow: Rosstat, 2019.
[5] SME/Post-Covid. Time for system solutions…
[6] On the Concept of long-term socio-economic development of the Russian Federation for the period up to 2020: Decree of the Government of the Russian Federation of November 17, 2008 No. 1662-r // Consultant Plus. URL: http://www.consultant.ru/document/cons_doc_LAW_82134/28c7f9e359e8af09d7244d8033c66928fa27e527/.
[7] GOST R 57194.1-2016. Technology transfer. General provisions. Introduction. 2017.05.01. M.: Standartinform, 2020.
[8] Id.

obtaining financial support necessary for organizing the introduction of innovations. In addition, the transfer of technology developed at the expense of the state budget can be considered as one of the tools of state support for business.

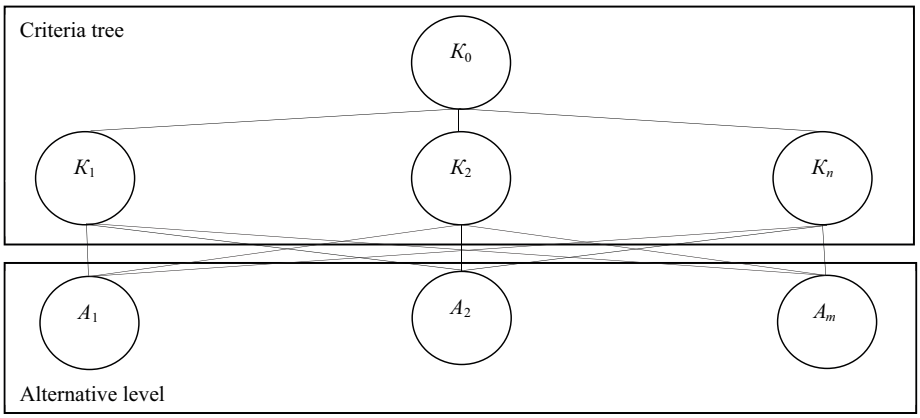
The state digital business support platform "My Business" provides business entities with access ршто consolidated information on the procurement system, available banking products and guarantees, educational programs, financial, property, consulting, information and innovation support programs, including the catalog of franchises, most of which are concentrated in the service sector. However, the platform lacks a database of technological profiles, that is, requests and proposals for technical and technological solutions adapted to the specifics of small business representatives. This information can be accessed on the SME Business Navigator Portal, as well as on the Russian Technology Transfer Network Portal.

In the context of a lack of real experience and professional skills in the implementation of innovative projects, small businesses face a number of obstacles to the introduction of new technologies, starting from the moment of justifying the choice of a project that can best meet the interests of a business entity and satisfy the existing financial, labor and technical constraints. Thus, the development of an effective method for choosing technical, technological and other solutions for their further implementation in the practice of small enterprises is an urgent scientific task and deserves special attention.

In this paper, in order to select the optimal technology, it is proposed to perform the following sequence of actions:

- Determining the current goals of the SME entity, the achievement of which should contribute to the implementation of technology;
- establishing a list of technological solutions that can be applied under a specific business entity;
- Formation of a group of experts whose opinions will be taken into account when making decisions;
- substantiation of the list of technology selection criteria;
- carrying out each expert in pairwise comparison of existing technologies for each decision criterion;
- submission of generalized results of expert assessments of all involved specialists in the form of fuzzy numbers;
- assessment of the existing alternatives according to hierarchy analysis method;
- Formulation of conclusions on the choice of optimal technology in order to further implement the activities of the enterprise based on the criterion for the maximization of the assessment obtained as a result of the calculations.

Fig. 1. Hierarchy of the technology choice problem



Where K_0 – main goal of technology selection;

$K_1, K_2, \ldots, K_n$ – technology evaluation ctiteria

$A_1, A_2, \ldots, A_m$ – technologies that can be implemented by a business entity.

Source: compiled by the authors based on [Saaty, 1989].

In accordance with the hierarchy analysis method of the hierarchy (graph of a special form), the problem of selecting technology for SMEs will have the following form (Fig. 1).

According to fig. 1 the achievement of the main goal indicated K_0, that is, the choice of the optimal technology is completely determined by the achievement of the criteria (K_1, K_2, ..., K_n). The role of each criterion in achieving the main goal is different, which is reflected in the assignment of different weighting factors to them. In this case, the weight of the main goal is equal to the sum of the weight indicators of the criteria. Determining the final set of evaluation criteria depends on the specifics of the business entity, its strategic goals and characteristics of business conditions. However, in the most general form, they can be classified into the following groups:

- consumer characteristics of goods or services resulting from the introduction of technology;
- analysis of the potential market (size, growth dynamics, main segments, difficulties in entering the market);
- assessment of the competitive environment;
- degree of technology readiness;
- legal protection of the idea;
- availability of resources.

At the level of alternatives (A_1, A_2, ..., A_m), there are points that characterize the options for technologies that can be introduced into the practice of a small enterprise. Lines connecting alternatives to criteria indicate that technologies should be analyzed in terms of their degree of compliance with the criteria.

Thus, having determined the weight of each criterion relative to the main goal, and then the weight of each technology from the position of each criterion, it is possible to determine the weight of each technology already from the position of the main goal, using hierarchical weighting operations:

$$Bec(A^i) = Bec(A^i/K_1) \cdot Bec(K_1) + Bec(A^i/K_2) \cdot Bec(K_2) + ... + Bec(A^i/K_n) \cdot Bec(K_n), \quad (1)$$

Where i – the number of alternative.

The technology with the greatest weight from the position of the main goal will be optimal [Saati, 1989].

Let's say a small business decides to purchase a franchise from among those recommended on the My Business platform, using the list of criteria mentioned above. At the same time, at the preliminary stage of selection, four franchises were admitted for consideration, each of which involves the provision of technical and technological services to the population, individuals and legal entities, which coincides with the scope of a small enterprise (in order not to disclose information related to the features of each franchise option, and not violate the copyrights of their owners, we will conditionally call them technology 1, 2, 3 and 4, respectively). To make a decision, a small enterprise formed a group of experts, including both employees of the enterprise and third-party specialists. In this case, the hierarchy of the franchise selection problem can be represented as a graph in Fig. 2.

For the value of the weight of the alternative relative to the main goal, it is first necessary to determine the weight of each decision-making criterion with respect to it by the expert method, and then set the weight of each technology in relation to each criterion.

The expert needs to conduct a series of pairwise comparisons of alternatives, determining on a nine-point scale (Table 2) a quantitative assessment that will indicate the relative advantage of one alternative over another.

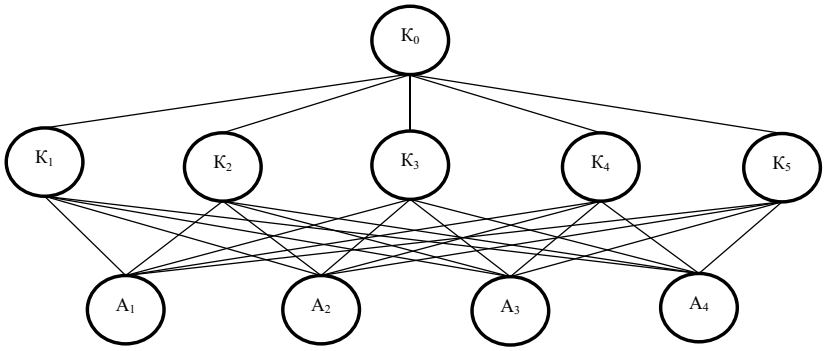
Table 2
Ratio scale

Extent of importance	Definitions	Explanations
1	Equal importance	Both objects contribute equally to the achievement of the goal.
3	Weak importance	Slight advantage of one object over another
5	Essential importance	Significant advantage of one object over another
7	Obvious importance	The advantage of one object over another is very strong
9	Absolute importance	The advantage of one object over another is more than obvious
2, 4, 6, 8	Intermediate values	Intermediate level between designated states

Source: [Saati T., 1989].

The quantitative result of pairwise comparisons of criteria from the point of view of the main goal is presented in the form of a matrix of pairwise comparisons with dimension $n \times n$: $G_K = (K_{ij})$, $(i, j = 1, 2, ..., n)$.

Fig. 2. Hierarchy of the problem of choosing a technology for an enterprise



Source: developed by the authors based on [Saati, 1989].

For the presentation of expert assessments, it is proposed to use the apparatus of the theory of fuzzy sets, which will minimize the risk of error from subjectivity. According to the theory, expert opinions can be represented as a fuzzy number $(L–R)$-type.

The fuzzy tolerance number $(L–R)$-type is characterized by the membership function presented in the formula (2):

$$\mu_A(x) = \begin{cases} L\left(\frac{a_1 - x}{\alpha}\right), a_1 - \alpha \le x \le a_1, \\ 1, a_1 \le x \le a_2, \\ R\left(\frac{x - a_2}{\beta}\right), a_2 \le x \le a_2 + \beta, \\ 0, \text{иначе.} \end{cases}, \quad (2)$$

where $[a_1; a_2]$ – is the $(L–R)$-type fuzzy tolerance number mode, α – is the left fuzziness coefficient, β – is the right fuzziness coefficient.

If we assume, that L and R of the membership function of the fuzzy numbers described above are represented by straight lines, then the $(L–R)$-type $A(a_1, a_2, \alpha, \beta)$ fuzzy tolerant number can be represented as a fuzzy trapezoidal number (fuzzy four) $B(b_1, b_2, b_3, b_4)$ so that:

$$\begin{cases} b_1 = a_1 - \alpha, \\ b_2 = a_1, \\ b_3 = a_2, \\ b_4 = a_2 + \beta. \end{cases} \quad (3)$$

Fuzzy number arithmetics is based on the principles of simple intervals.

In practice, the result of expert evaluation in the form of a fuzzy number is formed as follows: the expert evaluates the significance of one alternative in relation to another on a scale from Table. 2. Based on the results of a survey of all experts, a membership function is constructed that corresponds to a specific four of numbers, the meaning of which is as follows: the degree of significance of the alternative being evaluated

is in the range from b_1 to b_4, but most likely it is in the range from b_2 to b_3.

According to the hierarchy analysis method, the matrix of pairwise comparisons must meet the following requirements:

- All the elements of G_K matrix should not be negative: $a_{ij} > 0$ for all numbers $i, j = 1, 2, ..., n$;
- G_K matrix is antisymmetrical: $a_{ij} = \frac{1}{a_{ij}}$ for all numbers;
- G_K matrix is conjoint, that is equations $a_{ij} = a_{ik} \cdot a_{kj} = \frac{a_{kj}}{a_{ki}}$ have place for all numbers $i, j = 1, 2, ..., n$;
- n number is the maximum eigenvalue of the matrix G and for a single (normalized) column vector $W_K = (w_1, w_2, ..., w_n)^T$ with positive components an equation is done $G_K W_K = nW_K$.

Using the scheme of "comparison with a sample" (which is the first object of comparison), on the basis of the degree of advantage or lag of each object in relation to the first, quantitatively determined by experts, we will construct a matrix that satisfies all the specified conditions, for which we use formula 4:

$$a_{ij} = a_{i1} a_{ij} = \frac{a_{1j}}{a_{1i}}. \quad (4)$$

So, as a result of assigning quantitative estimates to the criteria for making a decision regarding the main goal, we get a fuzzy matrix of pairwise comparisons (Table 3).

This matrix needs to be defuzzified for further actions (Table 4).

Let us introduce a modified representative number [Akhrameyko et al., 2002]:

$$R(x) = \sum_{i=1}^{n} \left(r_i \cdot \frac{x_1^{a_i} + x_2^{a_i}}{2} \right) = \sum_{i=1}^{n} \left(\frac{1}{\sum i} \cdot \frac{x_1^{a_i} + x_2^{a_i}}{2} \right), \quad (5)$$

Where $R(x)$ – modified representative number, $\left(x_1^{a_i}, x_2^{a_i}\right)$ – i-th α-slice, r_i – is the weight coefficient of the i α-slice, i – is the number of the α-slice, n – is the number of α-slices.

The ranking of alternatives (construction of the priority vector) is based on the main eigenvector of the defuzzified matrix of pairwise comparisons.

Based on the simplified method of hierarchy analysis proposed by Nogin [Nogin, 2004], it can be argued that the eigenvector of the defuzzified matrix G_K will consist of the components of the last column of the pairwise comparison matrix normalized to the sum of these elements. This vector will be equal $W_K = (0{,}53;\ 0{,}17;\ 0{,}13;\ 0{,}1;\ 0{,}07)^T$.

Since the matrix is built according to the method of comparison with the sample, it initially meets all the requirements and does not need to be checked for consistency. But for additional verification of the accuracy of calculations, you can define the indicator of the consistency ratio (*OC*) as the ratio of the consistency index (*HC*) to the number corresponding to the random consistency of the matrix of the same order in percent. The consistency ratio should not exceed 20%. The consistency index is determined by formula (6):

Table 3
Matrix of pairwise comparisons of decision criteria

Criterion	K_1 – financial characteristics of the project	K_2 – consumption characteristics of goods and services	K_3 – the analysis of potential market	K_4 – resource security	K_5 – degree of technology readiness and legal protection of the idea
K_1 – financial characteristics of the project	(1; 1; 1; 1)	(2; 3; 4; 5)	(3; 4; 5; 6)	(4; 5; 6; 7)	(6; 7; 8; 9)
K_2 – consumption characteristics of goods and services	$\left(\frac{1}{5}; \frac{1}{4}; \frac{1}{3}; \frac{1}{2}\right)$	(1; 1; 1; 1)	$\left(\frac{3}{5}; 1; 1\frac{2}{3}; 3\right)$	$\left(\frac{4}{5}; 1\frac{1}{4}; 2; 3\frac{1}{2}\right)$	$\left(1\frac{1}{5}; 1\frac{3}{4}; 2\frac{2}{3}; 4\frac{1}{2}\right)$
K_3 – the analysis of potential market	$\left(\frac{1}{6}; \frac{1}{5}; \frac{1}{4}; \frac{1}{3}\right)$	$\left(\frac{2}{6}; \frac{3}{5}; 1; 1\frac{1}{3}\right)$	(1; 1; 1; 1)	$\left(\frac{2}{3}; 1; 1\frac{1}{2}; 2\frac{1}{3}\right)$	$\left(1; 1\frac{2}{5}; 2; 3\right)$
K_4 – resource technology	$\left(\frac{1}{7}; \frac{1}{6}; \frac{1}{5}; \frac{1}{4}\right)$	$\left(\frac{2}{7}; \frac{1}{2}; \frac{4}{5}; 1\frac{1}{4}\right)$	$\left(\frac{3}{7}; \frac{2}{3}; 1; 1\frac{1}{2}\right)$	(1; 1; 1; 1)	$\left(\frac{6}{7}; 1\frac{1}{6}; 1\frac{3}{5}; 2\frac{1}{4}\right)$
K_5 – degree of technology readiness and legal protection of the idea	$\left(\frac{1}{9}; \frac{1}{8}; \frac{1}{7}; \frac{1}{6}\right)$	$\left(\frac{2}{9}; \frac{3}{8}; \frac{4}{7}; \frac{5}{6}\right)$	$\left(\frac{1}{3}; \frac{1}{2}; \frac{5}{7}; 1\right)$	$\left(\frac{4}{9}; \frac{5}{8}; \frac{6}{7}; 1\frac{1}{6}\right)$	(1; 1; 1; 1)

Source: developed by the authors.

Table 4
Defuzzified matrix of pairwise comparisons of decision criteria

Criterion	K_1 – Financial characteristics of the project	K_2 – consumption characteristics of goods and services	K_3 – the analysis of potential market	K_4 – resource security	K_5 – degree of technology readiness and legal protection of the idea
K_1 – financial characteristics of the project	1.00	3.50	4.50	5.50	7.50
K_2 – consumption characteristics of goods and services	0.31	1.00	1.49	1.80	2.42
K_3 – the analysis of potential market	0.23	0.87	1.00	1.33	1.80
K_4 – resource security	0.19	0.69	0.88	1.00	1.44
K_5 – degree of technology readiness and legal protection of the idea	0.14	0.49	0.63	0.76	1.00

Source: developed by the authors.

Table 5
Matrix of pairwise comparisons of alternatives for each of the decision criteria

	A_1 – technology 1	A_2 – technology 2	A_3 – technology 3	A_4 – technology 4
K_1 *Criterion 1 «Financial characteristics of the project»*				
A_1 – technology 1	(1; 1; 1; 1)	$\left(\frac{1}{7};\frac{1}{6};\frac{1}{5};\frac{1}{4}\right)$	$\left(\frac{1}{9};\frac{1}{8};\frac{1}{7};\frac{1}{6}\right)$	$\left(\frac{1}{5};\frac{1}{4};\frac{1}{3};\frac{1}{2}\right)$
A_2 – technology 2	(4; 5; 6; 7)	(1; 1; 1; 1)	$\left(\frac{4}{9};\frac{5}{8};\frac{6}{7};1\frac{1}{6}\right)$	$\left(\frac{4}{5};1\frac{1}{4};2;3\frac{1}{2}\right)$
A_3 – technology 3	(6; 7; 8; 9)	$\left(\frac{6}{7};1\frac{1}{6};\frac{3}{5};2\frac{1}{4}\right)$	(1; 1; 1; 1)	$\left(1\frac{1}{5};1\frac{3}{4};2\frac{2}{3};4\frac{1}{2}\right)$
A_4 – technology 4	(2; 3; 4; 5)	$\left(\frac{2}{7};\frac{1}{2};\frac{4}{5};1\frac{1}{4}\right)$	$\left(\frac{2}{9};\frac{3}{8};\frac{4}{7};\frac{5}{6}\right)$	(1; 1; 1; 1)
K_2 *Criterion 2 «Consumption characteristics of goods and services»*				
A_1 –technology 1	(1; 1; 1; 1)	$\left(\frac{1}{8};\frac{1}{7};\frac{1}{6};\frac{1}{5}\right)$	$\left(\frac{1}{7};\frac{1}{6};\frac{1}{5};\frac{1}{4}\right)$	(3; 4; 5; 6)
A_2 – technology 2	(5; 6; 7; 8)	(1; 1; 1; 1)	$\left(\frac{5}{7};1;1\frac{2}{5};2\right)$	(15; 24; 35; 48)
A_3 – technology 3	(4; 5; 6; 7)	$\left(\frac{1}{2};\frac{5}{7};1;1\frac{2}{5}\right)$	(1; 1; 1; 1)	(12; 20; 30; 42)
A_4 – technology 4	$\left(\frac{1}{6};\frac{1}{5};\frac{1}{4};\frac{1}{3}\right)$	$\left(\frac{1}{48};\frac{1}{35};\frac{1}{24};\frac{1}{15}\right)$	$\left(\frac{1}{42};\frac{1}{30};\frac{1}{25};\frac{1}{12}\right)$	(1; 1; 1; 1)
K_3 *Criterion 3 «The analysis of potential market»*				
A_1 – technology 1	(1; 1; 1; 1)	(4; 5; 6; 7)	(5; 6; 7; 8)	$\left(\frac{1}{8};\frac{1}{7};\frac{1}{6};\frac{1}{5}\right)$
A_2 – technology 2	$\left(\frac{1}{7};\frac{1}{6};\frac{1}{5};\frac{1}{4}\right)$	(1; 1; 1; 1)	$\left(\frac{5}{7};1;1\frac{2}{5};2\right)$	$\left(\frac{1}{56};\frac{1}{42};\frac{1}{30};\frac{1}{20}\right)$
A_3 – technology 3	$\left(\frac{1}{8};\frac{1}{7};\frac{1}{6};\frac{1}{5}\right)$	$\left(\frac{1}{2};\frac{5}{7};1;1\frac{2}{5}\right)$	(1; 1; 1; 1)	$\left(\frac{1}{64};\frac{1}{49};\frac{1}{36};\frac{1}{25}\right)$
A_4 – technology 4	(5; 6; 7; 8)	(20; 30; 42; 56)	(25; 36; 49; 64)	(1; 1; 1; 1)
K_4 *Criterion 4 «Resource security»*				
A_1 – technology 1	(1; 1; 1; 1)	(5; 6; 7; 8)	(4; 5; 6; 7)	$\left(\frac{1}{9};\frac{1}{8};\frac{1}{7};\frac{1}{6}\right)$
A_2 – technology 2	$\left(\frac{1}{8};\frac{1}{7};\frac{1}{6};\frac{1}{5}\right)$	(1; 1; 1; 1)	$\left(\frac{1}{2};\frac{5}{7};1;1\frac{2}{5}\right)$	$\left(\frac{1}{72};\frac{1}{56};\frac{1}{42};\frac{1}{30}\right)$
A_3 – technology 3	$\left(\frac{1}{7};\frac{1}{6};\frac{1}{5};\frac{1}{4}\right)$	$\left(\frac{5}{7};1;1\frac{2}{5};2\right)$	(1; 1; 1; 1)	$\left(\frac{1}{63};\frac{1}{48};\frac{1}{35};\frac{1}{24}\right)$
A_4 – technology 4	(6; 7; 8; 9)	(30; 42; 56; 72)	(24; 35; 48; 63)	(1; 1; 1; 1)
K_5 *Criterion 5 «Degree of technology readiness and legal protection of the idea»*				
A_1 – technology 1	(1; 1; 1; 1)	$\left(\frac{1}{7};\frac{1}{6};\frac{1}{5};\frac{1}{4}\right)$	(1; 2; 3; 4)	(3; 4; 5; 6)
A_2 – technology 2	(4; 5; 6; 7)	(1; 1; 1; 1)	(4; 10; 18; 28)	(12; 20; 30; 42)
A_3 – technology 3	$\left(\frac{1}{4};\frac{1}{3};\frac{1}{2};1\right)$	$\left(\frac{1}{28};\frac{1}{18};\frac{1}{10};\frac{1}{4}\right)$	(1; 1; 1; 1)	$\left(\frac{3}{4};1\frac{1}{3};2\frac{1}{2};6\right)$
A_4 – technology 4	$\left(\frac{1}{6};\frac{1}{5};\frac{1}{4};\frac{1}{3}\right)$	$\left(\frac{1}{42};\frac{1}{30};\frac{1}{25};\frac{1}{12}\right)$	$\left(\frac{1}{6};\frac{2}{5};\frac{3}{4};1\frac{1}{3}\right)$	(1; 1; 1; 1)

Source: developed by the authors.

Table 6
Defuzzified matrix of pairwise comparisons of alternatives for each of the decision criteria

	A_1 – technology 1	A_2 – technology 2	A_3 – technology 3	A_4 – technology 4
K_1 *Criterion 1 «Financial characteristics of the project»*				
A_1 – technology 1	1.00	0.19	0.14	0.31
A_2 – technology 2	5.50	1.00	0.72	1.80
A_3 – technology 3	7.50	1.44	1.00	2.42
A_4 – technology 4	3.50	0.69	0.49	1.00
K_2 *Criterion 2 «Consumption characteristics of goods and services»*				
A_1 – technology 1	1.00	0.16	0.19	4.50
A_2 – technology 2	6.50	1.00	1.25	30.17
A_3 – technology 3	5.50	0.89	1.00	25.67
A_4 – technology 4	0.23	0.04	0.04	1.00
K_3 *Criterion 3 «The analysis of potential market»*				
A_1 – technology 1	1.00	5.50	6.50	0.16
A_2 – technology 2	0.19	1.00	1.25	0.03
A_3 – technology 3	0.16	0.89	1.00	0.03
A_4 – technology 4	6.50	36.67	43.17	1.00
K_4 *Criterion 4 «Resource security»*				
A_1 – technology 1	1.00	6.50	5.50	0.14
A_2 – technology 2	0.16	1.00	0.89	0.02
A_3 – technology 3	0.19	1.25	1.00	0.03
A_4 – technology 4	7.50	49.67	42.17	1.00
K_5 *Criterion 5 «Degree of technology readiness and legal protection of the idea»*				
A_1 – technology 1	1.00	0.19	2.50	4.50
A_2 – technology 2	5.50	1.00	14.67	25.67
A_3 – technology 3	0.49	0.10	1.00	2.40
A_4 – technology 4	0.23	0.05	0.63	1.00

Source: developed by the authors.

$$ИС = \frac{\lambda \max - n}{n - 1}, \quad (6)$$

Where λ_{max} – the maximum eigenvalue of the matrix, n – is the order of the matrix.

For the matrix of pairwise comparisons (Table 4), the consistency ratio is 5.65%.

Similarly, vectors of matrices of pairwise comparison of alternative technologies are found in relation to each of the decision criteria (Table 5) (that is, vectors W_{K_1}, W_{K_2}, …, W_{K_n} matrices G_{K_1}, G_{K_2}, …, G_{K_n} respectively).

Further in Table 6, the matrices of pairwise comparisons of alternative technologies are defuzzified according to the selected list of criteria for their evaluation.

The priority vectors of alternatives obtained for the above matrices will have the following form: $W_{K_1} = (0{,}06; 0{,}31; 0{,}43; 0{,}20)^T$, $OC_{K_1} = 5{,}41\%$; $W_{K_2} = (0{,}07; 0{,}49; 0{,}42; 0{,}02)^T$, $OC_{K_2} = 2{,}25\%$; $W_{K_3} = (0{,}13; 0{,}02; 0{,}02; 0{,}83)^T$, $OC_{K_3} = 1{,}90\%$; $W_{K_4} = (0{,}11; 0{,}02; 0{,}02; 0{,}85)^T$, $OC_{K_4} = 1{,}85\%$; $W_{K_5} = (0{,}12; 0{,}78; 0{,}07; 0{,}03)^T$, $OC_{K_5} = 4{,}08\%$.

The next step is to determine the vector of alternatives with respect to the main goal as the result of multiplying the matrices, which consist of the vectors W_{K_1}, W_{K_2}, …, W_{K_n} to the vector W_K:

$$W = [W_{K_1} W_{K_2} \ldots W_{K_n}] \cdot W_{K_n}. \quad (7)$$

As a result of multiplication, we get a vector $W_{K_1} = (0{,}080; 0{,}311; 0{,}309; 0{,}301)^T$.

The technology that corresponds to the largest element of the resulting vector is considered optimal. That is, in the analyzed situation, technology 2 can be chosen as the best.

Conclusion

The study analyzed key negative trends in the development of small and medium-sized businesses in the Russian Federation, including those related to the consequences of the coronavirus pandemic, as well as government support measures taken in 2020-2021. The expediency of creating conditions for the participation of business entities in the processes of technology transfer is substantiated. As a result, the paper proposes a method for selecting technologies for further implementation in the practice of small enterprises, based on the use of a simplified method for analyzing Saati hierarchies, modified by using fuzzy number tools to fuzzify expert judgments. This approach allows the enterprise to form a reasonable economic decision while reducing the volume of metamathematical operations and reducing the influence of subjectivism.

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The impact of digitalization on industry risks (exemplified by transport)

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Abstract

Today, digital transformation has become a strategic development priority for many advanced industries, including transportation. There are high expectations for cost reduction, increased product quality consistency, and improved manageability of production as a whole. However, the optimistic expectations of many executives do not take into account the changing industry risks that can seriously affect the outcome of digitalization.

The purpose of this article is to investigate the impact of the digitalization process of transport on related industry risks. The theoretical basis of the article is universal organizational science of A. Bogdanov. The object of the study is freight transport.

The article argues that industry risks can be classified into three subrisks: subrisks associated with industry technology; subrisks of coordination of interests of participants in the transport process; subrisks of the transporter to manage the long-term behavior of freighters and consignees. Quantitative models characterizing each of these subrisks are proposed.

This approach is tested with three examples: The Northern Sea Route, railway transport in Russia, and the sea route from South-East Asia to Europe. The actual subrisk and the quantitative level for each of these objects are determined.

It is stated that a radical change in the level of risk is possible primarily with the help of digital technology. At the same time, digitalization gives rise to fundamentally new risks, the main of which is the risk of exhausting the differences that have caused macroeconomic flows till now.

This article is a logical continuation of the article written by the authors I. Anokhov and O. Rimskaya "Digital twins and their application in transport economy", published in № 2.2021 in the journal "Strategic decisions and risk management".

Keywords: digital economy, digitalization, risk, industry, Northern Sea Route, railway transport, South-East Asia, Europe.

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Introduction

As you know, risk and profit are among the key characteristics of any economic activity and are directly dependent. As a result, the assessment of the risk level fundamentally affects the strategic decisions of individual entities and the state of the market as a whole.

Industry risks are in the focus of medium and large enterprises capable of planning their activities in the medium and long-term perspective. At the same time, approaches to the analysis of industry risks differ significantly.

You can often find the assessment of industry risk using weighting parameters set by one or another expert. However, in our opinion, the extreme subjectivity of this approach makes it ineffective.

A quantitative approach to the analysis of industry risks may seem less subjective, for example, through ranking human factors based on their interdependence [Carpitella et al., 2018. P. 12], compiling a risk matrix [Sun et al., 2017], Bayesian network analysis [Ko , Han, 2015], etc. Models of this kind are focused on the analysis of personnel behavior [Aliabadi et al., 2018] and remain "subjective in determining the likelihood and consequences of a security risk" [Guoa et al., 2021].

Another popular approach to assess industry risk is to judge the level of risk based on the company's public reporting [Murygin, Zhulanov, 2019]. This approach, perhaps, reduces uncertainty in one aspect - in the industry, but at the same time increases it in another, corporate aspect, since the reliability of public reporting is far from always obvious.

In general, these main approaches, in our opinion, do not consider the industry as a completely specific object of study and apply standard tools to industry risks: direct judgment, expert systems, code optimization, sensitivity analysis, probabilistic analysis, Monte Carlo modeling, kinetic tree analysis, expected cash value, risk-adjusted discount rate, and risk premium [Hwang, Chen, 2015. P. 219].

Meanwhile, attention should be paid to the fact that industry risks are not concentrated within a particular organization – their fundamental feature is an interorganizational, intersubjective nature. Perhaps, this is especially noticeable in the transport industry, which connects many local markets and directly depends on their current state.

1. Theoretical aspects: signals and information

In terms of "Tectology" by A.A. Bogdanov, this or that branch is an organized complex, understood by him as "the whole is greater than the sum of its parts". Because of this, industry risk is a completely separate type of risk, namely, the risk of maintaining a single whole.

Based on "Tectology", we can say that the reason for the appearance of such a "whole" is the difference: "Our world is generally a world of differences; only differences in energy voltages are manifested in action, only these differences are of practical importance. When activities and resistances collide, the practical amount embodied in real results depends on the way the two are combined; and for the whole, this sum increases on the side with more proportioned or "harmonious" connection and contains fewer "contradictions". This means a higher level of organization" [Bogdanov, 1989. p. 117].

If these voltages of energy differ significantly, then the difference in their potentials allows you to overcome the resistance of the external environment and gives start to flows between them: material, informational, labor and energy. Using natural scientific terminology, we can say that flows arise between two poles that have opposite charges of such a degree of difference that allows you to overcome the resistance of the surrounding space. Under the closure of the differences, a qualitatively new unified whole arises, the condition for the existence of which is the continuous circulation of flows.

From this point of view, any sectoral organized complex is generated by macroeconomic differences and is in demand only if it facilitates the passage and integration of certain flows. This is most clearly seen in the example of transport, which is designed to level natural resistance to cargo flows by leveling the landscape (that is, by creating roads, canals, bridges, etc.), arranging a supply and repair system, warehouses, loading and unloading points, etc.

Accordingly, the industry as a whole is characterized by its own specific types of risks which can be divided into three types:

1. Risks of environmental resistance. The influence of this kind of resistance is expressed on the external plane with a change in the cost of transportation. At the same time, in the transport sector, it is necessary to provide the marginal costs and prime costs of both the transported products and transport services significantly lower in total than those of alternative suppliers and carriers. Higher transportation costs may occur due to changes in energy costs, natural conditions, political unrest along the route lines, technological and economic restrictions (for example, pipeline transport can be economical, but it requires significant capital expenditures, whereas the liquefied natural gas supply system requires significant transformation costs), etc.

From an economic point of view, these risks can be expressed in terms of the marginal costs of the exporter (MC_{exp}), the competing seller in the local finished product market (MC_{loc}) and the transport carrier (MC_{trans}). A stable trade between the poles occurs if the sum of MC_{exp} and MC_{trans} is significantly lower than MC_{loc}, otherwise, any trade is inappropriate, i.e.:

$$MC_{exp} + MC_{trans} < MC_{loc}. \quad (1)$$

Accordingly, any transport movement of goods will be carried out only if inequality (1) is satisfied.

Inequality (1) shows the condition for the minimum technological and economic feasibility of carrying out cargo transportation for the local market. However, for regular transportation, the necessary conditions must be supplemented by sufficient conditions, that is, the minimum necessary technological and economic feasibility must be supplemented by a sufficient amount of revenue per unit of cargo. This question concerns the second type of risks.

2. Risks associated with the economic difference of the poles. In practice, this is expressed in the degree of difference between the purchase price of the transported product and the price of the local market to which this product is transported. This will be expressed as a comparison of the carrier's service tariff (P_{trans}), the price of the shipper's goods (P_{exp}) and the price of the goods in the delivery market (P_{loc}):

$$P_{exp} + P_{trans} << P_{loc}. \quad (2)$$

In other words, this type of risk reflects the cost feasibility of the transportation process, which is a consequence of the coordination of the interests of all market participants and their requests in the form of prices for their products and tariffs for services.

3. Risks associated with the long-term behavior of the subjects of the transport industry (primarily the consignor and consignee) and the ability of the carrier to influence it. This type of risks is associated with the ability of the carrier to acquire elements of market, monopoly power due to the growth of the efficiency of its activities. If the carrier is able to control the behavior of partners, then its marginal profit will be significantly higher. This can be expressed in terms of the marginal profit of the exporter (MPr_{exp}), the marginal profit of a competing seller in the local finished product market (MPr_{loc}) and the marginal profit of the transport carrier (MPr_{trans}):

$$MPr_{trans} > MPr_{exp} + MPr_{loc}. \quad (3)$$

We can depict the considered stages with the help of the corresponding curves (Fig. 1).

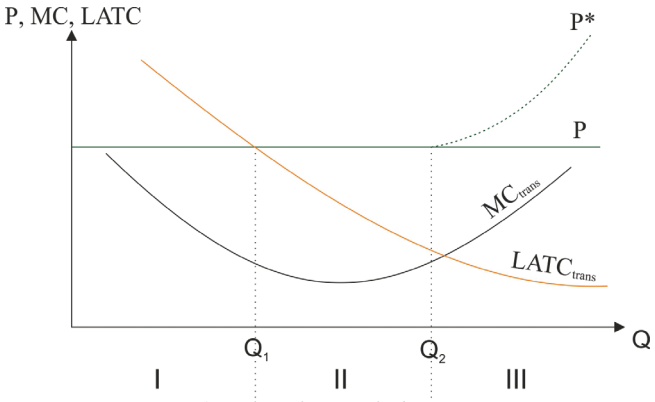
Fig. 1a shows the carrier's ability to manage its own costs and market price. Long-term average total cost of the carrier (LATC – longtime average total cost) shows a positive effect of scale and decreases with an increase in traffic. Fig. 1b shows that the exporter and the carrier can only work together effectively, that is, provide the marginal cost of the goods in a smaller amount than that of a local competitor.

At stage I (see Figure 1), the carrier manages to lower marginal cost at the same time as freight traffic increases, but the LATC value is much higher than the price level. Only upon reaching the volume Q_1 the transportation activity becomes break-even:

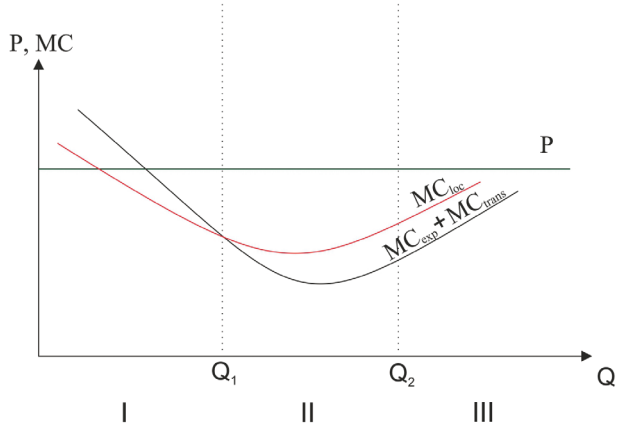
$$MC_{exp} + MC_{trans} = MC_{loc}. \quad (4)$$

At stage II (in section Q_1Q_2), the carrier achieves highly profitable activities, since there is a maximum difference between the sum of the marginal costs of the exporter and the carrier, on the one hand, and the price level in the consumer market, on the other hand. In addition, the difference between the sum $(MC_{exp} + MC_{trans})$ and MC_{loc} is maximum in this section.

Fig. 1. Graphical representation of risks



a) Market price, marginal costs
and long-term average total costs of the carrier



b) Market price and marginal costs
of the exporter, carrier and local competitor-seller

At stage III, the carrier's marginal cost begins to rise rapidly (Fig. 1a), but control over freight rates allows this increase to be offset by a controlled increase in the market price. The dotted segment P^* shows the situation when the carrier manages to increase the tariffs for its services by controlling the activities of the participants in the transportation process. As a result, despite the increase in marginal costs, his profit does not decrease. In other words, the increasing marginal cost in this case is passed on to the final consumer.

Based on the foregoing, with effective management of marginal costs, the price and the behavior of other actors, the carrier derives maximum benefits from the positive economies of scale, mastering all new technologies, increasing its competitiveness and the volume of cargo transportation. At the same time, he consistently moves from internal risks to regional, and then to global ones, which corresponds to the stages of transportation process technologies development and new technological structures [Ivanov, 2020]. This can be represented in the form of a graph (Fig. 2).

For convenience, the positive effect of scale on the graph is shown along the y-axis through the ratio $\frac{1}{LATC}$, which makes it possible to visualize the unidirectional change in the cost and volume of transportation.

At the first stage (in the section from 0 to Q_1 in Fig. 2), the technology of physical transportation is being developed in order to make it competitive for the delivery market, primarily in terms of costs. An example of this stage can be the transportation of liquefied gas and oil in tankers: despite the technical and technological sophistication of this process, the marginal costs of exporters often exceed the marginal costs of alternative delivery methods (primarily pipeline transport), that is, there is an inequality $MC_{exp} + MC_{trans} > MC_{loc}$.

If the issue of technological and economic feasibility of transportation is resolved, then at the second stage (section Q_1Q_2 in Fig. 2) the issue of its price feasibility is resolved. It is necessary to work out financial technologies, so that the interests of all participants in the transportation process are coordinated and the sale price of the finished product on the local market makes the activities of the exporter and the transport company more attractive than the alternative types of business activities available to them. In economics, this is denoted by the concept of "normal profit" - this is the amount of profit that is able to keep the entrepreneur in his field of activity. Examples of the successful implementation of this task can be found both in history and in modern times: the supply of ancient Rome with grain from Egypt, the export of spices from the Malacca Strait, the export of goods from modern China to Europe and America, etc. In all these cases, the price level in the supply market was so high that it covered all types of risks and made other types of entrepreneurship uninteresting, that is, the inequality $P_{exp} + P_{trans} << P_{loc}$ was fulfilled.

At the third stage (section Q_2Q_3 in Fig. 2), the carrier's activity becomes so effective that it is able to develop its own technologies that are inaccessible to competitors,

providing it with control over transport routes and long-term market dominance. Such examples include the control of railroad carriers over oil producers in the United States in the 19th century. (Standard Oil Company), modern oil and gas pipelines, man-made water canals (for example, Suez), etc. In all these cases, carriers, due to their monopoly position, are able to extract a much larger marginal profit per unit of cargo than shippers and consignees, that is, $MPr_{trans} >> MPr_{exp} + MPr_{loc}$.

Implementation of the balanced strategy shown in fig. 1 and 2 is possible only if the subject continuously develops technologies, is able to perceive causal relationships, has a long-term planning horizon, can take into account the interests of all transportation subjects and predict their behavior. Ultimately, it all comes down to the ability of working with data and information models, simultaneously solving a system of inequalities:

$$\begin{cases} MC_{\exp} + MC_{trans} < MC_{loc} \\ P_{\exp} + P_{trans} < P_{loc} \\ MPr_{trans} > MPr_{\exp} + MPr_{loc} \end{cases}. \quad (5)$$

All three types of inequalities must be observed simultaneously by the carrier in order to remain competitive in the market.

2. Practical application of the model

The model presented above is based on detailed internal data of the carrier, shipper and consignee. This kind of data is not available for analysis by an external researcher, which encourages the use of proxy data. In this regard, further analysis will be based on publicly available data on transport routes showing varying degrees of efficiency: the Northern Sea Route, the Russian railway and the Southeast Asia-Europe sea route. At the same time, the analysis presented below does not claim to be absolutely accurate, but is aimed at demonstrating the very analytical approach to the issue under study.

Based on fig. 2 we will present the risk map of the carrier (Fig. 3).

Let us consider the square $0ABQ_1$ which shows the effectiveness of the carrier's management of its technology of cargo transportation. If the transport company develops in a balanced way (that is, the volume of traffic increases simultaneously with the decrease in LATC), then the area of the triangle 0AB is equal to the area of the triangle $0BQ_1$, and their ratio will be equal to one:

$$\frac{S_{0AB}}{S_{0BQ_1}} = 1. \quad (6)$$

If their ratio is less than one, then the transport company develops according to a rationalization model: the technology gradually improves, the cost of transportation decreases, but the volume of transportation does not change. If the ratio is greater than one, then the transport company develops according to a conservative model: the transportation technology remains the same, the cost of transportation does not change, but the volume of transportation grows due to an increase in the nominal quantity of the same rolling stock. At the same time, each deviation in one direction or another indicates a carrier's imbalance and an increase in the risks of degradation (with a conservative strategy) or the risk of being forced out of the market by a larger player (with a rationalization strategy).

Formula (6) can be denoted as a balanced risk management coefficient (Kb): if Kb = 1, then the risks of the carrier company are minimal; if Kb → ∞, then the risks of technological degradation of the carrier company increase Kb → 0, then the risks of "pupation" in its niche

Fig. 2. Increase in the carrier's cargo turnover and types of risks with a balanced strategy

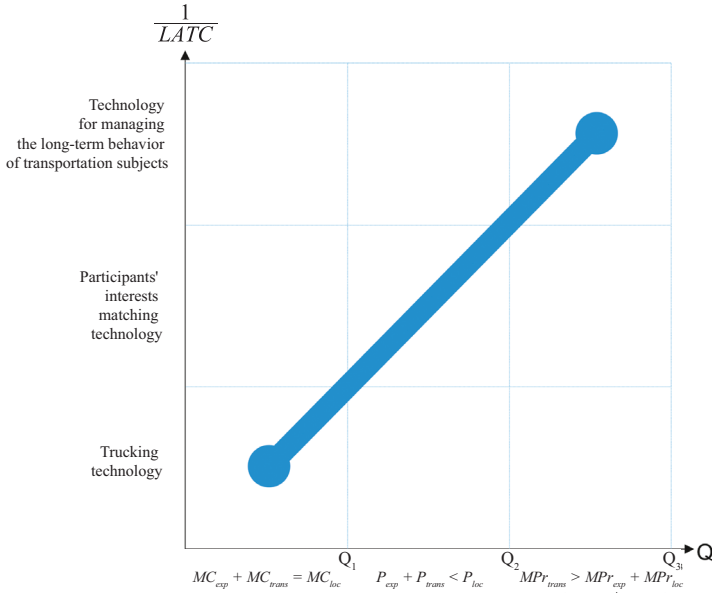
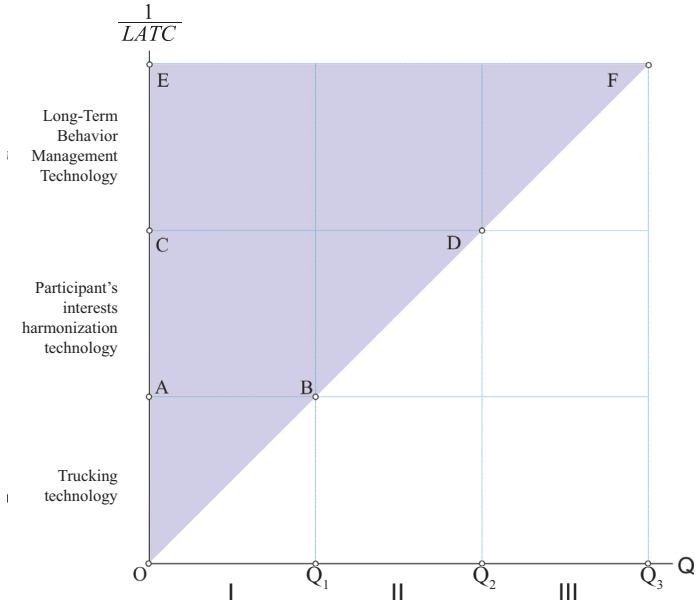


Fig. 3. Carrier's risk map



and the inevitable subsequent loss of control over the market increase for the carrier company.

In a similar way, the technology of matching interests risks (square $0CDQ_2$) and the technology of managing the behavior of other market entities risks (square $0EFQ_3$) can be analyzed.

As a result, the risks of a particular enterprise can be represented as a three-component indicator:

$$Kb = (Kb_I; Kb_{II}; Kb_{III}), \quad (7)$$

Where Kb_I – coefficient of balanced risk management of transportation technology; Kb_{II} – coefficient of balanced risk management of the technology of interests matching; Kb_{III} – coefficient of balanced risk management of control over the long-term behavior of consignors and consignees.

Let us apply this approach to practical examples: the Northern Sea Route, the Russian railway and the sea route Southeast Asia – Europe.

The Northern Sea Route currently has increased marginal costs for both carriers and exporters for the following reasons:

1. "Ice conditions on some sections of the routes have significant spatial and interannual variability" [Erokhin, 2017. P. 9].

2. "High insurance costs, low speeds of progress, the strictest safety rules, the highest environmental risks, unpredictable ice conditions, constant deviations of ships from their intended courses, lack of qualified and experienced sailing in high latitudes of ship crews" [Erokhin, 2017. P. 9].

3. The passage of transport vessels requires the services of an icebreaking fleet, which, due to the short navigation season, is not used for a full year and therefore requires high costs.

4. Infrastructural security of the Northern Sea Route requires significant investments, as there is a poor condition of meteorological warning services, a lack of information on ice migration, and the unsatisfactory condition of Russian ports, harbors and other facilities.

5. "There are restrictions on the reception of large-tonnage ships by Russian harbors east of Murmansk in case of unforeseen circumstances"[1].

The above data on the Northern Sea Route allow us to present the state of risks of this object as follows (Fig. 4a).

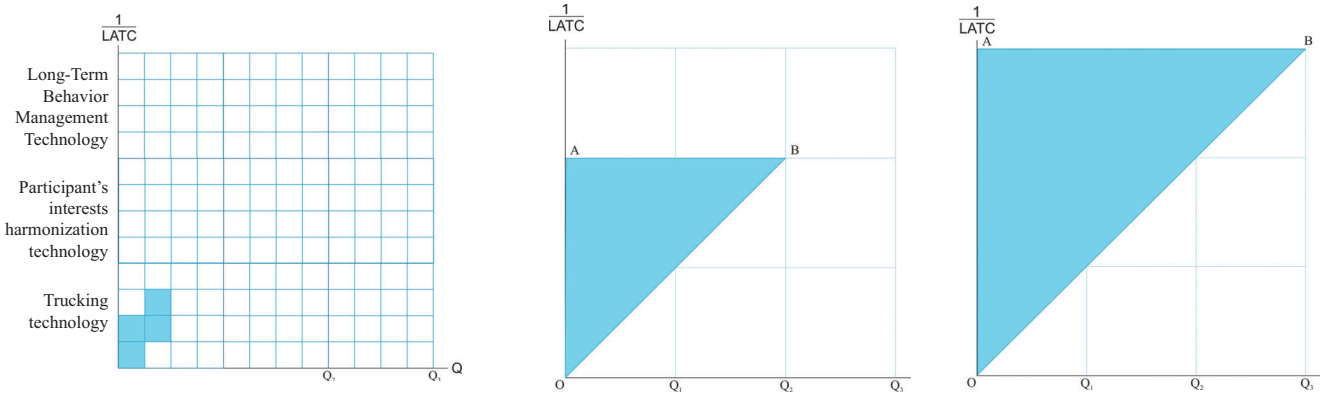
The volume of traffic along the Northern Sea Route is gradually increasing, but marginal costs and prime cost are inelastic, there is no decrease in LATC (Fig. 4a). As a result, there is no productive activity in the technology of matching interests and in the technology of managing the behavior of consignors and consignees.

Thus, $Kb_I = 9 / 7 = 1.3$; $Kb_{II} = 0$; $Kb_{III} = 0$ or, using expression (7), (1.3; 0; 0).

The analysis of Russian railway transport, carried out in the article [Rimskaya, Anokhov, 2021], allows us to conclude that it has successfully overcome stages I and II (Fig. 3) and has come close to the need to master the technology of long-term management of the behavior of consignors and consignees. Based on this, it is possible to similarly build an enlarged risk map for railway transport (Fig. 4b), according to which its coefficient of balanced risk management Kb = (1; 1; 0).

The third object - the sea route Southeast Asia - Europe - has been perhaps the most important transport channel of the continent and the world for centuries, provides the most economical method of transportation, guarantees low risks, satisfies the interests of all participants in the process and determines the vital activity of many companies, industries and even states . For these reasons, it is possible to present an enlarged risk map for this path (Fig. 4c), the balanced risk management coefficient Kb = (1; 1; 1).

Figure 4. Situational risk maps



a) Risk map for the Northern Sea Route

b) Risk map for railway transport

c) Risk map for the Southeast Asia – Europe Sea Route

[1] Kornilov V. (2013). The Arctic has always attracted the attention of romantic explorers, practical industrialists, hunters and people prone to adventurism. *Maritime news of Russia*, 16.

3. Digitalization in transport and risk changing

The above examples show that risks initially decrease as marginal cost decreases, then as LATC decreases, and finally as marginal profit increases. In turn, the reduction of marginal costs requires an increase in organization (in the understanding of Bogdanov) through the continuous improvement of technologies, which makes it possible to more effectively overcome the resistance of the external environment.

At the same time, the risk maps presented above show the current state of affairs in risk management. However, the reality of tomorrow will be totally digitalized, which will undoubtedly have a decisive impact on the nature of risks and risk management.

As already discussed by [Rimskaya, Anokhov, 2021], digitalization allows us to divide production processes into two classes:

1. Unpredictable production processes associated with the volatility of market demand and the external environment as a whole. Such processes require more or less significant participation of a person who is able to make decisions in an unstable environment.

2. Routine production processes that can be planned, prepared and executed without human intervention using cyber-physical systems. Such processes are focused mainly on meeting the basic, slightly changing needs of a person, which allows them to be predicted quite accurately and to plan the corresponding production capacities for them. As a result, it is these processes, that are most suitable for digitalization based on unconditionally executable algorithms.

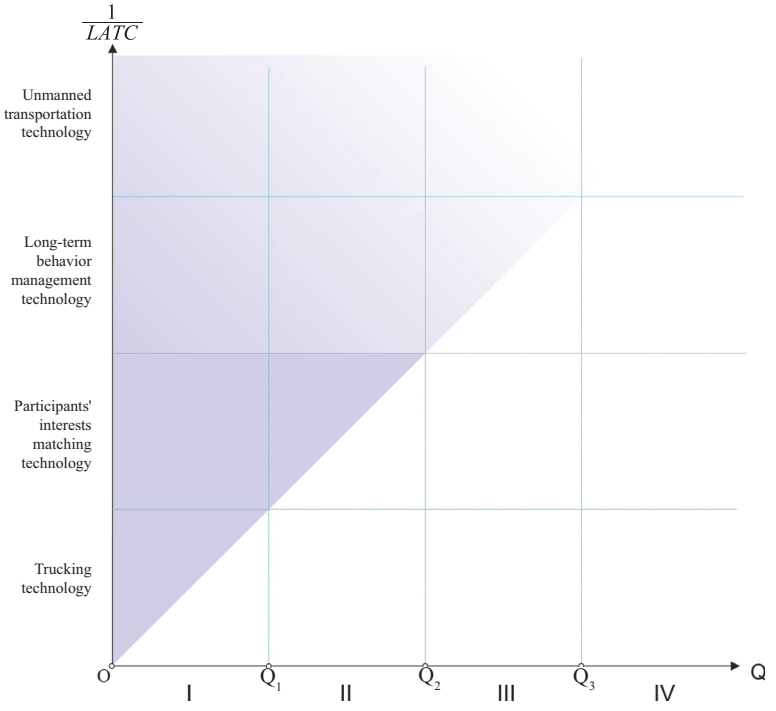
In this respect, the digitalization of routine processes will generate another level on the risk map (Fig. 2) - the level of digital planning technology, unmanned production and transportation (Fig. 5).

This entails a new round of increasing the volume of production with a simultaneous reduction in cost, while giving rise to a radically new type of risks - the risks of human interaction with the dehumanized technosphere. Such risks would include:

- risks of increasing concentration of managerial functions in the hands of ever smaller entities (often anonymous);
- risks of losing control over the technosphere;
- Risks of losing a number of key competencies by humanity: physical labor, the ability to build communications, combine labor, exercise operational control over the production process, etc.

However, the most important risk of the new stage will be the risk of exhausting the need for transportation as following: the more regular the routine needs are satisfied, the less significant they become for a person, the less their consumer value for him and the more willingly he switches to substitute goods and alternative goods. In other words, the consequence of digitized supplies will be the gradual displacement of absolute needs to the periphery of human consciousness, the alignment of the poles and the exhaustion of macroeconomic differences. As a result, the need for transport as such will gradually decrease.

Fig. 5. Risk map with a new technological level



Digitized routine processes will automatically cease to be a source of profit and the basis of competitiveness. They will remain a way to satisfy absolute needs, but will not have consumer value.

In addition, the extreme predictability of routine production processes eliminates short-term risks, but gives rise to long-term ones: the lack of human attention inevitably leads to the degradation of equipment and obsolete technologies.

Such risks are more long-term and more fundamental than their previous types. The tools for managing these qualitatively new risks will be qualitatively different from those used today. Today's risk management tools (self-insurance, hedging, diversification, reserve formation, limiting, etc.) are focused on the transfer of risks in time, space, horizontally (within the same reproduction chain) or vertically (for example, within TNCs). At the new stage, something fundamentally different happens: a zone with near-zero risks and a zone with maximum risks are distinguished.

Most likely, the following can be attributed to risk management tools in the digital economy:

1. Diversification by the nature of human needs rather than by product, consumer or market: predictable and unpredictable.

2. Endowing cyber-physical systems with ultimate autonomy and flexibility in creating transport and production systems for current, unpredictable human needs.

3. Ultimate templating of all stages of predicted needs and the production process aimed at meeting them. This ensures the systematic loading of production capacities without stocks and reserves.

4. Improvement of the signaling system between humanity and the dehumanized technosphere.

5. The search for new values and meanings of human existence, restarting the transcontinental flows of goods, energy, information and labor.

Conclusion

The article considers sectoral transport risks and proves that they are heterogeneous, quantifiable and include three sub-types of risks: risks of physical technology, risks of matching interests, and risks of managing the long-term behavior of shippers and consignees.

Digitalization and the digital economy give rise to another category of risks before our eyes: the risks of digital planning technology, unmanned production and unmanned transportation. The search for tools to stop these risks is the task of the very near future.

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Industrial digitalization: An empirical assessment of the digital maturity of enterprises

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Abstract

The digitalization of Industry 4.0 is one of the key challenges facing industrial companies. Modern technologies such as the Industrial Internet of Things, cloud computing and blockchain, big data collection and analytics, machine learning technologies, digital twins, and human-machine interaction have a wide range of effects for industrial companies and can fundamentally change the way they do business or lead to the creation of new ones.

Industry 4.0 technology implementation projects are complex in nature, as they require the involvement of various specialists from a variety of professional fields. At the same time, the development of one or another area of activity within companies can be in different stages, which affects the success or failure of the implementation of certain areas of activity in the framework of projects for the introduction of Industry 4.0 technologies.

Thus, within the framework of the study, the goal is to develop a method that allows you to assess the readiness of industrial enterprises to implement digital technologies.

At the first stage of the study, a list of directions and aspects of digital transformation was developed. At the second stage, using interviews with experts, the degrees of significance of each of the proposed aspects were calculated. In conclusion, the assessment of digital maturity was carried out on a sample of industrial enterprises using a combination of previously obtained expert assessments and surveys within enterprises.

Keywords: digitalization, fourth industrial revolution, industrial companies.

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Introduction

At present, the fourth day of the industrial revolution is the driver of major changes in industrial companies. Technological innovations that are industry 4.0 investors have either already been successfully implemented in some companies or are at the stage of pilot projects [Trachuk, Linder, 2017b]. At the same time, the pandemic has significantly increased both the pace of the development of new technologies and the speed of their deployment within industrial enterprises.

Industry 4.0 digital technologies used by industrial enterprises to improve business practices or develop new technologies include:

- industrial internet of things;
- cloud computing and blockchain;
- collection of big data and their subsequent analytics;
- machine learning technologies;
- digital twins;
- human-machine interaction, including virtual and augmented reality, robotics and automation.

Industry 4.0 technology projects tend to involve somewhat attractive activities. The deployment of Industry 4.0 technologies includes a hardware part that, according to the workload and the number of specialists from different departments can be considered as a stand-alone project, which involves new installation or retrofitting of existing equipment, its tuning and testing. In order to ensure the possibility of interaction between the installed equipment, complex firmware is also being developed, which also needs support. In order to process and analyze the received data, it is necessary to develop or ensure the integration of hardware with applications and services, which, from the point of view of implementation, act as a traditional IT project [Digital technologies 2019].

At the same time, the practice of implementing industry 4.0 technologies demonstrates that the use of digital solutions is recognized successful if companies have achieved a positive economic effect in relation to the production methods and business models used previously [Trachuk, Linder, 2017a].

A digital technology-based solution includes many components that are combined into a single system: sensors, devices, gateways, network infrastructure, cloud or local servers, analytical platforms. The successful integration of these components requires the organization to have a certain level of competencies, as well as a certain level of maturity of the technologies and the infrastructure used, compliance with which forms the prerequisites for the successful implementation of industry 4.0 technologies [Kuznetsova, Rud, 2011].

Industry 4.0 technology projects are complex in nature, as they require the involvement of various specialists including developers, specialists in data management and processing, specialists in the field of communication networks and device management.

At the same time, the development of a particular area of activity within an organization may have different stages, which defines success or failure of the implementation of certain activities within the project on introduction industry 4.0 technologies [Gokhberg et al., 2010].

Table 1
Barriers of digital technologies adoption in industrial companies

Barrier	Studies
The necessity to attract more investements	[Teplykh, 2015; Arnold et al., 2016; Trachuk, Linder, 2017a; 2017b; Barriers in development.., 2019; Komarova, 2019; Nalbandyan, Khovalova, 2020]
Lack of free cash	[Zuev, 2012; Arnold et al., 2016; Trachuk, Linder, 2017a; 2017b; Nalbandyan, Khovalova, 2020; Pandemic and the transition of companies.., 2020]
Lack of support from enterprise management	[Gokhberg et al., 2010; Golikova et al., 2012; Ismagilova et al., 2017; Barriers in development.., 2019; Nalbandyan, Khovalova, 2020]
The need to change the business model of the company	[Digital technologies.., 2019; Nalbandyan, Khovalova, 2020]
Inconsistency of the implemented digital technologies with the strategic goals of the company	[De Boer et al., 2020]
Lack of qualified personnel capable of implementing/ using digital technologies	[Gokhberg et al., 2010; Golikova et al., 2012; Ismagilova et al., 2017; Barriers in development.., 2019; Trachuk, Linder, 2017a; 2017b; Nalbandyan, Khovalova, 2020]
Resistance from the company's static organizational culture	[Kazantsev, Logacheva, 2014; Trachuk, Linder, 2017a; 2017b; Ismagilova et al., 2017; The intelligent enterprise.., 2019]
Insufficient cybersecurity	[Golikova et al., 2012; Industry 4.0 after.., 2016; Haddud et al., 2017; Trachuk, Linder, 2018; Buer et al., 2018]
Lack of standards for digital technologies and directions for their development.	[Kamble et al., 2018; Barriers in development..,, 2019; Nalbandyan, Khovalova, 2020]
Underdevelopment of the legal regulation of personal data and cybersecurity	[Digital decade.., 2017; Nalbandyan, Khovalova, 2020]
Difficulty in implementing digital technologies	[Digital technologies.., 2019; Nalbandyan, Khovalova, 2020]
Unpreparedness of the enterprise infrastructure for the introduction of digital technologies	[Mityaeva, Zavodilo, 2019; Digital technologies.., 2019; Nalbandyan, Khovalova, 2020]

Source: compiled by the author.

Fig. 1. Directions of assessing the readiness of organizations to implement Industry 4.0 technologies

Organizational readiness
• Resistance to change by employees of the organization
• Insufficient process maturity of the organization
• Lack of visible effect from the introduction of industry 4.0 technologies
• Lack of financial resources
Internal competencies of the organization
• Lack of necessary internal personnel competencies
• Lack of standard digital solutions and architectures
Readiness to work with data and their analytics
• Lack of experience in large data management and analysis
• Heterogeneity of data generated by digital devices
Infrastructural and technological readiness
• Lack of necessary organization infrastructure
• System and data security in the application of industry 4.0 technologies

Source: compiled by the author.

Thus, the purpose of this work is to develop a method that allows assessing the readiness of industrial enterprises to implement digital technologies based on assessing their compliance with the success factors for the implementation of industry 4.0 technologies, and conducting an assessment.

1. Methods for assessing digital maturity of industrial companies

In order to form directions for assessing the readiness of companies for digital transformation, a review of domestic and foreign statistics on the implementation of industry 4.0 technologies, scientific publications in this area, as well as reports and cases on the implementation of various industry 4.0 technologies published by consulting, manufacturing and research organizations were carried out. The barriers identified during the analysis of the literature are grouped in Table 1.

The identified barriers to the implementation of industry 4.0 technologies were analyzed and structured into four main categories, which are proposed to be used in the model as directions for assessing the readiness of organizations to implement industry 4.0 technologies. The categories as follows from the analysis are presented in Fig.1.

These areas influence various aspects of project realization for the implementation of industry 4.0 technologies; the assessment of project maturity together allows us to assess the readiness of the organization to implement digital solutions. The high degree of maturity of the organization within these areas creates the prerequisites for overcoming these barriers, as well as for the successful implementation of digital solutions and the achievement of planned results.

Based on the identified barriers, as well as the analysis of studies, factors were formulated that influence the success of projects for the implementation of industry 4.0 technologies, which were structured within the framework of the above directions for assessing the readiness of organizations. A description of the directions proposed for evaluation, as well as aspects of the successfull implementation of digitalization projects used to assess the level of organization maturity are presented below.

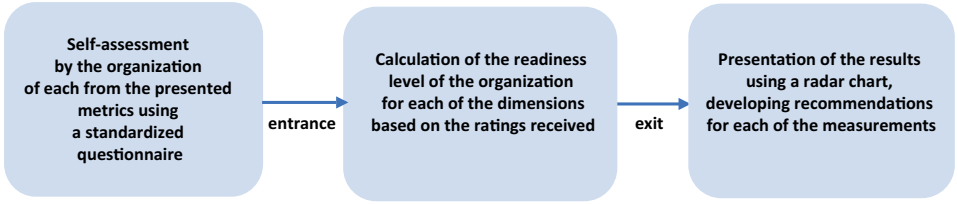
Organizational readiness. As part of this direction, it is proposed to assess the readiness

Fig. 2. Elements of the organizational readiness assessment model

Directions				
Aspects	**Organizational readiness**	**Internal competencies of the organization**	**Infrastructural readiness of the organization**	**Readiness to work with data and their analytics**
	Availability of a developed business case for the application of industry 4.0 technologies	**An experience and expertise of the employees in the implementation of industry 4.0 technologies**	**Organization Infrastructure Maturity Level**	**Data management and processing**
	Availability of organizational resources and support by management	**The experience of the employees in the field of analysis and data management**	**The development of storage technologies and data processing**	**Integration and data analysis**
	Strategic readiness of the organization		**The development of data protection and security technologies**	
	Strategic readiness of the organization			
	Process management maturity and level of digitalization			

Source: compiled by the author.

Fig. 3. Process of assessing an organization's readiness to implement Industry 4.0 technologies



Source: compiled by the author.

of an organization to implement industry 4.0 technologies in terms of having a well-developed business case for their application [Industry 4.0 after.., 2016], the maturity of the organization's business processes and assessing the degree of their digitalization [Digital Technologies.., 2019], the availability of resources for the implementation of the project, as well as the characteristics of the corporate culture of the organization [Sousa Jabbour et al., 2018].

2. Internal competencies of the organization. As part of this direction, it is proposed to assess the internal competencies of employees in the organization, to what extent the company's specialists are ready for the deployment of industry 4.0 technologies and their support. It is also proposed to evaluate the experience and level of expertise of specialists in the implementation of digital transformation projects [Haddud et al., 2017].

3. Infrastructural and technological readiness. As part of this measurement, it is proposed to assess the readiness of the organization's infrastructure for the deployment of a digitalization strategy, the readiness of technological equipment for processing and analytics of the received data, as well as the security of the digital solutions and data storage system [Kamble et al., 2018; Barriers in development.., 2019; Mityaeva, Factory, 2019].

4. Willingness to work with data and their analytics. This dimension evaluates how an organization manages and processes data. At the same time, the greatest value of the generated data lies in the possibility of their interpretation

Table 2
Organization readiness levels in the "Organizational readiness" direction

Readiness level	Readiness assessment	Characteristics
1	1–8	The organization is just beginning to study the prospects for the application of industry 4.0 technologies, the organization's management does not evaluate or is only beginning to evaluate the possible directions for the organization to use industry 4.0 technologies, the organization does not have internal or external experts in the field of implementing digital projects, or the organization has just started training and / or searching for them. The company is characterized by a low level of process maturity, as well as minimal process digitalization. At this readiness level, the organization has low potential to successfully implement Industry 4.0 technologies.
2	9–17	The organization analyzes and develops promising business scenarios for applying Industry 4.0 technologies. The company's management is developing road maps for the development of digital technologies. The company's business processes are at an average level of maturity in terms of collecting, integrating and exchanging data; the company is characterized by the digitalization of key business processes. In a company, there may be a tendency for employees to resist change. The organization has identified potential internal and/or external experts necessary for the implementation of digital projects. At the same time, the organization has the potential to successfully implement projects to introduce industry 4.0 technologies.
3	18–25	The organization has an understanding of promising business scenarios for applying Industry 4.0 technologies. The management of the organization provides broad support for the introduction of modern technologies and tools and is ready to invest in them. Employees of the organization are open to the use of new technologies and solutions. The company has a high potential for the successful implementation of digital projects and / or creates partnerships with digital solution providers. The company's business processes are at a high level of maturity in terms of collecting, integrating and exchanging data, for a company characterized by a high degree of digitalization.

Source: compiled by the author

and analysis, which is also included in the list of factors assessed within this area [Barriers in development.., 2019; Nalbandyan, Khovalova, 2020].

Thus, the general structure of the model can be represented in the form of four directions, with the detailing of each direction into a number of aspects of digital transformation. (Fig. 2).

Within the framework of the proposed model, the process of assessing the readiness of an organization to implement industry 4.0 technologies for each of the areas includes several stages, the sequence of which is shown in Fig. 3.

In order to assess the readiness of the organization in each of the proposed areas, a standardized questionnaire was developed, presented in the Appendix. The proposed questionnaire contains a list of closed questions, for each of which the respondent chooses one of the proposed options, which, in the respondent's opinion, most accurately and fully reflects the features and stages of development of certain areas of activity in the company. The questionnaire can be transferred to the organization both in printed form and with the use of various electronic means (sending by e-mail, using web resources to conduct a survey). The data obtained as a result of the survey is used as the basis for calculating the level of readiness of the organization in each of the areas under consideration.

At the same time, not all aspects of digital transformation have the same impact on the success and effectiveness of projects to implement industry 4.0 technologies. In order to determine the degree of significance of each of the proposed aspects for the successful implementation of projects, a series of interviews were conducted among experts with broad practical knowledge and experience in implementing industry 4.0 technologies. Based on the interviews, the average assessments of experts for each of the aspects of digital transformation, as well as areas, were calculated, which were brought to a single scale for assessing the organization's readiness in various areas and are considered as a weighting factor.

Thus, based on the ratings obtained as a result of filling out the questionnaire, the readiness score (RL_D) of the organization is calculated as the sum of the weighted averages of answers to questions within a certain factor, adjusted for the significance of this factor in terms of its impact on the success of the digital transformation project:

$$RL_D = \sum \frac{\sum_{i=1}^{n} S_{DFi}}{n} * W_{DF},$$

where D – is the direction of the organization's readiness assessment; F – the studied aspect of success; n – is the number of questions within the studied factor; S – is the value of the answer to the question; W – is the significance of the aspect of digital transformation.

After the organization completes the questionnaire, the responses received are processed in accordance with the above formula. Based on the results obtained, a radar diagram is constructed, where the organization is assigned a certain level of readiness in each of the analyzed areas.

Based on the assessments received, recommendations are developed for each of the analyzed areas, which can be

Table 3
Organization readiness levels in the “Internal competencies of the organization” direction

Readiness level	Readiness assessment	Characteristics
1	1–8	The organization does not have employees with practical experience in implementing digital projects. The development and implementation of all digital systems, as well as their support and maintenance, are carried out by external experts. The level of of employees’ expertise and management of the organization are insufficient to plan the resources necessary for the implementation of digital projects. The company does not have internal or external experts in the field of big data analytics. At this readiness level, the organization has a low potential to successfully implement Industry 4.0 technology implementation projects.
2	9–17	The organization has established partnerships with external experts in the development and implementation of projects for the deployment of digital systems. Management and support of existing systems is carried out by the internal forces of the organization, employees of the organization can form a rough estimate of the resources necessary for the implementation of a digital project. The development of data processing algorithms and their analysis is carried out by external experts or in-house specialists with the necessary experience. At the same time, the organization has the potential to implement projects successfully in order to introduce industry 4.0 technologies.
3	18–25	The company has its own team of specialists who develop, deploy and maintain both existing and new systems. Employees of the organization have a high level of expertise in assessing the resources required for the implementation of projects. The company has its own data analysts who develop algorithms and solutions for integrating data from various systems and processing it. The company has a high potential for the successful implementation of digital projects.

Source: compiled by the author.

Table 4
Organization readiness levels in the "Infrastructure and technological readiness" direction

Readiness level	Readiness assessment	Characteristics
1	1–8	The current infrastructure of the organization does not provide the ability to integrate and exchange data between different devices and systems, and also does not allow to process data from multiple sources. Data from different sources are often manually transferred between systems. The organization does not have an understanding of potential storage and processing technologies, or the organization has just begun to analyze the target architecture in order to implement digital solutions. At this readiness level, the organization has low potential to implement Industry 4.0 technology projects successfully.
2	9–17	At this level, the infrastructure of the organization allows you to collect and process data from multiple sources, the interaction of equipment and information systems is automated within the framework of individual processes or activities. The organization has an understanding of the necessary infrastructure improvements to implement industry 4.0 technologies, and advanced analytical tools can also be applied. At this readiness level, the organization has the potential to successfully implement Industry 4.0 technology projects.
3	18–25	The infrastructure of the organization at this level of development is characterized by the ability to process large amounts of data received from multiple sources, the presence of close integration between various devices and equipment, the integration of systems and devices into a single system. The organization has already implemented data processing systems, and also uses analytical tools with machine learning algorithms and / or predictive analytics. The organization has a high potential to implement or expand the use of Industry 4.0 technologies.

Source: compiled by the author.

Table 5
Organization readiness levels in the "Readiness to work with data and their analytics" direction

Readiness level	Readiness assessment	Characteristics
1	1–8	The organization lacks a unified approach to managing and merging data from various sources. The organization's specialists lack experience in working with big data. Automated analytical methods and tools are not used, or basic analytical methods are used that require additional analysis and interpretation by the organization's employees. The organization's specialists do not have experience in designing and managing analytical systems; data from various sources is not combined and used for analytical purposes.
2	9–17	The organization has formed data management mechanisms, identified promising scenarios for the use of digital data for analytical purposes. The organization has experience in integrating heterogeneous data and analyzing it using modern analytical methods (BI, data mining). Analytical processes are automated and integrated into individual business processes of the company. The company has the potential to implement industry 4.0 technologies.
3	18–25	The organization has developed data integration and management mechanisms; it has experience working with big data, the solutions used are able to process large volumes of heterogeneous data and clean them from noise. The organization has experience in working with advanced analytical systems; analytical processes are automated and integrated into the company's business processes. The organization has a high potential to implement or expand the use of Industry 4.0 technologies.

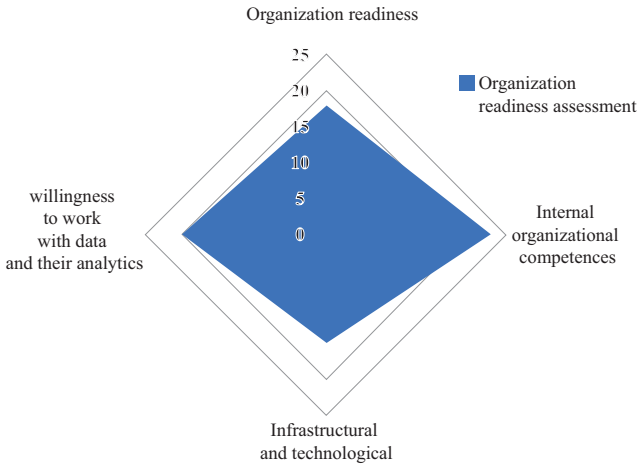
Source: compiled by the author.

Table 6
A scale for correlating the total score with the level of digital maturity of the company

Sum of points in all areas	Level of digital maturity of the company
0–34	Low
35–69	Average
70–100	High

Source: compiled by the author.

Fig. 4. Radar chart of the organization's readiness level for each of the analyzed areas



Source: compiled by the author.

further used to make a decision on the introduction of industry 4.0 technologies and form (if necessary) measures aimed at developing certain areas of the organization's activities in order to increase the level of readiness for the implementation of digital projects . Below are descriptions of the readiness levels of the organization in each of the areas, as well as possible recommendations for their improvement within the considered areas of assessment.

1. Organizational readiness. The readiness levels of the organization within the framework of this direction, as well as their characteristics, are presented in Table. 2.

2. Internal competencies of the organization. The readiness levels of the organization within the framework of this direction, as well as their characteristics, are presented in Table. 3.

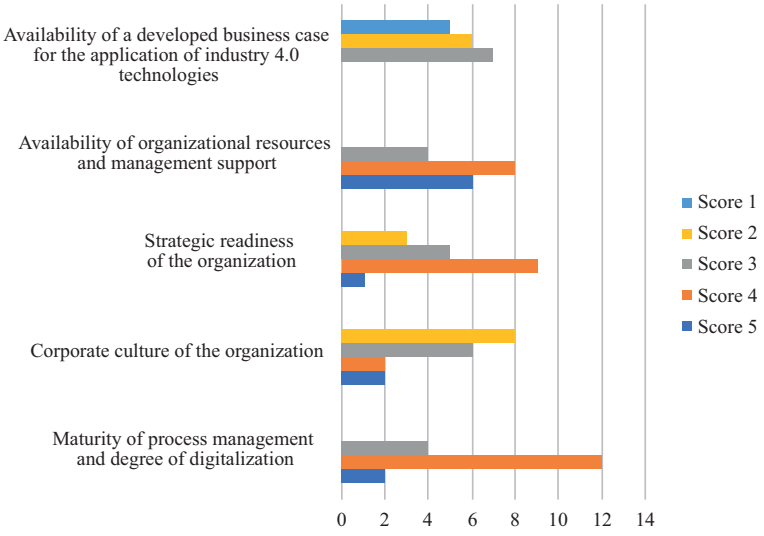
3. Infrastructural and technological readiness. The readiness levels of the organization within this area, as well as their characteristics, are presented in Table 4.

4. Willingness to work with data and their analytics. The readiness levels of the organization within this area, as well as their characteristics, are presented in Table 5.

The maximum score for the readiness of enterprises to implement industry 4.0 technologies for each individual area is 25 points, and the maximum possible score for all areas of assessment is 100. Within the framework of the proposed model, based on the value of the overall readiness indicator, the final assessment is given to readiness of industrial organizations for the successful implementation of industry technologies 4.0. The scale of correlating the final score with the level of digital maturity of the company is presented in Table. 6.

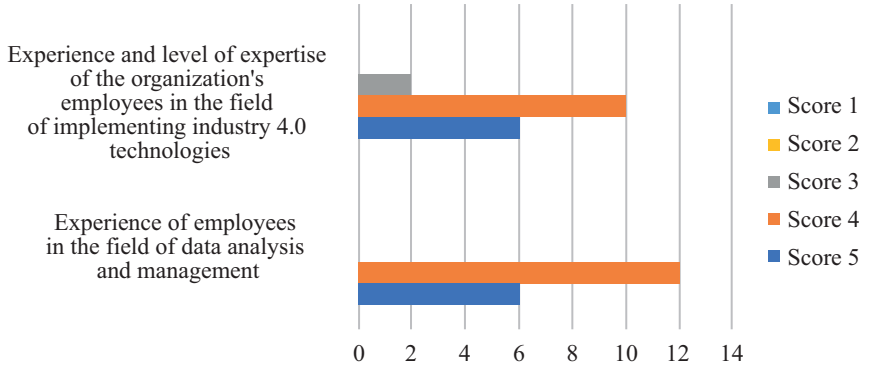
Organizations that have achieved a high level of digital maturity have significant potential for successful project implementation. Mid-range organizations also have the potential to implement successfully Industry 4.0 technologies while improving the organization's experience with digital data and its analytics. The value of the summary score corresponding to a low level indicates the need for improvements in the development of certain areas of activity of industrial organizations before the introduction of industry 4.0 technologies, in particular, the need to develop technical infrastructure, business cases for the application of industry 4.0 technologies, develop skills and experience of employees in the field of data management and analysis.

Fig. 5. Occurrence frequency of expert assessments for aspects of digital transformation of the "Organizational readiness" direction



Source: compiled by the author.

Fig. 6. Occurrence frequency of expert assessments for aspects of digital transformation of the "Internal competencies of the organization" direction

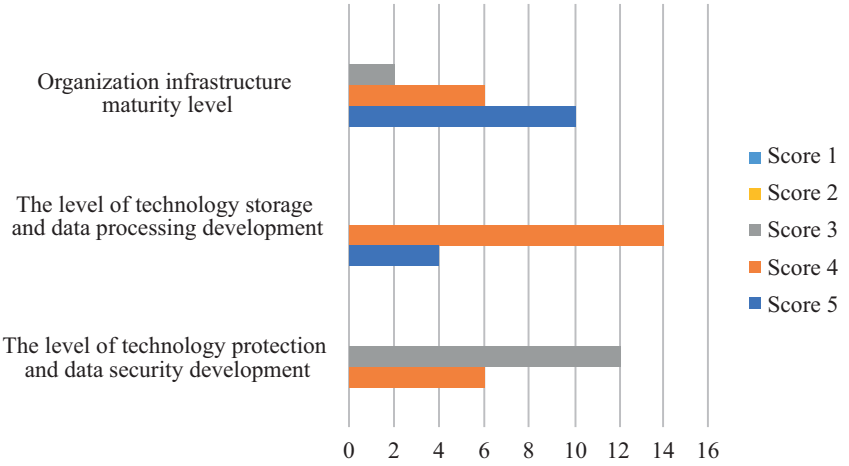


Source: compiled by the author.

Fig. 4 shows an example of a radar diagram of the level of organization readiness for each of the analyzed areas, which allows you to visualize the result of the analysis of the digital maturity of the organization.

Thus, the proposed technique allows you to assess the level of readiness of the organization based on the evaluation of its compliance with the success factors of industry 4.0. technology implementation, as well as to identify areas of industrial enterprises. The level of their development must be improved to ensure the successful realization of projects on the implementation of industry 4.0 technologies.

Fig. 7. Occurrence frequency of expert assessments for aspects of digital transformation of the "Infrastructure readiness of the organization" direction



Source: compiled by the author.

2. Determination of digital transformation influence aspects

In order to determine the degree of importance of the proposed aspects, a series of interviews with representatives was conducted for successful implementation of projects:

- various departments of consulting companies with experience in developing and implementing comprehensive IT projects, including projects for the implementation of industry 4.0 technologies;
- IT integrators providing services for the development and deployment of IT systems, as well as integrating digital systems with various devices and equipment.

In total, 18 experts were interviewed who evaluated the importance of each aspect on a scale from 1 (minimum impact on the success of project implementation) to 5 (a high degree of influence on the success of the project) in the form given in the annex.

To ensure high quality and verification of the results of the survey, the following was a discussion of the responses received with the help of a questionnaire, as well as clarification. The interaction with respondents was remotely using video conferencing technologies. The choice of a remote format of the interviews is due to the current restrictions on full-time events. Also, the remote format has made it possible to increase the coverage of respondents.

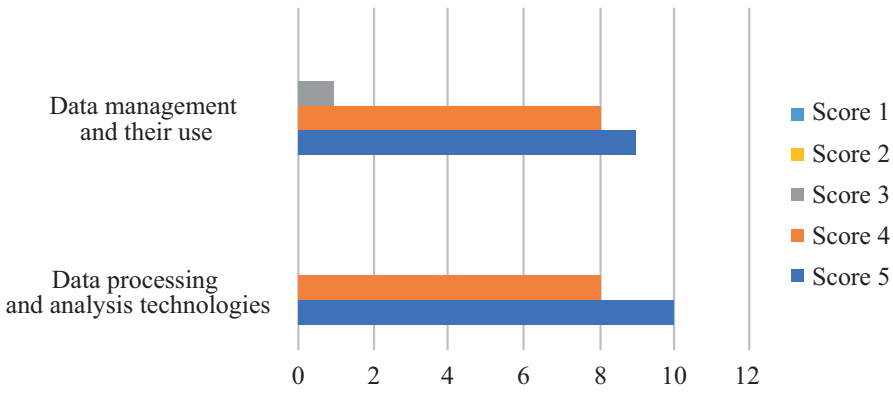
According to the results of the survey, frequencies of validity of the aspects of digital transformation were obtained.

The frequency of expert assessments for aspects of the digital transformation for the direction "Organizational readiness" is shown on Fig. 5.

Within the "Organizational readiness" area, according to the results of the survey, the most significant aspect was the "Availability of organization resources and support from management" (with an average score of 4.11), which can be explained by the organization's need for free funds or the ability to attract additional funding for successful deployment and subsequent exploitation of digital technologies. The significance of aspects related to the maturity of process management and the strategic readiness of the organization received moderate assessments from experts (with an average score of 3.89 and 3.44, respectively). The lowest assessment by experts (average score – 2.11) was received by the aspect "Having a developed business case for the application of industry 4.0 technologies".

The frequency of expert assessments for aspects of digital transformation of the direction "Internal competencies of the organization" is shown in Fig. 6.

Fig. 8. Occurrence frequency of expert assessments for aspects of digital transformation of the "Readiness to work with data and their analytics" direction



Source: compiled by the author.

Table 7
Surveys results of experts in order to determine
the degree of impact of aspects of digital transformation

Aspect of digital transformation	Average score	Significance
Organizational readiness		
Availability of a developed business case for the application of industry 4.0 technologies	2.11	0.64
Availability of organizational resources and management support	4.11	1.25
Strategic readiness of the organization	3.44	1.05
Corporate culture of the organization	2.89	0.88
Maturity of process management and degree of digitalization	3.89	1.18
Internal competences of the organization		
Experience and level of employees' expertise in the field of implementing industry 4.0 technologies	4.22	2.47
Experience of employees in the field of data analysis and management	4.33	2.53
Infrastructural readiness of the organization		
Organization infrastructure maturity level	4.44	1.85
Level of data storage and processing development	4.22	1.76
The level of data protection and security development	3.33	1.39
Readiness to work with data and their analytics		
Data management and their usage	4.56	2.53
Data processing and analysis technologies	4.44	2.47

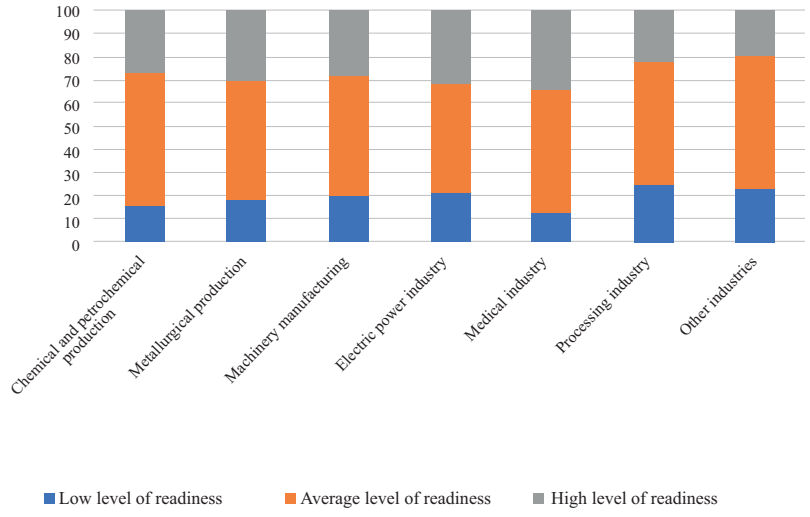
Source: compiled by the author.

Both aspects characterizing the direction "Internal competencies of the organization" were highly appreciated by the experts. The success of the implementation of industry 4.0 technologies largely depends on the development of digital competencies of both managers introducing the implementation and employees who exploit the implemented technologies in the future. Experts note that often it was the lack of leadership and analytical competencies of the organization's employees that led to a significant decrease in the effectiveness of the introduction of digital technologies.

The frequency of expert assessments occurence for digital transformation aspects of the "Infrastructural readiness of the organization" direction is shown in Fig. 7.

For the "Infrastructural readiness of

Fig. 9. Ratio of high, medium and low digital maturity companies by industry sector



Source: compiled by the author.

the organization" direction the most significant aspects were the "Level of maturity of the organization's infrastructure" (average score – 4.44) and "Level of development of data storage and processing technologies" (average score – 4.22): unavailability of the organization's infrastructure, as well as the insufficient level of technological development of the organization which impedes the integration of modern digital solutions can significantly slow down the introduction of industry 4.0 technologies and reduce the economic effect of their implementation.

Moderately significant (average score – 3.33) was the aspect related to data protection and cybersecurity. The significance of this aspect was noted not only for enterprises, the performance of which directly depends on the level of their cybersecurity, but also for companies whose products consumers place high demands on ensuring data confidentiality.

The occurrence frequency of expert assessments for aspects of digital transformation in the "Readiness for working with data and their analytics" direction is shown in Fig. 8.

As part of the "Readiness for working with data and their analytics" direction, both aspects received a high average rating, since the availability of data processing technologies and the ability to effectively process and apply them in production processes have a direct impact on the effectiveness of technology implementation.

In order to apply the results of the survey of experts in the near future, the significance of aspects for each of the areas for assessing the digital maturity of industrial enterprises was calculated using the ratio:

$$W_{DF} = \overline{A_{DF}} \cdot \frac{b}{\sum_{i=1}^{m} \overline{A_{DFi}}},$$

where W – is the significance of digital transformation aspect; A – is the average assessment of digital transformation aspect significance; m – the number of aspects of digital transformation in the direction of assessing digital maturity; b – the maximum score for the question of the questionnaire for assessing the readiness of the organization to implement industry 4.0 technologies.

The average estimates and the significance of digital transformation aspects calculated based on the results of expert surveys are presented in Table. 7.

Thus, on the basis of the interviews, the weight coefficients of the aspect significance of digital transformation were obtained for further use in the methodology for assessing the digital maturity of industrial enterprises.

3. The results of digital maturity assessment on a sample of industrial enterprises

During the next stage of the study, digital maturity assessments were carried out on a sample of industrial enterprises using a combination of previously obtained expert assessments and surveys within enterprises (self-assessments) with details on digital transformation aspects within areas. The sample size was 126 industrial organizations. The characteristics of the sample are presented in Table. 8.

According to the results of the survey, industrial companies were assigned a level of digital maturity, the results of which are presented as a ratio of companies with a high, medium and low level of digital maturity, according to industry sectors (Fig. 9).

Most of the industrial organizations studied are at the intermediate level of digital maturity. From 20 to 34% of companies received a high level of digital maturity in the context of their industry, from 13 to 25% – low.

Thus, most industrial companies will have to form a strategy to strengthen digital competencies in order to successfully implement and subsequently apply Industry 4.0 technologies.

Table 8
Sample characteristics

Characteristics of the sample companies	Number of companies	Share of companies %
Sector		
Chemical and petrochemical production	24	19
Metallurgical production	22	17
Engineering industry	11	9
Electric power industry	14	11
Medical industry	29	23
Manufacturing industry	15	12
Other industries	11	9
Company lifespan		
Less than 5 years	13	10
5-10 years	47	37
More than 10 years	66	52
Average number of employees		
500-1000 people	10	8
1001-5000 people	54	43
Более 5000 people	62	49
Revenue for the year from sales (excluding VAT)		
No more than 50 mln rub	21	17
50-500 mln rub	48	38
From 500 mln rub	57	45

Source: compiled by the author.

In terms of organizational readiness, companies need to increase the level of process maturity, ensure the collection, integration and exchange of data on business processes. They should also reduce the level of resistance to changes on the part of employees and ensure openness and involvement in the development of new technologies. The development of partnerships with digital solution providers, as well as the involvement of external and internal experts in the implementation of innovative technologies, will also become factors in the successful implementation of digital projects.

In the context of the readiness of companies in the direction of "Internal Competences of the Organization", the focus should be on increasing the level of specialist team expertise involved in the development, deployment and subsequent maintenance of both existing and new systems, as well as the introduction of tools for analyzing, processing and interpreting the data obtained.

As part of the "Infrastructural and technological readiness" direction, organizations will have to provide the ability to integrate and exchange data between various devices and systems, as well as implement mechanisms for processing data from multiple sources. It is also important to provide a comprehensive view of the necessary infrastructure improvements for the implementation of industry 4.0 technologies.

In the “Readiness for working with data and their analytics” direction, one should also focus on improving the competencies of employees in the field of data analytics and building large analytical systems, as well as highlighting promising scenarios for using digital data for analytical purposes. Analytical processes should be automated and integrated into individual business processes of the company.

Thus, in order to increase the assessment of the level of readiness within each of the areas and, as a result, achieve a higher level of digital maturity, companies need to determine the current state and prospects for the introduction of digital technologies, the target vision and metrics for assessing the success of the planned digital transformation, which will form the basis for building roadmap for digital transformation. The basis for successful digital transformation should be the development of human resources and the strengthening of its digital competencies, the level of digital culture and cybersecurity. Also, companies should form an understanding of the model for financing the introduction of digital technologies. The final stage will be the calculation of metrics that characterize the success of the digital transformation.

Conclusion

The paper presents the results of developing a method that allows to assess the readiness of industrial enterprises to implement digital technologies based on assessing their compliance with the success factors for implementing industry 4.0 technologies.

A review of domestic and foreign literature made it possible to identify barriers to the introduction of digital technologies in industrial companies, as well as factors that affect the success of projects for the implementation of industry 4.0 technologies. The analysis and structuring of these factors made it possible to identify four areas for assessing the digital maturity of industrial companies: organizational readiness, internal competencies of the organization, infrastructural and technological readiness, as well as readiness to work with data and their analytics.

To assess digital maturity in these areas, a list of questions was developed to assess each aspect of digital transformation. As a result of interviews with experts, the degree of the proposed aspects significance for the successful implementation of digital transformation projects was calculated.

Next, a digital maturity assessment was carried out on a sample of industrial enterprises using a combination of previously obtained expert assessments and surveys within enterprises, which showed that most of the companies from the sample are at an average level of digital maturity.

In conclusion, the main directions for the development of digital competencies of industrial companies for the successful implementation and subsequent application of industry 4.0 technologies are put forward.

As a further study of the digitalization of industry, a deeper elaboration of each area to strengthen digital competencies and, as a result, the formation of guidelines for industrial enterprises on the development of a digital transformation strategy are seen interesting.

Appendix

Questionnaire for assessing the readiness of an organization to implement industry 4.0 technologies

Direction "Organizational readiness"

1. Availability of a developed business case for the application of industry 4.0 technologies

1.1. Has your organization identified a business case that can be addressed by implementing Industry 4.0 technology solution?

1) Not yet.
2) Not yet, but we plan to do so.
3) We are thinking about how to do it.
4) We have identified possible applications for Industry 4.0 technologies.
5) We have developed a specific use case for Industry 4.0 technologies that is necessary.

1.2. Has your organization identified key performance indicators to measure the success of the digital project(s)?

1) Not yet.
2) Not yet, but we plan to do so.
3) We are thinking about how to do it.
4) We identified possible performance indicators.
5) We have identified key performance indicators and can measure them.

2. Availability of organizational resources and management support

2.1. Does your organization have spare resources available to invest in at least one pilot project?
1) No.
2) No, but we are looking for available resources.
3) We have identified several potential funding sources.
4) Yes, the organization will have available sources of funding when it is necessary.
5) Yes, free funding sources are available now.

2.2. Your organization's senior management is committed to support emerging technology initiatives as they have the potential to improve competitiveness and/or operational efficiency.
1) Strongly disagree.
2) Disagree.
3) Neutral.
4) I agree.
5) Completely agree.

3. Strategic readiness of the organization

3.1. Has your organization developed a roadmap for deploying Industry 4.0 technology projects that outlines the data, architecture, and computing resources needed, and the team to deliver it?
1) No.
2) Not yet, but we know how to develop it and what needs to be reflected in it.
3) We have already started developing such a roadmap.
4) Yes, but the developed map does not cover all of these aspects.
5) Yes, the company has developed a roadmap.

3.2. Has your organization identified internal or external (consulting services, IT integrator services) experts to implement IoT projects?
1) No.
2) No, we are looking for external partners and/or candidates for advanced training.
3) We have already identified several potential partners and/or internal experts, but have not engaged anyone yet.
4) Yes, we have identified internal experts, established partnerships with external experts.
5) Yes, we have identified internal and external experts, and also have free resources to attract additional experts if necessary.

4. Corporate culture of the organization

4.1. Employees of your organization actively share successful practical experience, are ready to support and advise their colleagues, and take an active part in solving complex complex problems.
1) Strongly disagree.
2) Disagree.
3) Neutral.
4) I agree.
5) Completely agree.

4.2. Employees and management of your organization have a positive attitude towards the introduction of new technologies and other innovations. New technologies are quickly integrated into the organization's business processes and actively used by employees and managers.
1) Strongly disagree.
2) Disagree.
3) Neutral.
4) I agree.
5) Completely agree.

5. Maturity of process management and level of digitalization

5.1. Your company has considered the organizational implications of deploying Industry 4.0 technologies. The company develops targeted processes as a result of the introduction of new technologies and other innovations.
1) Strongly disagree.
2) Disagree.
3) Neutral.
4) Agree.
5) Completely agree.

5.2. How would you characterize the stage of digitalization of your operations?
1) Pre-digital, most of the company's processes are carried out without the use of digital technologies.
2) Digitalization within the framework of separate pilot projects, within the framework of certain areas of activity, the use of digital technologies are being tested.
3) Digitization of basic operating processes, key processes are carried out using digital technologies.
4) Partial digitalization, the main as well as supporting business processes are covered by the use of digital technologies.
5) Full digitalization, all business processes of the organization are carried out using modern digital technologies.

Internal competencies of the organization

6. Experience and level of expertise of the organization's employees in the field of implementing industry 4.0 technologies

6.1. Does your organization already have one or more teams of specialists who have the skills and competencies in the development, implementation and management of digital projects?
1) No.
2) No, but we are actively forming such a team.
3) No, but our organization has established partnerships with external experts who have the necessary experience.

4) Yes, but the employees are not a part of a single team.
5) Yes, we have a dedicated team of digital integrators.

6.2. Employees of the organization have experience in implementing IT platforms, as well as integrating various devices and equipment into a single infrastructure. Do the organization's specialists independently deploy, manage and support the organization's digital systems?
1) No, separate contractors are involved for each task.
2) No, we have a single partner that implements, integrates and manages the organization's IT infrastructure.
3) No, the organization's specialists independently manage and support existing systems, the implementation and integration of new systems is carried out by an IT integrator.
4) Yes, the organization's specialists independently deploy, manage and support the organization's IT infrastructure with the involvement of external experts for the implementation of large projects.
5) Yes, the organization's specialists independently design, develop, implement and support all digital systems used in the organization.

6.3. The organization employs staff with a high level of expertise in terms of forecasting the required amount of time, labor and financial resources needed to implement digital projects.
1) Strongly disagree.
2) Disagree.
3) Neutral.
4) I agree.
5) Completely agree.

7. Experience of the organization's employees in the field of data analysis and management

7.1. Does your organization already have one or more teams of specialists who have the skills and experience in data processing and analysis?
1) No.
2) No, but we are already looking for similar specialists (internal and external).
3) No, we have external experts in this area.
4) Yes, we have a small team.
5) Yes, we have a separate dedicated team of digital data analysts.

7.2. Does your organization employ analysts who can independently develop data processing and analysis algorithms?
1) No.
2) No, but we are already looking for such specialists.
3) No, we have external experts in this area.
4) Yes, we have analysts with certain skills in the field of building digital analytics.
5) Yes, we have a dedicated team in the organization with extensive experience in data analytics in systems based on industry 4.0 technologies.

Infrastructural and technological readiness of the organization

8. Maturity level of the organization infrastructure

8.1. The infrastructure of your organization allows you to work with a large number of connected devices, provides the ability to integrate and exchange data between various devices and systems, and also has the necessary computing power to process and analyze the transmitted data.
1) Strongly disagree.
2) Disagree.
3) Neutral.
4) I agree.
5) Completely agree.

8.2. Your current architecture can automatically collect and process data from multiple sources.
1) Strongly disagree.
2) Disagree.
3) Neutral.
4) I agree.
5) Completely agree.

9. Development level of data storage and processing technologies

9.1. How much data is your organization capable of storing and processing?
1) We do not collect data.
2) Megabytes.
3) Gigabytes.
4) Terabytes.
5) Petabytes.

9.2. The organization has an understanding of the technologies for storing, processing and analyzing data from the Internet of things. The organization has already implemented data processing systems - locally, based on a cloud solution or using edge computing?
1) No, our organization has not formed an idea about this.
2) No, the idea of this has not been formed yet, but we are already working on it.
3) Yes, we have an idea about this, but a specific system has not yet been selected.
4) Yes, we have an idea about it, we already know which system meets the requirements of our company.
5) Yes, we have an idea about this, we already use one or more data processing systems.

9.3. What type of data analytics is used in your organization?
1) There are no data analytics systems in our organization.
2) Our organization uses systems of descriptive (descriptive) analytics.
3) Our organization uses predictive analytics systems.
4) Our organization uses predictive analytics systems using real-time data.
5) Our organization uses big data analytics systems using

machine learning/artificial intelligence algorithms.

10. Level of development of data protection and security technologies

10.1. Does your organization use robust data protection practices? Where possible, will these methods be applied in the deployment of Industry 4.0 technologies?

1) We haven't thought about data protection for the Internet of Things yet.
2) We have already begun to study data protection mechanisms in industry 4.0 technology systems.
3) We have already identified target data protection mechanisms, and also analyzed the applicability of existing mechanisms for data protection.
4) Yes, we have already developed a data and systems security solution, but have not implemented it yet.
5) Yes, we have developed reliable data protection methods, the methods have already been implemented and tested in practice.

10.2. Your organization has developed digital data security solutions. The management of the organization provides funding for the development of security solutions for the collected and processed data.

1) Strongly disagree.
2) Disagree.
3) Neutral.
4) I agree.
5) Completely agree.

Willingness to work with data and their analytics

11. Data management and processing

11.1. The organization has developed a view of all data sources and systems, as well as their interaction. Data can be compared with systems and sources.

1) Strongly disagree.
2) Disagree.
3) Neutral.
4) I agree.
5) Completely agree.

11.2. Does your organization handle big data?

1) No.
2) No, but we are studying the mechanisms for storing and processing big data, as well as options for their use.
3) No, we have already developed a solution, as well as applications for big data.
4) Yes, but in limited quantity and variety.
5) Yes, in great quantity and variety.

11.3. Does your organization have solutions for working with heterogeneous data and cleaning data from information noise?

1) No, we do not have such a solution.
2) No, but we are studying the mechanisms of working with heterogeneous data and cleaning data from information noise.
3) No, but we are already developing a similar solution.
4) Yes, we have a solution that can work with heterogeneous data.
5) Yes, we have a solution that can work with heterogeneous data and clean it from noise.

12. Data integration and analysis

12.1. Your organization has experience in combining heterogeneous data from multiple sources for further analysis.

1) Strongly disagree.
2) Disagree.
3) Neutral.
4) I agree.
5) Completely agree.

12.2. In your organization, analytics is automated and is the basis for management decision making and business process management.

1) Strongly disagree.
2) Disagree.
3) Neutral.
4) I agree.
5) Completely agree.

12.3. What analytical methods does your organization use?

1) We have no experience yet.
2) OLAP/BI tools, dashboards, reports.
3) Those above, plus data mining.
4) Those above, as well as predictive analytics.
5) Those above, plus more advanced analytics like cognitive computing/artificial intelligence.

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Developing microgeneration based on RES as a driver of decarbonisation and economic growth in Russia

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Abstract

Having analysed the domestic and foreign experience of developing the market of microgeneration based on renewable energy sources (RES) the authors conclude that a smart industrial policy can ensure an expedited transition to zero-carbon economy and stimulate economic growth. Research background – Russia's commitment to achieve carbon neutrality by 2060. Research purpose – assessing the prospects and barriers in the development of microgeneration based on RES. Methods – generalising, comparing, analysing empirical evidence of microgeneration market development in Russia and abroad, calculating the levelized cost of electricity (LCOE) of a solar plant and comparing it with current low voltage tariffs for small and medium-sized businesses. Results and novelty – the authors have determined the most effective industrial policy tools for developing the market of microgeneration based on RES.
Keywords: industrial policy, RES, microgeneration, zero-carbon economy.

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Introduction

Currently, about 80% of the world's countries have committed themselves to achieving carbon neutrality by a specific date[1]. Russia has determined that it will achieve the specified goal by 2060. At the same time, the President of the Russian Federation V.V. Putin instructed the Government about the Strategy for the socio-economic development of the Russian Federation with a low level of greenhouse gas emissions until 2050. It is necessary to provide for a reduction in the volume of net greenhouse gas emissions accumulated in the Russian Federation from 2021 to 2050 to lower values compared to the indicators of the European Union[2].

One of the significant sources of CO_2 emissions in the world is the sector of housing and communal services. In 2020, the operation of buildings and structures generated about 30% of global energy demand, and emissions from the operation of buildings and structures amounted to about 28% of the total global energy-related CO_2 emissions [Global status report.., 2021]. An effective tool for reducing the carbon footprint of buildings and structures, along with increasing energy efficiency and energy saving, is the transfer of energy supply to microgeneration facilities based on renewable energy sources (RES).

The article provides an empirical analysis of the world experience in the development of microgeneration based on

[1] About 80% of the world's countries have set deadlines for achieving carbon neutrality (2021). *TASS*, 31 October. URL: https://tass.ru/obschestvo/12812589.
[2] Clause 14 of the List of instructions for the implementation of the Message of the President of the Russian Federation to the Federal Assembly of the Russian Federation of April 21, 2021 No.753.

renewable energy since 2010. The factors that stimulate and hinder the development of the microgeneration market are identified as well as the most effective tools to support the development of microgeneration applicable to the domestic market.

An assessment of the development potential of the microgeneration market in Russia was carried out. An analysis of the cost (LCOE) of a solar power plant for various regions of Russia was carried out, based on its comparison with low-voltage tariffs for small and medium-sized businesses, conclusions were drawn about the prospects for the development of microgeneration in Russia, and the main instruments of industrial policy in this market were identified.

1. Incentives and obstacles for the development of microgeneration abroad

World experience shows that the development of microgeneration based on RES is mainly aimed at solving two main tasks: reducing the negative impact on the environment and obtaining positive economic effects. The study [Motyka et al., 2020] cites the results of a survey of US private homeowners: 68% of those surveyed want to reduce their carbon footprint, while 53% stated that it is extremely important that part of the electricity they consume is generated from renewable energy sources. Business is also increasingly focused on the environmental agenda and seeks to introduce renewable energy technologies in its activities, and this trend will be maintained in the long term.

A survey of 291 residents in the UK [Balcombe et al., 2014] showed that economic benefits and the desire to reduce the negative impact on the environment were considered as the main motives for using microgeneration. The authors [Hakon et al., 2018] also conclude in their study that the presence of state support schemes has accelerated the development of microgeneration in Germany, the UK and Norway. For Germany and the UK, decarbonization has been a significant driver of growth in this area. In Norway, low economic support and low electricity prices have limited the number of prosumers. Nevertheless, the decline in prices for solar power plants contributes to the growth of microgeneration inputs. At the same time, electricity prices and feed-in tariffs play an even less significant role compared to the cost of microgeneration facilities [Pearce, Slade, 2018]. The presence of feed-in tariffs only contributes to the earlier development of microgeneration, which would grow in any case, since its prices will continue to decline in the long term.

In turn, the authors [Balcombe et al., 2014] also recognized the economic aspects of project implementation as the most significant barriers to the development of microgeneration based on RES: high capital costs, inappropriate configuration of the house, insufficient potential benefit, as well as the risk of losing money when moving to another house. The second most important obstacle to the development of microgeneration is the difficulty in finding reliable information necessary for making a decision.

Similar conclusions regarding the importance of having accessible and reliable information on microgeneration can be found [Palm, 2018]. From 2008 to 2014, the photovoltaic system market in Sweden grew thanks to the introduction of subsidies. However, since 2014, barriers have emerged that have seriously slowed down the pace of microgeneration development in the country, such as an increased administrative burden and difficulties in finding reliable information, including what reliable professional installers are and how much a household will receive when selling electricity in network.

These conclusions are supported by other authors who note that access to reliable information is important [Simpson, Clifton, 2015; Hakon et al., 2018], and the growth of the microgeneration market stimulates the provision of expertise and technical solutions to facilitate the involvement of new households in the microgeneration market [Korsnes, Throndsen, 2021].

Table 1
Factors of considerable importance for the development of microgeneration based on RES

Main factors	Possible instruments of state policy	Effects
Economic incentives such as reduced capital and installation costs	Subsidizing equipment manufacturers	Development of the domestic industrial RES cluster
The prospect of obtaining additional financial benefits	Tax incentives for end consumers	Stimulation of demand for microgeneration based on RES
Availability and reliability of information on microgeneration	Informing about existing economic incentives and opportunities for the use of renewable energy	

According to the results of the study of international experience in table. Table 1 shows the most significant factors that have a significant impact on the development of the microgeneration market based on RES, and possible public policy tools that can stimulate the development of this sector of the economy, ensuring economic growth and achieving carbon neutrality.

2. Instruments for stimulating the development of microgeneration based on RES used in Russia

In December 2019, the Federal Law on Microgeneration №471[3] came into force, establishing the right of any individual or legal entity owning a microgeneration facility to supply excess electricity to the grid. At the same time, the energy sales organization is obliged to buy this electricity.

On March 2, 2021, Decree of the Government of the Russian Federation No. 299 was issued, defining the features of the legal regulation of relations regarding the operation of microgeneration facilities and their interaction with grid and energy retail companies[4].

According to the adopted documents, the owner of the microgeneration facility must perform the actions shown in Fig. 1.

When implementing technological connection, the grid company installs a metering device free of charge - a special bidirectional meter, which should provide hourly measurements of active and reactive energy in AC networks and thanks to which the power supply company will be able to remotely analyze the amount of energy consumed and generated by the microgenerator.

The payment for technical connection for microgeneration facilities is currently preferential and involves a fee only for "paper" in the amount of not more than 7.6 dollars, provided that the distance from the site boundaries to the power grid facilities is no more than 300 m in cities and no more 500 m - in the countryside[5].

The mechanism of operation of the microgeneration facility is based on the fact that the generated electricity is primarily used to cover the load of the consumer, and the part of the electricity that turned out to be “extra” at that moment goes to the external network, which in this case plays the role of an external huge energy storage. Then the consumer at the right time "takes" his surplus on the terms of netting (balancing) or implements it and receives payment for it.

As an supplementary incentive mechanism, in addition to the possibility of reducing the volume of purchased electricity and selling the resulting surplus until 2029, the sale of energy by the owner of a microgeneration facility is not subject to personal income tax (depending on the income of an individual - 13 or 15%).

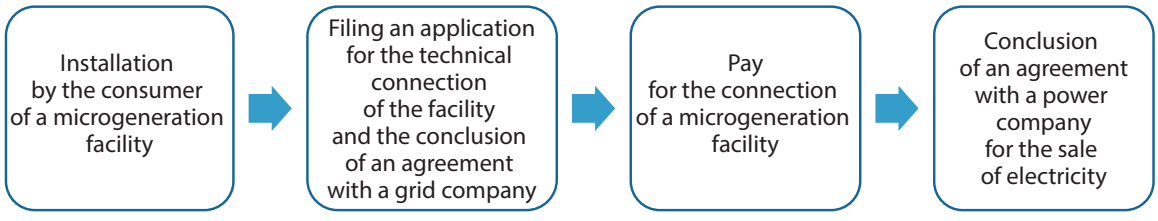
A serious drawback of the implemented mechanism for the development of microgeneration is that it does not apply to apartment buildings.

It was expected that the introduction of the considered mechanism for stimulating microgeneration would lead to its explosive growth. But this did not happen - for the most part due to insufficient awareness of the population about the benefits of this tool.

3. Assessment of the development potential of the microgeneration market in Russia

It is rather difficult to reliably assess the current level of development of the microgeneration market based on RES in Russia, given that all its players are small companies that do not publish their data, and state statistics on commissioning microgeneration facilities is not kept. According to available rough estimates, up to 100 MW of solar power plants were installed in this sector in 2014-2020 (and the domestic market is represented mainly by photovoltaic installations). At the same time, the main volume of commissioned microgeneration based on RES fell on 2020 and amounted to 50–60 MW [Lanshina, 2021]. A large share of this volume

Fig. 1. Procedure for obtaining the microgeneration status



[3] Federal Law No. 471 of December 27, 2019 “On Amendments to the Federal Law “On the Electric Power Industry” in Part of the Development of Microgeneration”. . URL: http://publication.pravo.gov.ru/Document/View/0001201912280019.
[4] Decree of the Government of the Russian Federation from 02.03.2021 No. 299 “On Amendments to Certain Acts of the Government of the Russian Federation in Part of Determining the Peculiarities of Legal Regulation of Relations with the Operation of Microgeneration Facilities”. URL: http://publication.pravo.gov.ru/Document/View/0001202103060015.
[5] Decree of the Government of the Russian Federation from December 27, 2004 No. 861 “On Approval of the Rules for Non-Discriminatory Access to Electricity Transmission Services and the Provision of These Services…”. URL: http://www.consultant.ru/document/cons_doc_LAW_51030/.

is installed at the facilities of legal entities, 10–15 MW fall on individuals[6].

To date, microgeneration in Russia has not yet become widespread, however, the potential of the microgeneration market based on RES is assessed as very significant, despite the fact that there is no understanding of the real scale of the installed capacity of already implemented projects.

According to expert estimates, starting from 2021 and over the next five years, the volume of commissioning of microgeneration based on renewable energy sources in Russia will amount to 150–200 MW per year, and the market turnover will reach about $140 million [Renewable energy market.., 2021]. According to other estimates, RES-based microgeneration can provide an additional 0.6 GW of generating capacity [Khokhlov et al., 2018]. In total, the achievable potential of the microgeneration market based on RES without a negative impact on the energy system is estimated by experts up to 15 GW [Rozhenko, 2018; Losse et al., 2019]. At the same time, the Russian Ministry of Energy expects a slight increase in microgeneration volumes - in the amount of 15–30 MW per year[7].

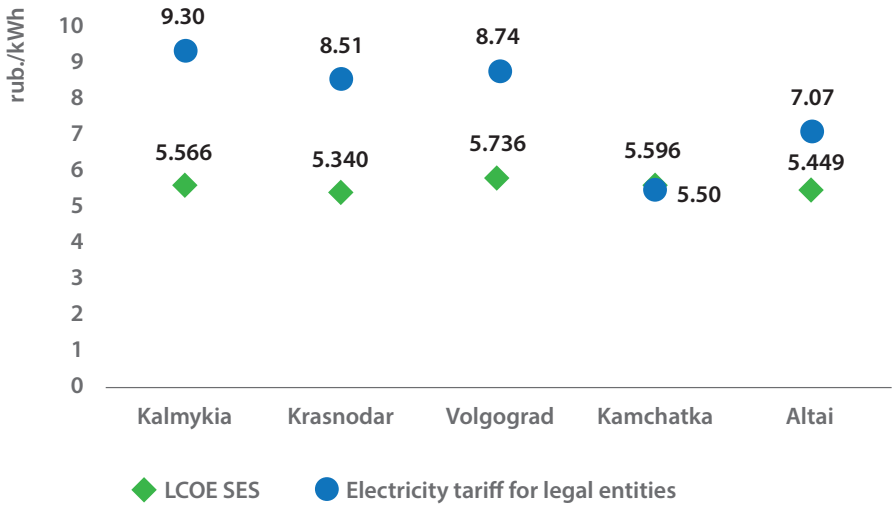
The main growth drivers of the microgeneration market in Russia are the increase in electricity prices and the reduction in the cost of renewable energy equipment. According to the Association of Guaranteed Suppliers and Energy Retail Companies, the total cost of electricity in Russia, depending on the region, is in the range of 0.08–0.15 USD/kWh.[8] By 2025, in some regions, tariffs may increase to $0.2/kWh [Lanshina, 2021]. This encourages consumers of electricity to look for alternatives to energy supply, one of which is the construction of their own microgeneration based on renewable energy sources.

In the Krasnodar Territory, Kalmykia, Altai, Volgograd Region, the price of electricity for small and medium-sized businesses on low-voltage networks is in the region of 0.8–0.12 USD/kWh. And the price of electricity (Levelized Cost of Electricity, LCOE), generated using microgeneration based on photovoltaic cells, according to our estimates, is about 0.08 USD/kWh. In the long term, this gap will only increase due to rising prices for electricity from the energy system and a decrease in the cost of renewable energy equipment (Fig. 2).

Taking into account the noted trends in the domestic market of microgeneration based on RES, additional mechanisms to stimulate its development on the part of the state will be required only if there is an interest in higher rates of decarbonization of the housing and communal services sector and the implementation of an industrial policy aimed at strengthening the Russian sector of the renewable energy industry.

Given that tax incentives for owners of microgeneration are already provided. In order to achieve these goals for decarbonization and ensure economic growth, industrial policy should include the tools to subsidize the domestic renewable energy industry, reduce transaction costs associated with finding bona fide suppliers, as well as informing consumers about advantages of using own microgeneration based on RES.

Fig. 2. Value of solar power and electric power from the grid in Russian regions in 2021



[6] Shakhrai I.S. There is simply no market – it needs to be created (2021). *Kommersant,* 57. URL: https://www.kommersant.ru/doc/4753144.
[7] The sun of our roofs (2021). *Kommersant,* 57. URL: https://www.kommersant.ru/doc/4753266.
[8] Electricity tariff base. URL: https://time2save.ru/calculaters/nereguliruemie-ceni-na-elektroenergiu.

Conclusion

The analysis of the potential for the development of microgeneration based on RES in Russia indicates that this sector can become one of the tools for reducing CO_2 emissions in the housing and communal sector and the Russian economy as a whole. In addition, the use of tools to stimulate the development of the microgeneration market based on renewable energy sources, which have shown their effectiveness in foreign markets, will significantly accelerate the decarbonization of the domestic economy and ensure the economic growth of the national economy.

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Strategic management in ecosystems: Analysis of the Russian experience

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Abstract

Ecosystems as new organizational forms of business, whose activity generates changes in the theory and practice of management, have become a significant phenomenon of the modern economy. The article discusses the features of the strategy development of ecosystems based on digital platforms, the typology of strategies and the directions of classical approaches transformation to the strategic development of ecosystem players. The research methodology includes the analysis of scientific approaches within the framework of the emerging ecosystem theory as well as the systematization of the national digital ecosystems' practice based on the analysis of real situations from various spheres of Russian business. As a result of the analytical study, the multi-vector strategies of Russian ecosystems are described; the dominant directions of development in transaction ecosystems and decision ecosystems are identified and systematized on the basis of the Ansoff matrix. The directions of transformation of traditional methods and tools of strategic management in a broad context are revealed from the standpoint of market and intra-ecosystem interactions. The obtained results contribute to the urgent scientific discussions concerning the prospects and limitations of the digital ecosystems development, changes in the nature and models of competition, as well as the problems of traditional management methods transformation in the digital economy.

Keywords: ecosystems, digital platforms, mechanisms of growth, strategies of Russian ecosystems.

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Introduction

In the digital economy, the trend of the formation of ecosystems as new organizational forms and business growth mechanisms is actively developing. Modern ecosystems are becoming "digital superpowers" that can control critical bottlenecks, extract additional value, and upset the global competitive balance [Yansiti, Lakhani, 2021. p. 225]. By erasing traditional industry boundaries and networking previously disparate industries, offering consumers a variety of services in a seamless experience, the owners of well-known ecosystems (Apple, Microsoft, Amazon, Alphabet, Facebook, Tencent, Alibaba) are strengthening their role in the economy. Russian companies that develop an ecosystem approach are still significantly inferior to world leaders, but five companies (Yandex, Mail.ru, 1C, Tinkoff, Wildberries) entered the top 100 technology companies in the developing countries in 2020 - applicants for technological leadership, according to BCG consulting company[1].

However, the development of ecosystems is changing not only the global business landscape, but also the business

[1] 2020 BCG Tech Challengers, exeb. 3. URL: https://www.bcg.com/publications/2020/bcg-tech-challengers-thrive-in-emerging-markets.

model of companies, shifting the focus from internal development to working with partners, networking and digital business transformation. These changes actualize the search for new mechanisms of strategic management based on the analysis of best practices and their scientific generalization.

The purpose of the study is to identify the features and directions of transformation of classical approaches to the development of strategies for companies that form ecosystems based on their digital platforms.

To achieve this goal, based on a comparative analysis of the strategies of Russian ecosystem companies, the following tasks were solved:

1) generalization of theoretical and methodological approaches to the study of ecosystems and development of research design using the BCG ecosystem typology;
2) identification of vectors for the development of two ecosystem types and their systematization based on the Ansoff matrix;
3) determination of the main development aspects of strategic management in the world of ecosystems and digital platforms.

1. Ecosystems: theoretical and methodological foundations of the research

Borrowed from biology, the term "ecosystem" was introduced into business circulation by J. Moore, who suggested that the ecosystem would become a new important organizational form of business in the world of rapidly developing technologies [Moore, 2006]. Indeed, the world's dominant ecosystems are largely shaped by high-tech companies based on digital platforms. Currently, within the framework of the emerging theory, several areas or ecosystem concepts have been identified: innovative and entrepreneurial, a business ecosystem, an ecosystem based on digital platforms [Jacobides et al., 2018; Hein et al., 2020], transaction and decision ecosystems [Pidun et al., 2019]. In the article, we consider ecosystems based on digital platforms (since the most developed ecosystems in Russia belong to this type), dividing them into ecosystems of transactions and decisions.

A digital platform is defined as a set of components (software and hardware, service modules, etc.) and rules for the interaction of participants [Eisenmann et al., 2011], which are organized by the platform owner. As the technical infrastructure of ecosystems, digital platforms tend to have a modular architecture that includes a relatively stable core and flexible periphery [Tiwana, 2018], creating competitive advantages through the scale and matching supply and demand [Thomas et al., 2014; Constantinides et al., 2018]. Along with the architecture of a digital platform, many researchers identify such structural elements as activities and actors [Adner, 2017; Kapoor, 2018; Hein et al., 2020]. The platform owner organizes interactions between actors, thereby forming an ecosystem within which transactions are facilitated, innovation processes are accelerated, and additional opportunities are provided in terms of analytics, joint value creation and development of participants. The rules for the organization and interaction of actors within an ecosystem are determined by the ownership status [Gawer, Cusumano, 2015; Tiwana, 2018]. Based on this, A. Hein and co-authors propose the following definition: a digital platform ecosystem includes a platform owner who, through management, facilitates the mechanisms for creating value on the platform within the interaction of the owner, independent ecosystem complementizers and consumers [Hein et al., 2020. P. 90] .

When analyzing the best practices for developing ecosystems, researchers study the problems of innovation [Evans, 2016; Eferin et al., 2019], interaction with the external environment [Demil et al., 2018], the impact of the complexity of the digital platform on the transition of participants to competing ecosystems [Ozalp et al., 2018], the interaction of ecosystem actors based on the roles they play [Alstein et al., 2017; Adner, 2017; Jacobides et al., 2018], monetizing the activities of ecosystem participants [Williamson, de Meyer, 2019].

A significant part of the work is devoted to strategic analysis and development of an ecosystem strategy, which R. Adner defines as a method that a central firm uses to coordinate the actions and interests of partners while maintaining its role in a competitive ecosystem [Adner, 2017; Xing et al., 2017]. It should be noted that, despite the huge potential of the ecosystem approach, not all companies have managed to create a successful platform, let alone form a developing ecosystem based on it [Yoffie et al., 2019; Zhu, Iansiti, 2019]. The complexity of forming an ecosystem strategy as a dynamic group of largely independent actors is due to the fact that, on the one hand, it must determine the general vector of ecosystem development, and, on the other hand, ensure coordination of actions and a balance of values and interests of its participants. The difficulties are exacerbated by the fact that platform companies are becoming inverted in nature [Parker et al., 2017; Alstyne, 2019], focused on enabling users to meet diverse cross-sectoral needs in a seamless experience [Pidun et al., 2019]. As a result, approaches to strategic management are being transformed in the ecosystem world [McIntyre, Srinivasan, 2017; Jacobides, 2020; Yansity, Lahani, 2021], the analysis of which determines the relevance of the presented study from the standpoint of theory and practice.

2. Study design

The Central Bank of Russia lists six companies as creators of ecosystems in our country: Sberbank, VTB, Tinkoff, MTS, Yandex and Mail.ru[2]. To understand whether there are other contenders for creating ecosystems we analyzed the 10 most expensive Runet companies at the beginning of 2021, according to Forbes (capitalization is more than 1 billion rubles), based on the following features: the presence of a digital platform, the variety of services and goods offered, independence (the company is not included

[2] Ecosystems: approaches to regulation. Public consultation report (2021). M.: Bank of Russia, April: 12-15.

in the above ecosystems)[3]. There were six such companies, but Yandex and Mail.ru Group (MRG) are already on the list of the Central Bank of the Russian Federation, respectively, Wildberries, Ozon, Avito and 1C are added to the potential creators of ecosystems. There are other platform companies in the Forbes rating, but some of them have already been absorbed by other ecosystems (these are Delivery Club, Aliexpress Russia, Citymobil, Okko, Goods, 2GIS); the scale of other companies' business is still small.

As a result, the list of companies selected for analysis included 10 representatives of different businesses, and most importantly, different types of platforms on which the ecosystem is formed. Further, using the methodological approach of the BCG consulting company [Pidun et al., 2019], we identified transaction and decision ecosystems.

The group of transaction ecosystems includes three companies: Wildberries, Ozon and Avito, which belong to the type of aggregator platforms, providing data aggregation and transaction implementation. The remaining seven companies form solution ecosystems. These are Yandex and MRG, which are high-tech diversified holdings and, in fact, are national digital diversified ecosystems. 1C Company has formed a specialized ecosystem of technological solutions for automating management and accounting at enterprises in various industries. Three banks (Sberbank, VTB, Tinkoff) and the telecommunications company MTS also announce the formation of ecosystems and transformation into high-tech IT companies.

Then, based on available open information, the specifics of growth strategies in each group of Russian ecosystems were determined within the framework of two main vectors of ecosystem development: vertical and horizontal [Chung et al., 2020].

When moving vertically, ecosystem organizers focus their efforts on the development of key technologies and products based on the platform core, remaining within industry boundaries, but striving to increase their influence or even dominate at touch points in the customer journey.

The horizontal vector of ecosystem formation involves expanding the value proposition and diversifying the product portfolio, often accompanied by crossing traditional industry boundaries, entering new areas of activity and expanding the pool of participants.

As they move vertically and horizontally, ecosystem organizers bring together various links in the value chain, forming customer-centric value propositions, providing an end-to-end (seamless) experience with a wide range of services through a single access (ID or superapp[4]). However, the ways and mechanisms for bringing together ecosystem participants differ; we highlight partnership and investment mechanisms, as well as the organic growth of the ecosystem through the internal resources of the organizing company.

3. Ecosystems of transactions

In the digital economy, ecosystems are formed by platform-type companies, and since aggregator platforms that operate in bilateral markets initially appeared and became most widespread in practice, it is natural that a large number of ecosystems are formed on the basis of aggregator companies in the process of their evolutionary development [Lee, 2013 ; Trabucchi, Buganza, 2020]. Moreover, such an ecosystem can remain vertically oriented or gradually diversify, as, for example, the Alibaba ecosystem [Tan et al., 2016].

The leader among Russian aggregators is the Wildberries marketplace (second place in the list of the most expensive Runet companies, according to Forbes), the main characteristics of which are given in Table. 1. Created in 2004, the Wildberries online store has turned into a marketplace operating on a commission business model: partners independently form the range of goods for sale through the marketplace, and can also determine the warehouse policy. Wildberries provides the e-commerce platform, logistics of goods and receives a commission based on the results of sales. The emphasis in the business model is on the rapid delivery of goods to the regions, for which the networks of its own distribution centers in large cities and points of issue of orders with the possibility of trying on goods (more than 7 thousand points) are expanding. In 2021, Wildberries bought Standard-Credit Bank to settle accounts with suppliers and create loyalty programs on its basis.

In general, the Wildberries multi-vector strategy is a strategy of organic growth and market expansion within the marketplace business model, the hallmarks of which are dynamism, a quick response to changing market conditions, the ability to change partnership models with suppliers and working conditions with consumers quickly.

The second place goes to Ozon, founded in 1998 as a service for selling books. The business model of Ozon, unlike Wildberries, is a hybrid one, it includes its own online store and marketplace (Table 1). Ozon's strong point is its multi-channel delivery system, including parcel lockers and pick-up points, supported by a developed IT infrastructure based on its own technological platform. The company is unprofitable and is developing at the expense of investors investing in logistics and the creation of distribution centers. To expand financial services in May 2021, the company acquired a bank renaming it into Ozon Bank.

Overall, Ozon's multi-vector strategy is one of aggressive growth and market expansion within a hybrid business model with an emphasis on multi-channel delivery.

The third major aggregator is Avito company, created in 2007, which implements the business model of the classified, or bulletin boards from individuals and legal entities. In terms of popularity and the number of ads, Avito takes the first place in Russia, every month it is visited by about 50 million people. Avito development tools are organic growth, acquisitions, various forms of partnership. Avito provides entrepreneurs with a convenient tool for creating online

[3] URL: https://www.forbes.ru/biznes-photogallery/421235-30-samyh-dorogih-kompaniy-runeta-reyting-forbes.

[4] ID - a single unique identifier. Superapp is an application with an extended set of functions (services) that keeps the user within the same ecosystem

Table 1
Comparative characteristics of Russian aggregator companies in 2020

Company parameters	Money turnover, billion rub	Growth compared to 2019, %	Capitalization, billion USD.	Number, thousand people	Business model	Financial partners
Wildberries	437.2	96	14.5	More than 20	Marketplace	Bank
Ozon	197.4	144	10.6	12	Internet shop + marketplace	«Ozon bank»
Avito	29.0	20	4.9	2.1	Classified + marketplace (plan)	Naspers Foundation

stores where they can post information about their products. Neural network technologies make it possible to recognize and identify a product based on a photo, simplifying the procedures for sorting and placing products on the site. Strategic plans are related to business transformation: Avito plans to turn into an online marketplace while operating on the basis of a combination of marketplace and classified business models.

Comparative characteristics of the activities of aggregator companies, systematized in Table 1 show that they are focusing on their core business and business model development, realizing the vertical development vector of their ecosystems.

Moreover, if Ozon initially functioned as an online store, and Avito as a classified one, then over time they created marketplaces as a way to grow through an affiliate network, thereby changing the strategy for creating value for consumers. This similarity of strategies and the convergence of business models turned the considered companies into direct competitors, which forces them to look for new strategic development alternatives aimed at vigorous expansion into the regions and rapid adaptation to regional specifics based on the use of platform advantages, retaining customers and partners, and encouraging them exclusively use one platform.

In general, the main aspects of the transformation of approaches to the strategic management of transaction ecosystems are the multi-vector strategies (commodity and market expansion, the internal development of platform technologies as a factor in supporting dynamic market behavior), the desire to enter the financial sector to provide new strategic initiatives, the creation of additional value for consumers for partnership account, search for new alternatives for linking participants to the ecosystem.

So far, the development plans of the reviewed companies do not include statements about possible business diversification, which is apparently explained by the competition between them and other marketplaces for Russian consumers.

4. Ecosystems of solutions

Seven large Russian ecosystems are based on solutions to various customer problems: an information retrieval system (Yandex), a mail service (Mail.ru), banking (Sberbank, Tinkoff Bank, VTB) and telecommunications services (MTS), automation of management and accounting at enterprises (company 1C). Moreover, only the 1C company solves the problems of customers in the B2B market, the rest of the companies work simultaneously in the B2B and B2C markets.

Researchers note that companies, which have succeeded in creating a critical mass of client, can use this asset to enter many different markets and form new networks that mutually reinforce each other's positions [Yansity, Lahani, 2021]. Having formed extensive client bases in the consumer market, the named domestic companies (with the exception of 1C) have engaged in horizontal development, forming new networks and diversifying their activities. The related diversification of the 1C company is apparently due to the fact that it operates in the B2B market, where, unlike consumer markets with massive same-type demand, the needs of companies are differentiated and depend on many specific factors. Attempts by other ecosystems to create solutions for B2B markets are still limited (SberB2B wholesale marketplace).

For a comparative analysis of the diversification level of solution ecosystems, the authors identified the most common categories of services in Russian practice that can be available to consumers:

- information and reference services (search, maps, mail, analytics);
- electronic commerce;
- offline services (delivery, taxi, car sharing, etc.);
- media services, entertainment, communications (news, cinema, music, video, games, social networks, etc.);
- classifieds - sites of ads from individuals and companies;
- financial services (payment systems, banking, insurance services, discount programs);
- health, education, children;
- new technologies (cloud storage, voice assistants, identification systems).

Also, to assess the level of diversification of various ecosystems, we estimated, according to financial statements, the share of the income of the organizing company from the underlying business.

The leader in the development of a national diversified ecosystem focused on the widest possible range of services for customers is Yandex, founded in 2000. In 2019, Yandex entered the top 100 fastest growing companies in the world, according to Fortune, ranking 24th. In 2020, the company's revenue amounted to 218.3 billion rubles, an increase of 24%. The capitalization of the company at the beginning of 2021, according to Forbes, is $ 22.98 billion, this is the most expensive company on Runet. However, experts note that with an increase in turnover, the company's profit grows slowly, since many new types of businesses are low-margin. Yandex's key business remains its search engine (about 60% share in Russia), which is constantly evolving based on artificial intelligence technology. In 2018, the share of Yandex's R&D expenses was 17.7% of revenue, which is higher than that of Amazon.com (12.7%) and Alphabet (14.6%)[5].

In the process of diversifying the ecosystem, more than 90 Internet services for users have been created, which cover all the categories we have identified. These are information retrieval services, e-commerce, media and entertainment, education (Yandex.Textbook and the School of Data Analysis), health, finance (Yandex Pay, BCS Investments), new technologies (Alice voice assistant, Yandex.Browser ", "Yandex.Disk", drones). For a long time, the majority of the company's revenue was generated by the advertising model of search, but as new services develop, the share of their income is approaching half.

The choice of new directions for the company is based on constant experimentation with creative ideas for the development of technologies and finding integration and synergy between services within the ecosystem. In the process of creating an ecosystem, a wide range of growth mechanisms was used: acquisitions, alliances, organic growth through internal entrepreneurship. In April 2021, Akropol Bank was purchased, which will contribute to the development of financial services for consumers of the Yandex ecosystem.

In general, Yandex's diversified growth strategy is aimed at expanding the range of services provided while maintaining the dominant role of the key search business and constantly developing technologies.

The creator of another national diversified ecosystem, Mail.ru Group (MRG), declares an ambitious goal - to become the country's largest ecosystem - and characterizes its business model as an ecosystem of ecosystems. In 2020, the company's revenue grew by 21.2%, amounting to 107.4 billion rubles. However, with a turnover of about twice less than that of Yandex, Mail.ru is estimated by the market at 3.8 times cheaper.

The key business and origin of the company was the mail service and search engine, but now it accounts for approximately 1% of Russian search. MRG focuses on communication and entertainment services, expanding the value proposition through development in complementary areas. The company's portfolio includes social networks (VKontakte, Odnoklassniki), which brought almost half of the company's revenue in 2020, and multiplayer online games. As part of the diversification, the Yula ad service, the Skillbox educational service, the Health and All Pharmacies services, the Marusya voice assistant, VK Pay and Money mail.ru financial services, entered the ecosystem as joint ventures. food delivery aggregators Delivery Club and Samokat, taxi service Citymobil, etc. In other words, following the competitors, MRG develops all categories of services, but at the same time places a strong emphasis on partnership and multi-brand, which has come into conflict with the development of the ecosystem as single seamless space for consumers. In October 2021, the company rebranded and introduced a single VK umbrella brand for all the company's services and projects[6].

Overall, MRG's diversified growth strategy is based on developing partnerships and redefining the core business, combined with rebranding.

A comparative analysis of two national ecosystems created on the basis of IT companies shows that, despite their pronounced individuality, the strategies for forming the ecosystems of Yandex and MRG show much in common:

- Ecosystems rely on large amounts of user data accumulated after the use of the underlying technology;
- the main priority of the company's development is customer orientation and strive to implement a single sign-on to meet the diverse needs of users (the principle of superapps);
- Strategies distinguish between vertical and horizontal vectors of development. But if approximate parity between key and additional services has been achieved in the Yandex ecosystem, then in the Mail.ru ecosystem the share of the key service is steadily declining, and the main contribution is made by communication and entertainment services;
- ecosystems are structures managed and coordinated by a central firm (hub), which determines the rules for entry and behavior of participants;
- the desire to form a portfolio of services that cover the majority of human needs leads, as expected in [Srnichek, 2019], to the gradual convergence of initially different ecosystems, which become direct competitors.

Commercial banks and telecommunications firms have also accumulated large amounts of customer data, which are facing growth challenges and threats from high-tech companies, forcing them to go down the path of creating digital ecosystems.

The undisputed leader is Sberbank, which since 2017 has been building an ecosystem outside the banking sector. After rebranding in 2020, Sber brought together under this name dozens of products that form a "universe of useful services for life and business development" that save the most valuable thing – customer time (the Sber ecosystem includes more than 50 companies). However, despite significant investments in

[5] URL: https://raex-rr.com/country/RAEX-600/innovative_companies.
[6] URL: https://www.tatar-inform.ru/news/mailru-group-smenit-nazvanie-na-vk-5839465?utm.

non-financial business, its contribution to the total revenue of Sberbank in 2020 remained at the level of less than 1%. In the future, it is planned to increase the share of this sector to 20–30%, in particular, Sber expects to become one of the top three leaders in the Russian e-commerce market.

The digital ecosystem of Sberbank is being created mainly through the acquisition of companies, which can be explained by the bank's powerful financial resources. So, in 2019, Sberbank bought a 46.5% stake in the Rambler Group holding (includes Okko online cinema, Rambler.ru search engine and mail service, Gazeta.ru, Lenta.ru, etc.), in 2020 75% stakes of 2GIS was acquired, which allowed Sber to fill a gap in information and reference services. In April 2021, the creation of a joint venture between Sberbank and Rostelecom, Digital Identification Technologies was announced. Along with business diversification, Sber is actively developing its technologies, combining various services into a single ecosystem[7]. At present, Sber ecosystem is only slightly inferior to the Yandex ecosystem in terms of the variety of services offered, covering all the categories of services we have identified.

The development of the ecosystem is proclaimed as its strategic goal by the financial corporation TCS Group Holding, Tinkoff brand. Established in 2006, Tinkoff Bank has developed a fintech area and positions itself as an ecosystem of financial and non-financial services for clients. It includes such segments as auto (car loans, insurance, rent), home (insurance, mortgage), travel (tickets, hotels, etc.), leisure and entertainment (movie tickets, theater tickets, etc.). The holding is interested in independent partners connecting to the platform through open programming interfaces (APIs). Although there were also purchases of businesses: a payment service and a share in the Kassir.ru service were bought.

The bank has already created a superapp that brings together more than 20 services of Tinkoff and its partners. The company is trying to diversify, but so far banking is the main source of income.

The vector of ecosystem development around its business also attracts other banks. In particular, VTB announces the formation of an open VTB ecosystem based on a partnership model, for which a digital platform has been developed and APIs have been opened. Priority areas for the development of the ecosystem have been identified: e-commerce, Internet and media, telecom and communications, housing and utilities, transport and logistics.

Table 2
Comparative characteristics of Russian diversified ecosystems of solutions in 2020

Ecosystem indicators	Technological background (basic business)	Share in incomes of the basic business, %,	Number of services (assessment)	Single point of entry	Strategic positioning	Strengths
«Yandex»	Search platform	50	More than 90	Superapp «Yandex GO»	Customer oriented Ecosystem	Technology and engineering
Mail.ru Group	Post service /Social networks and games	≈ 70	30–40	Common ID (plan)	Ecosystem of ecosystems for man and his needs	Audience Leadership
«Sber»	Banking platform (Platform V)	≥ 99	More than 80	SberID	A universe of useful services for life and business development	Financial resources
«Tinkoff»	Fintex	76	More than 20	Superapp	Lifestyle banking	Internet bank
MTS	Telecom	81	More than 30	No	Product ecosystem	Data centers and communication channels countrywide

Note. The table does not include VTB, where the process of ecosystem formation is at an early stage.

[7] At the beginning of 2020, Sberbank began to cross-link services with each other, forming package offers or bundles for customers (2020). *Harvard Business Review - Russia*. January February. p. 67.

However, in order to reduce the risks of banking activities, the Central Bank of Russia proposes to limit the investments of credit institutions in ecosystems by setting a limit on investments in non-core (immobilized) assets, which may lead to a decrease in the attractiveness of the idea of forming banking ecosystems.

The players in the telecommunications sector are also following the course towards the formation of ecosystems. Thus, MTS announces a strategy for transforming into an IT company that is forming its own ecosystem. Telecommunications remains MTS's key business (81% of revenue in 2020), while other areas (media, e-sports, fintech, etc.) provided almost a third of the company's annual growth. According to the management, the main task of MTS is to fill the ecosystem with its own and partner applications and services while maintaining a focus on traditional business and ensuring synergy of services. It is planned to strengthen the presence in complementary markets with faster growth rates, implementing a diversification strategy.

Due to financial opportunities, the company uses various growth mechanisms: from organic growth and partnerships to acquisitions of other companies. Thus, the purchase of two ticket operators allowed MTS to become the leader in sales of theater and concert tickets in Russia (Ticketland.ru brand). In general, the MTS ecosystem is at the initial stage of formation, while there is no seamlessness in terms of access to services, there are no superapps, but more than 30 applications are available to customers.

Other telecommunications companies (Rostelecom, MegaFon) are only taking tentative steps towards creating ecosystems.

An analysis of the strategic goals and development trajectories of companies from the financial and telecommunications sectors (Table 2) allows us to conclude that the course towards the formation of ecosystems around key technologies is motivated by the struggle for customers, the desire for growth and, at the same time, business stability in the face of growing threats.

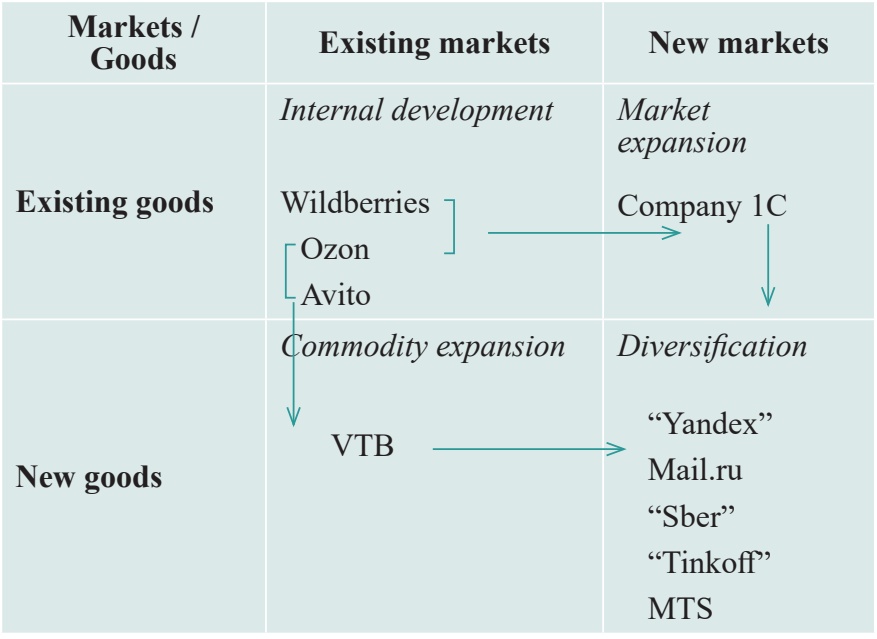
Note. The table does not include VTB, where the process of ecosystem formation is at an early stage.

The three recognized leaders occupy different positions in the market, which is reflected in their positioning and development strategies. Yandex has reached parity in terms of revenue from the core business and diversified services. Mail.Ru Group positions itself as an ecosystem of ecosystems, and in the process of developing the ecosystem, the basic business was redefined: from the mail service to communications and entertainment. Basic business dominates in Sberbank, and the regulator represented by the Central Bank of Russia may become a barrier to achieving the stated goal - bringing the share of income from non-financial services to 20-30%[8].

Two other companies - Tinkoff and MTS, as well as VTB, Rostelecom, MegaFon, are followers, implementing catch-up strategies.

In general, the landscape of Russian diversified ecosystems is very mobile, they are dynamically developing vertically and horizontally, processes of convergence and copying of services are taking place (after the voice assistant Alice from Yandex, Marusya from Mail.Ru appeared, Oleg from Tinkoff), alliances are created and disintegrated ("Yandex" – "Sber", "Sber" – Mail.Ru), acquisitions are

Fig. 1. The Ansoff Matrix for the strategies of Russian ecosystem players



[8] Sberbank was reminded that it is still a bank (2021). *Expert*, 27:4.
The Central Bank of the Russian Federation believes that large ecosystems can create systemic risks for the economy, therefore it introduces a new standard for regulating the activities of banks - a risk-sensitive limit as a percentage of the bank's capital, as a result, the bank will have to finance the development of the ecosystem from its own capital.

underway, shares in competing ecosystems are being bought. All diversified ecosystems declare customer centricity as a core value and go in the direction of creating a seamless path for customers by creating superapps.

Aggregator companies develop core competencies and form networks of actors around their digital platforms that perform various activities, trying to attract both consumers and suppliers. The convergence of the business models of participants leads to increased competition and stimulates the development of differentiated competitive strategies aimed at creating unique value for consumers.

With regard to diversified solution ecosystems, it is necessary to note the clearly manifested process of their convergence, which also leads to direct competition of ecosystems, intensifying the struggle for customers. The prevailing mechanisms for the growth of such ecosystems turn them into centrally controlled conglomerate structures with common ownership and a minimum level of partnership. On the one hand, this creates financial risks for the core business and for new services, and on the other hand, it provides conditions for the development of new promising markets through cross-subsidization. The most important strategic task in this case is portfolio management, aimed at finding the potential for synergy between services and platforms within the ecosystem.

The partner network of 1C company allowed to develop the strategy of market expansion actively, while the hallmark of the partnership strategy is the inclusion of independent developers in the number of participants, making a significant contribution to the development of the basic product of the digital platform. An important strategic task in relation to such ecosystems is the formation of rules for the interaction of different actors within the ecosystem, ensuring a continuous flow of innovations.

Conclusion

Based on a comparative analysis of the development processes of leading Russian companies that form ecosystems based on their digital platforms, it is shown that all of them are dynamically changing in the struggle for customers, their time, money and transactions. However, the development strategies in this competitive struggle among companies differ significantly, as shown in the Ansoff matrix (Fig. 1).

The directions of transformation of classical approaches to the development of strategies for ecosystem players are identified:

- Strategies become multi-vector (implemented in a wide range of business areas) and multi-agent, including a variety of partners and interest groups;
- the object of strategic analysis is not the supply chain, but the partner network formed around the digital platform, within which value is created for consumers, while the network architecture ensures the achievement of synergy between the products and services of the ecosystem, and the migration of value goes towards a seamless customer experience;
- specific aspects of ecosystem strategies related to the interaction of its participants are being developed and aimed at balancing their interests and stimulating innovative activity (determining the rules for entering the ecosystem, the principles of pricing and distribution of added value, access to data). An integral characteristic of ecosystem development strategies is the acquisition (partnership) of a financial company;
- new strategic alternatives are being formed related to the retention of participants within the ecosystem (difficulty in their transition);
- Against the backdrop of increased competition and convergence of ecosystem activities, various forms of cooperation between ecosystems are developing, co-competition strategies are acquiring new features.

The directions of traditional methods and tools of strategic management development in the world of ecosystems identified as a result of the study are of interest to specialists in the field of strategic management. The landscape of Russian ecosystems formed on the basis of digital platforms and its development trends described in the article can be useful to practitioners, primarily managers of ecosystem organizers, as well as other business entities that can potentially join the ecosystem.

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Entrepreneurship in sports industry: Directions, innovations and support

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Abstract

Within the framework of this article, the authors analyze the following areas of entrepreneurial activity in sports industry: sports and health services, including fitness clubs, sports clubs, schools and academies; managing the competitions (leagues); corporate sports; media resources; bookmakers, e-sports. As part of the work, positive examples of entrepreneurship in sports industry were noted, as well as the role, interests and tasks of the state. The directions of innovative development within each of the identified blocks are considered separately. The authors also systematized support measures for development entrepreneurship (small and medium enterprises – SME) and identified its features for the sports industry. Following directions for further research are proposed: analysis of individual markets for entrepreneurship in the sports industry; development and testing of methods for assessing the effectiveness of support measures for SME in sports industry; development of professional training of entrepreneurs for the sports industry.

Keywords: sports management, fitness management, sports innovation, fitness innovation, fitness industry, corporate sports, marathon market, sports media, bookmakers, eSports.

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Introduction

Among the values of physical culture and sports contained in the Strategy for the Development of Physical Culture and Sports until 2030, there is sustainable economic development - the desire for innovation, support for competition and private initiative, as well as the development of forms of proportionally combined budgetary and non-budgetary financing of sports. At the same time, such a concept as "entrepreneur" is not even mentioned in the Strategy.

Among Russian scientists systematically dealing with the development of entrepreneurial activity in Russia and competition in it, it is necessary to single out Yu.B. Rubin [Rubin, 2021], which proves that entrepreneurship is a specific type of labor activity.

V.A. Lednev [Lednev, Bratkov, 2019; Lednev, 2020; 2021] in his works showed the interest of the state in the development of entrepreneurial activity in the sports industry. The author outlined the main trends in the development of entrepreneurship in mass sports, showed how the club system can influence the involvement of various categories of Russian citizens in sports.

V.V. Kudryavtsev [Kudryavtsev, 2019] analyzes the role of the state and the business community in the development

of physical culture and sports, and also proposes a number of measures to stimulate private initiatives including tax incentives (partly already implemented in Russia), the creation of information Internet portal system that would be able to unite the state, sports organizations, athletes, entrepreneurs and consumers of sports services, as well as the provision of affordable loans, low rental rates, "especially where it is possible to create bicycle, sports, cross-country, ski and mountain ski tracks, where it is possible to organize sports schools, clubs, to hold sports events. Also, the author [Kudryavtsev, 2017] identifies four areas where entrepreneurial activity in the field of sports can be carried out:

- preparation, organization and holding of sports events and provision of sports and health services;
- training of athletes, production of sports equipment, information and advertising support;
- construction of sports facilities, security, provision of transport, household, information technology and other services;
- Mass media, betting companies, etc.

This classification seems to be somewhat confusing - some activities can be assigned to several groups at once, and the principle of attributing to a particular area is not described accurately enough. It is also doubtful to classify such structures as entrepreneurial, such as:

- all-Russian and regional physical culture and sports organizations (federations, unions, associations) in various sports;
- public physical culture and sports societies;
- defense sports and technical organizations.

Finally, entrepreneurship in the sports industry can hardly be of a non-commercial nature, since the primary goal of any entrepreneur, regardless of the field of activity, is to make a profit.

MM. Ishchenko and S.I. Izaak [Ishchenko, Izaak, 2017] refer to sports industry entrepreneurs as sports goods manufacturers, sports TV channels, radio stations, websites, professional clubs, sports shops, sports facilities, fitness clubs, infrastructure facilities, bookmakers. At the same time, the authors emphasize the importance of using innovative technologies that allow optimizing the use of budgetary and non-budgetary sources of funding, improving sports results, involving the general population in sports, and improving the quality of sports services.

This study will present the author's approach to structuring entrepreneurship in the sports industry, consider the areas of innovation in this area, as well as relevant support measures.

1. State and entrepreneurship

The state today is extremely interested in the development of entrepreneurship in sports. First of all, this applies to mass sports. Very ambitious tasks have been set in Russia to attract various categories of Russian citizens to go in for sports. As part of the national goals, it is necessary to reach the involvement of various categories of citizens in sports up to 55% by 2024. As part of the Strategy for the Development of Physical Culture and Sports until 2030, this figure should be increased up to 70%. It is quite obvious that the state bodies responsible for the development of physical culture and sports (federal and regional levels) cannot cope with such tasks on their own. Therefore, it is necessary to attract private business to do it systematically and in all regions of the Russian Federation. Of course, today entrepreneurship in the sports industry is already developing, there is certain success and achievements. But still, there is not enough long-term and systematic support for this activity on the part of the state. As positive examples of the development of entrepreneurial activity in sports, one can name the long-term development of the fitness industry, the emergence of a large number of marathons, the development of private corporate leagues and the emergence of private sports clubs and schools. These are very important phenomena that are already becoming sustainable.

Therefore, we can say that the interests of the state and business finally coincide, and it is very good that we are talking about national goals and the implementation of indicators of the Strategy for the Development of Physical Culture and Sports.

If we talk about different categories of Russian citizens, then we must remember that many go in for sports at the place of study, work and residence. Further, it will be shown how individual segments are developing today, in particular the fitness industry, corporate sports and mass sports in various forms of their development.

2. Entrepreneurship market in the sports industry

If we objectively evaluate the level of entrepreneurship in the Russian sports industry, it should be noted that there are still very few real examples of private initiative in professional sports. Now the main tasks are a gradual departure from the use of budget funds, the widespread use of marketing tools to earn money and a phased transition to self-sufficiency models. We can definitely say that these are long-term tasks. A modest share of private clubs testifies to the low entrepreneurial activity in professional sports [Solntsev, 2020]. For example, in the Russian Premier League (RPL), only Krasnodar can be called fully private. At the same time, its owner Sergei Galitsky does not consider football a business[1]. Spartak Moscow does not disclose its full ownership structure and is also heavily affiliated with the Lukoil oil company, while CSKA ceased to be private after being taken over by the state-owned VEB. Positive dynamics has emerged in other football leagues: the number of private clubs in the FNL and FNL-2 is gradually growing, but none of them can boast of stable and positive financial results so far. Club owners also do not perceive sports as a business. In support of this, one can cite a quote from the shareholder of the Veles football club Evgeny Shilenkov: "Football is not a business for me, it does not bring money"[2].

[1] Sergei Galitsky: Is football a sport or a business? (2015). *Sport-Express*. URL: https://www.sport-express.ru/football/rfpl/reviews/896606/.
[2] Iliev S. (2020). Evgeny Shilenkov: I want to create a project where the club is the face of a person. Like Galitsky. URL: https://news.sportbox.ru/Vidy_sporta/Futbol/Russia/1st_division/spbnews_NI1194078_Jevgenij_Shilenkov_Khochu_sozdat_takoj_projekt_gde_klub__lico_cheloveka_Kak_u_Galickogo.

In mass sport, or, as they say abroad, sport for everybody, in Russia there are quite a few successful examples of entrepreneurial activity development. Let us consider the main ones.

1. The Russian fitness industry is today an obvious leader in entrepreneurship activity. This is a full-fledged and independent segment of the sport industry with an established infrastructure. There are almost eight thousand fitness clubs, fitness centers and fitness studios in Russia. This activity, under certain conditions, can be investment-attractive in the market, even though the coronavirus pandemic has greatly affected the income of fitness clubs.

2. Mass sports today provide many successful examples of entrepreneurial projects. A large number of competitions in various sports are regularly held (marathons and half marathons, bike rides, triathlon competitions, cross-country skiing, etc.). All this, as a rule, is a private initiative and private business. Very often such competitions gather thousands of solvent participants.

3. In recent years, a real boom has begun in the creation of private sports clubs, schools, academies and centers. This is applicable to both game and individual sports: football, hockey, boxing, MMA, e-sports, skateboarding, figure skating, diving, gymnastics, synchronized swimming. This explains only one thing: the client wants to play sports and is ready to pay money for a qualitative service.

4. For many years, various corporate leagues have been developing, which offer their customers the opportunity to participate in competitions on a regular basis. Once it all started with football, but today there are leagues that are not even for team sports. It is very important for clients when the leaders of these leagues take on numerous problems in organizing competitions, and clients pay registration fees for participation and just enjoy it.

5. Sports media today are represented not only by state publications – there are a number of successful projects created by private entrepreneurs. One of the criteria for success is mergers and acquisitions worth millions of dollars.

6. The betting business has been and remains one of the most closed, but the role of private investors in its development is obvious. None of the areas of the sports business shows such growth rates. The state continues to restrict the promotion of gambling, while the admission of betting companies to the professional sports market has created a stable source of income and even helped many clubs to survive.

7. E-sports can compete with bookmakers in terms of turnover growth, and traditional sports in terms of the number of participants involved. For many fans of computer games, this direction has become not just a hobby, but also a profitable business, which has a rather low entry threshold in terms of initial investment.

All these trends show that private business has studied the potential desires of customers well and is ready to provide a diverse range of products and services today.

3. Fitness industry

When we talk about entrepreneurial activities in the sports industry, we can recognize that the fitness industry is today its most dynamically developing and commercially attractive sector. If we take 1990-1991 as a reference, when the first fitness clubs appeared in Russia, then the domestic fitness industry has achieved excellent results in less than 30 years.

To be fair, it must be remembered that in the early stages of its development, the state practically did not notice this phenomenon. The Ministry of Sports of the Russian Federation often said that fitness clubs are commercial enterprises and they have nothing to do with sports at all. Then the situation began to change gradually, as the state authorities responsible for the development of physical culture and sports began to set the task of attracting Russian citizens to sports. It turned out that the interests of the state and the entire fitness industry coincide.

Today the situation has changed – government authorities and the fitness industry are working together. In 2019, historic amendments were made to the Federal Law "On Physical Culture and Sports in the Russian Federation", and fitness centers became full-fledged subjects in the field of physical culture and sports. Now the Russian Ministry of Sports regulates the fitness industry in a certain way.

If we analyze the scale of the fitness industry development, it is better to refer to official statistics. The data on the dynamics of the development of the fitness industry are given in Table 1.

Another important innovation was a tax deduction that can be issued when paying for sports and recreation services from 2022. You can return 13% of the costs for the subscription, but not more than 15,600 rubles.

The official statistics included only those fitness clubs that submit official reports. The actual number of clubs may be higher. However, in any case, the general dynamics of the development of the fitness industry is impressive – after all, 30 years ago everything started from scratch.

Table 1
Development dynamics of fitness industry in 2015–2020

Indicators	2015	2016	2017	2018	2019	2020
Number of fitness clubs (thousands)	5355	6069	6308	7065	7593	7812
Number of people involved in fitness clubs, million people.	3413	3992	5230	5399	6268	6674

If we analyze the structure of fitness clubs, then we must admit that they differ in terms of the available infrastructure, the range of sports and recreational services, and the number of people involved. There are already quite a few networks of fitness clubs, both federal and regional. Despite these differences, they share several important features.

Among the main features of the Russian fitness industry are the following.

All fitness clubs were originally created as commercial enterprises, as someone's specific private business, immediately focused on making a profit.

2. At the origins of each fitness club were private investors who relied solely on themselves and their capabilities, including financial ones. They did not count on the help of the state at all.

3. In order to make money on the provision of sports and fitness services, it was necessary to master quickly and effectively the entire set of various marketing tools for working with each client of a fitness club. It must be remembered that when clients pay their own money for services, they are very hypercritical about the price / quality ratio.

4. Today in the Russian fitness industry there is a certain competition for the client, and this will certainly lead to an increase in the overall level of quality of sports and recreation services. As a result, unscrupulous players will leave the market.

For the effective development of the fitness industry, related industries are also very important, which include manufacturers of sports equipment. Domestic players are still inferior to such international companies as Technogym or Peloton, but they have already achieved unconditional success. For example, Kenguru builds sports grounds all over the world: beyond the Arctic Circle, on the coast of the Sea of Japan and in Australia. Today, Kenguru's official representative offices operate in 21 countries. The same can be said about equipment manufacturers. Russian companies such as Forward, Zasport and Bosco cannot yet compete with Nike, Adidas and Puma, but they already occupy a certain market share and can count on growth.

Therefore, now, even despite the coronavirus pandemic, the Russian fitness industry has good opportunities for further development, taking into account the coincidence of interests with the state, bearing in mind national goals for the development of a healthy lifestyle and involvement in sports.

4. Grassroots sports

Recently, quite a lot of mass competitions in various sports have been held in Russia. The pandemic affected their number, but to a certain extent, it also provided pent-up demand for the future. Among the most popular are marathons and half marathons, triathlon competitions, bike rides, cross-country skiing. Tens of thousands of people take part in each such competition. What do these competitions have in common? The vast majority of them are carried out by organizers for whom this is a private business. Therefore, it can be argued that today there is a great interest for entrepreneurship in mass sports.

Probably, as a positive example, it is best to name the dynamics of the development of marathon distances in our country. In 2013, the Moscow Marathon was held for the first time. The mass consumer immediately showed interest in this event. Just a few years later, the organizers decided to create the "Running Community" of the Moscow Marathon and now offer their customers more than ten different events. For example, the Fast Dog cross, the April race, the Night Run, the Krylatsky trail, the Lisya Gora cross, etc., that is, a large number of competitions of interest and depending on physical fitness. In addition, the organizers have created a running club where you can train regularly and prepare for competitions.

Given the fact that interest in running today is observed throughout the country, in 2015 the National Running Community was created in Russia, which organizationally and methodically unites today more than 200 marathons and half marathons throughout Russia. The organizers aim to increase their target audience to 2 million people by 2022 in 80% of the Russian Federation subjects. Of course, this is a very ambitious task.

Despite the explosive growth in the popularity of running marathons, its decline should be noted (Fig. 1), which nevertheless leaves the room for the development.

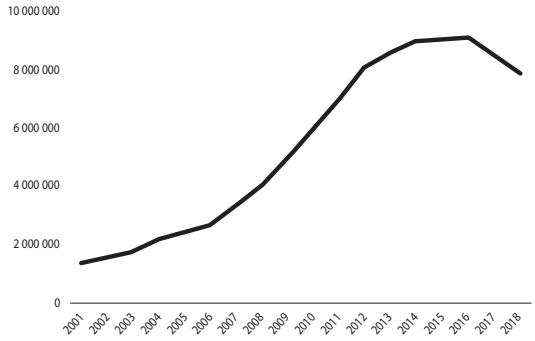
So far, the Moscow Marathon remains one of the most popular in Russia, in which more than 22,000 people took part in 2020[3]. In 2021, the event was canceled due to the difficult epidemiological situation. So far, the demand for Russian races is seriously lagging behind the world leaders. For example, for the London Marathon (which is part of the so-called The World Marathon Majors, which unites Boston, Chicago, New York, Berlin, London and Tokyo) in 2020, 457,861 applicants were registered - more than 10% more than in 2019 . Of these, only 17,500 were accepted (mostly due to the pandemic)[4]. The biggest marathons have a solid prize pool, ranging from $313,000 in London to $825,000 in New York. The first place winners receive approximately $100,000 each (2018 data).

In Russia, the cost of a race for 1000 people on average starts from 2–2.5 million rubles. (excluding prize money). At the same time, mass city launches with street closures cost more than 100 million rubles. As a rule, a significant part is financed by local authorities.

[3] Zabgaeva A. (2020). A new record and an ambiguous finish: how the Moscow Marathon 2020 went. URL:https://www.championat.com/lifestyle/article-4140361-rezultaty-moskovskogo-marafona-2020-kak-proshjol-zabeg.html.

[4] Carter K. (2021). Everything you need to know about Running All 6 Abbott World Marathon Majors from the hardest marathon to get into (it's not Boston) to the easiest course to run. URL: https://www.runnersworld.com/races-places/a28307813/world-marathon-majors-faq/.

Fig. 1. Total number of people participating in running marathons in the World



Source: The state of running. 2019. URL: https://runrepeat.com/state-of-running.

Part of the money can be compensated by contributions from participants. Abroad, they can account for half of the costs, in Russia this figure does not exceed 20%[5]. The main source of income comes from sponsors, and with proper organization and favorable market conditions, it allows you to count on payback and low profitability. It is important to note that almost every marathon or other mass race is a private business, which confirms the steady interest in entrepreneurial activity in the running industry.

5. Private sports clubs, schools and academies

In the last few years there has been a boom in the creation of private clubs, schools and academies in different regions of Russia. Moreover, this phenomenon is becoming quite stable. Private clubs and schools are created both in popular and commercially attractive sports (football, MMA, figure skating, boxing, etc.) and not yet the most popular ones (gymnastics, skating, diving, etc.). Many chess and e-Sports clubs have been created.

Why is this happening? There are several main reasons.

- A fairly large number of Russian citizens are ready to actively and regularly go in for sports, and do it in good conditions and under the supervision of coaches. Many are not satisfied with the prices and services of fitness clubs. In addition, discerning and trained clients want to train in specialized clubs, for example, only in running or skiing ones.
- Sports schools and academies appeared as a kind of alternative to the already existing state ones. There are at least two advantages to private schools. They take almost everyone who wants it – after all, the client pays money. Parents don't always want their children to be Olympic champions. Motive two: children should play sports for health, and they are under the supervision of coaches and in comfortable conditions. In addition, very often in private schools and academies there is a more individual approach to each child, taking into account his characteristics, both physical and psychological.
- Potential entrepreneurs have realized that there is a fairly large demand for such sports and recreation services, which means that this can become a good and long-term business. So, for example, the network of football schools "Championika" has 170 franchisees teaching children in 750 points in more than 150 regions. In the most successful year for the company in 2019, the network's revenue amounted to 77.9 million rubles excluding VAT, and net profit - 16.4 million rubles.[6]

Recently, there has been another trend in the creation of private clubs, schools and academies. Quite a few well-known athletes and coaches have decided to try their luck and hand at entrepreneurship. They are trying to use their popularity, stardom and recognition in the sports world and among the fans. By the way, this is a common practice in the world, and it is very good that Russian athletes do it. Here are some of them as an example[7]:

- ski academy of Nikita Kryukov - Olympic champion in cross-country skiing;
- Gymnastics Academy Anton Golotsutskov - Olympic medalist in artistic gymnastics;
- Ekaterina Lobysheva's school of champions - Olympic medalist in speed skating;
- Gleb Galperin's FlyDiving school - Olympic medalist in diving;
- "Academy of Champions" by Nikita Nagorny - Olympic champion in artistic gymnastics.

We believe that this is a very good practice, because we have a huge number of champions in various sports and just star athletes. When they create their own business in the sports industry, this gives them a great opportunity, while remaining in sports, to benefit themselves, their clients and, ultimately, the state.

[5] Sinitsyna I. (2018). Who makes money running marathons. URL: https://www.vedomosti.ru/business/articles/2018/09/20/781538-kto-zarabativaet-marafonov.
[6] Podtserob M. (2021). How two Moscow financiers developed children's football. URL: https://www.vedomosti.ru/management/articles/2021/05/24/871151-detskii-futbol.
[7] Moreover, we deliberately do not take the so-called commercial sports (football, hockey, figure skating, boxing and others), but show not the most popular sports.

6. Corporate sports

In corporate sports, private sports clubs and leagues have appeared, and corporate leagues have become a mass phenomenon. This is not about leagues created by large companies and banks (Sberbank, Rosneft, Gazprom, Rostec, etc.), corporate leagues are created as a private business in various sports: football, volleyball, basketball. Moreover, there are leagues for non-game sports. They offer their clients to participate in competitions on a regular basis, form the list of participants themselves, develop a calendar and conditions, and resolve issues of organizing competitions, from sports facilities to judging. Clients are only required to give their consent and pay the registration fee. More often, teams of the same holding participate in such leagues. It depends on the ability to assemble the right team. Sometimes the organization pays for participation in such leagues, but most often the team members pay the registration fee jointly. These teams train and participate in competitions, that is, they play their favorite sport for their own money and have fun. The owners of these already quite numerous leagues are trying to do their job qualitatively, expanding their target audience, knowing well that the success of their own business depends on this.

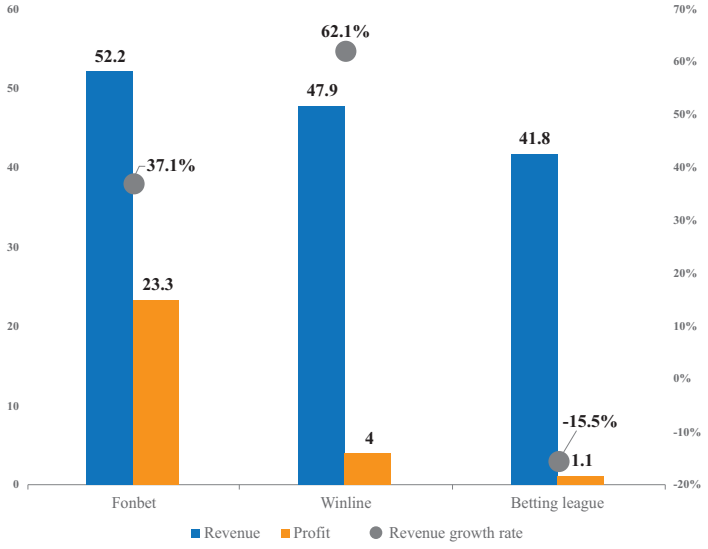
7. Media

The growth of the sports media market is confirmed by mergers and acquisitions. So, at the end of February 2021, the sports.ru portal changed its owner, the majority shareholder of which was Tkachenko, the president of the consulting company ProSport Management German. The buyer was Aleksey Nechaev, the founder and main shareholder of Faberlic, the initiator of the Captains educational program aimed at military-patriotic education and teaching the basics of doing business. Nechaev is also part of the central headquarters of the All-Russian People's Front movement, created at the initiative of the President of Russia, and in 2020 he created the New People political party, which received 15 seats in the State Duma in the 2021 elections. According to RAS, the revenue of the parent Sports.ru LLC in 2019 amounted to 416.5 million rubles, net profit – 17.5 million rubles. The amount of the transaction has not been officially disclosed, but market participants estimate it at approximately $25 million.[8]

Another promising deal, which was announced in June 2021, is the possible purchase by Sberbank of Telesport, which owns the rights to show several tournaments, including the Russian Football Cup.

However, despite the growth of private players in the sports media market, it is quite difficult for them to compete with state-owned companies. This was clearly demonstrated by the deal for the sale of television rights to show matches of the Russian Premier League. Initially, it was planned to hold a competition among Match-TV (Gazprom-Media), Yandex, as well as video services Start (the main owner is MegaFon) and Okko (Sberbank). However, in the end, the rights were sold to Match-TV without a tender. In the seasons 2022/23 and 2023/24, the league will receive 6.6 billion rubles each, in the seasons 2024/25 and 2025/26 - 7.7 billion rubles each.[9] At the same time, the parties to the agreement did not officially confirm these amounts. Also, the structure of the deal is not disclosed, in particular, it is not clear whether the said amounts include the cost of content production ("production"). Nevertheless, this example shows the emergence of competition in the market and the strengthening of the role of private entrepreneurs.

Fig. 2. Financials of Russian betting companies leading in the market



Source: 600 largest companies in Russia 2021. URL: https://www.kommersant.ru/appsgroup/462? regionid=77.

[8] The ex-owner of Sports.ru spoke about the decision to sell the publication in 2020 (2021). *RBC.* URL: https://sportrbc.ru/news/6038f8749a79477afa017955?ruid=uUjlA15HqrZP34lwAxZuAg.
[9] The Match TV offer bribed the Premier League. What will change for clubs (2021). *RBC.* URL: https://sportrbc.ru/news/615c8fb69a79478c8e534f94.

8. Bookmakers

By the end of 2021, the legal betting market in Russia may grow to about 295 billion rubles. This is 25% more than in 2020 and 40% more than in 2019. In 2020, the market growth was 13%. In total, in 2020, legal bookmakers earned 238 billion rubles.[10] Foreign companies are also showing growth. For example, the Entain international group of companies, which includes bookmakers Bwin, Ladbrokes, BetMGM, Sportingbet, gambling companies PartyPoker, CasinoClub, etc., announced an 11% increase in revenue in the first half of 2021. The figures of the market leaders are presented in Fig. 2. It is interesting that the leaders of the Russian bookmaker market showed such impressive results during the period of the general decline for the country's key companies.

However, these growth rates may slow down. In Russia, new legislation will have a significant impact: from September 2021, bookmakers pay a percentage of revenue not to leagues, but to a single regulator, and the deductions themselves will increase significantly. This will reduce the margins of the business, but, taking into account the turnover in the market, it will still allow you to get a decent profit.

9. E-sports

In mid-October 2021, the Russian group Team Spirit won the tenth world championship in Dota 2 – The International, the prize fund of which amounted to $40 million. During the period of pandemic restrictions, e-Sports not only did not suffer, but also received a new impetus for the development. This was made possible by the intersection of two directions at once, which have grown with the onset of the COVID-19 pandemic: technological services and systems, as well as entertainment content that can be consumed without leaving home.

According to the research company NewZoo, the audience of e-Sports competitions in the world in 2020 grew by almost 10%, amounting to 436 million people. NewZoo predicts that the average growth in the coming years will be 7.7% and by 2024 the number of viewers will reach 577 million people. The revenue of the e-Sports market in 2020 decreased by 1.1% – to $947 million. However, the growth by 14.5% is already expected in 2021. On average, until 2024, it will grow by 11.1% per year[11].

In 2020, there were 664 transactions related to the gaming industry in the world. Of these, 359 were directly related to games, 149 to platforms and technologies, 103 to e-Sports, and 53 to other segments. The total volume of transactions was $33.6 billion. $24.5 billion was spent on gaming companies, $7 billion on platforms and technologies, $614 million on e-Sports companies, and $1.4 billion on the rest. Most often, transactions were concluded in the United States, then - China[12].

The largest player in the Russian e-Sports market can be recognized as Esforce, which is part of the Mail.ru Group and unites the e-Sports Virtus.pro; RuHub, a Russian-language e-Sports broadcasting studio; e-Sports media Cybersport.ru; tournament organizer Epic E-sports Events and e-Sports and entertainment complex Yota Arena. However, so far this asset does not bring financial returns to the shareholder: according to the annual report of Mail.ru, for 2020 Esforce brought losses in the amount of 425 million rubles. The asset depreciation loss amounted to 1.3 billion rub. Earlier, at the end of 2019, the holding had already written off 4.5 billion rubles due to Esforce repricing. That is, in total, Mail.ru Group wrote off losses in the amount of 5.8 billion rubles due to Esforce, and the fair value of the e-Sports holding decreased 12 times - to 500 million rubles.[13] At the same time, the number of new projects in e-Sports is growing, forming a promising direction for private capital even in the context of a pandemic.

10. Innovation driven by entrepreneurs in the sports industry

The last of the considered activity areas in the sports industry - e-sports in itself is an innovation that exists and is commercialized thanks to new technological solutions.

Innovations introduced in the fitness industry can be classified as follows:

1. Transferring workouts online, developing specialized applications and manufacturing equipment that allows you to watch broadcasts, communicate with coaches and other participants, organize competitions (for example, Mirror and Peloton companies).

2. The development of computer vision technologies, sensors and detectors that monitor a number of indicators and control the correctness of the exercises.

3. Application of virtual reality technologies for training simulations.

Marathons during the pandemic were also transferred to the virtual space, which, of course, can be recognized as an innovative solution. In terms of new technologies projects for monitoring the condition of runners and skiers should be noted, which are implemented with the help of sensors in sneakers and insoles in ski boots and integrated with special applications that allows you to compete and communicate with other participants.

Sports media today work mainly in the Internet space, which is difficult to recognize as an innovation. At the same time, new technological solutions are used in broadcasting sports events, which are transferred to virtual reality, and allow to visit stadiums and museums of clubs. In addition, traditional shooting of matches is moving to a new level: the number of cameras, image quality is growing, and the use of 3D graphics in game analysis is increasing.

Modern betting companies are also becoming a high-tech area that requires a lot of IT solutions: collecting sports statistics, processing payments, fighting fraud, organizing broadcasts, ratio calculating, customer loyalty systems,

[10] Lebedeva V. (2021). The stakes have gone up, gentlemen. URL: https://www.kommersant.ru/doc/4997818.
[11] Rozhdestvenskaya Ya (2021). Esports has captivated football players and investors. URL: https://www.kommersant.ru/doc/4739827.
[12] Bespyatova E. (2021). InvestGame: in 2020, transactions worth $ 33.6 billion were carried out in the gaming industry. URL: https://app2top.ru/analytics/investgame-v-2020-godu-v-igrovoj-industrii-by-lo-provedeno-sdelok-na-33-6-mlrd-180269.html.
[13] Mail.ru lost billions of rubles on eSports (2021). URL: https://www.cnews.ru/news/top/2021-04-29_mailru_poteryala_milliardy_rublej.

developing a website, mobile application, Telegram bots. On average, IT spending in 2021 has risen by about 10% of a company's revenue[14]. For example, in the first half of 2021, Fonbet's total investment in software development and IT infrastructure amounted to more than 700 million rubles - 30% more than in the previous year. Investments in the development and online support of the betting line amount to more than 1 billion rubles for half a year. The main incentive for automation was the growth in the share of online bets: about 90% of bets are made online, the same is about the share of online in revenue. In addition, the need for IT resources is stimulated by the need to integrate with a single center for rate transfers.

Sports schools use digital solutions used by professional sports clubs, but due to limited financial resources, on a more modest scale. They are mainly related to monitoring the actions of athletes during games and training, as well as within the framework of medical support. As a rule, all these solutions are integrated into a mobile application that allows players to communicate with the coach and with each other.

Thus, today's entrepreneurs have a range of innovative solutions available to make training more effective and interesting, collect and process the necessary data, involve the maximum number of participants (athletes, fans, coaches) and, finally, expand the market and increase sales. It seems that the greatest potential in the sports industry in the face of ongoing restrictions may be virtual reality technologies.

11. Measures to support entrepreneurs in the sports industry

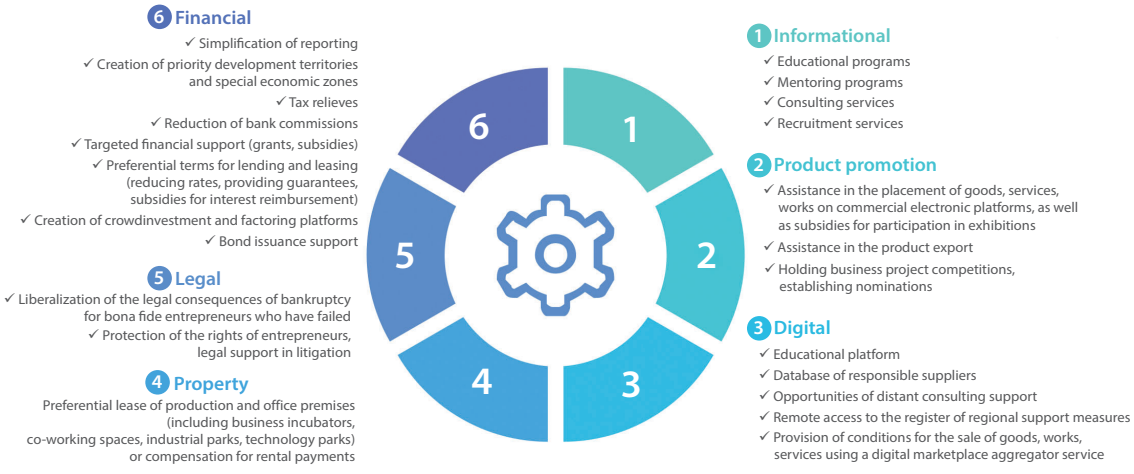
The topic of supporting the business community has become particularly relevant during the pandemic. The most complete list of support measures (classified according to a specific criterion) can be found in the OECD [Policy Responses to Coronavirus.., 2021] and the World Bank [Map of SME-Support.., 2020]. Among foreign and Russian authors who have studied the tools to support entrepreneurs, one can note [Watson et al., 1998; Storey, 2008; Mole et al., 2011; Vertakova et al., 2016; Zabolotskaya, 2019; Oguntoye and Quartey, 2020]. It is also worth noting the measures implemented in Moscow. Based on the analysis of these works, measures to support entrepreneurs can be systematized as follows (Fig. 3).

Of course, all these tools are relevant for the sports industry. It must be recognized that support in many of these areas is already underway. For example, a tax deduction was introduced for those involved in physical culture and sports. A number of preferences are provided to sports projects aimed at solving social issues, mechanisms of public-private partnership are being actively implemented. As one of the support measures, it can be proposed to create sports clusters (similar to special economic zones), which provide participants with comprehensive support in all selected areas. At first, such clusters can unite not only the sports business, but also all sectors of the creative economy, entertainment and tourism industries.

At the same time, it seems that state support should be provided not for the sector as a whole, but based on certain criteria that characterize the efficiency of entrepreneurs and the impact of their activities on the economy and the social sphere. Such criteria may include:

- creation of new jobs;
- tax deductions (prospective and for previous periods);
- assistance in achieving the indicators set in the national projects, as well as certain metrics set at the regional level (for example, increasing the number of people involved in physical culture and sports);
- Savings in budget expenditures, for example, the development of physical culture and sports can help reduce crime, improve health, achieve success in education, therefore, the state, by investing in the development of sports, will be able to reduce costs in other areas [Davies et al., 2021].

Fig. 3. Tools aimed at entrepreneurs' support



Source: compiled by the authors.

[14] Lebedeva V. (2021). Bet on IT. Why bookmakers are increasing the cost of their IT infrastructure. URL: https://www.kommersant.ru/doc/5050994.

Further research can be devoted to the development and testing of methods for evaluating such criteria and effects.

Conclusion

In the framework of this article, the authors tried to analyze the development of entrepreneurship in the sports industry, showing the specific features and trends for different areas of this already established phenomenon. It is very important to understand that the interests of the state coincide with the interests of private business. Moreover, there are quite a few areas of entrepreneurship in sports. There are business structures that provide sports and health services, such as fitness clubs, sports clubs, schools and academies. Various media resources are successfully operating, from websites and digital platforms to TV channels. Bookmakers directly finance various sports organizations (federations, leagues and clubs) as sponsors and expect to increase their target audience and get maximum profit through sports events.

So far, there are very few positive examples of entrepreneurship in professional sports. This is a matter of time, since the state has already outlined its interests and tasks. Funding from budgetary sources will be gradually reduced, which means that professional clubs will inevitably have to earn money themselves and reach self-sufficiency, so they will have to master various marketing tools and attract trained managers with the necessary professional competencies. But this is another topic, perhaps for future research.

An important feature of entrepreneurship that must be considered in any industry is the threshold for entering a business or the required amount of initial investment. In the sports industry, this threshold is quite low for private schools, leagues, corporate sports, online publications, where at first no serious investments are required and the primary is an accurate market analysis, choosing your niche, and quality of services. At the same time, the fitness industry and professional sports, on the contrary, are available only to a limited circle of investors with sufficient capital.

Based on the analysis, the authors can formulate the following directions for further research in this area:

- analysis of markets (directions) of entrepreneurship in the sports industry;
- development and testing of methods for evaluating the effectiveness of measures to support entrepreneurship in the sports industry;
- areas of professional training of entrepreneurs for the sports industry.

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Transition to sustainability: An empirical analysis of factors motivating industrial companies to implement ESG practices

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Abstract

Currently, more and more companies follow the principles of sustainable development and implement ESG practices in corporate strategies. At the same time, a number of Russian companies experience barriers to implementing ESG practices and do not have the necessary competencies to build work on the implementation of sustainable development practices. In this context, it is important to understand the factors contributing to the implementation of ESG practices in Russian industrial companies.

The research presented in the article is based on the data of a survey of 167 industrial companies. The results obtained allow us to speak about a variety of factors influencing the implementation of environmental, social and managerial initiatives. Thus, new technologies, consumer expectations, companies' work on international markets, and regulatory requirements are the key factors in the implementation of environmental practices by industrial companies. Costs of current operations, the presence of a division and/or manager responsible for achieving sustainability goals, investment attractiveness, profitability of operations and operational efficiency improvements are drivers for the introduction of social practices by industrial companies. The implementation of management practices is most influenced by the factors of having units responsible for achieving sustainability goals, consumer expectations, companies' performance in international markets, investment attractiveness and costs of current operations.

The results of the study lead to conclusions about the need to create specialized units responsible for the implementation of sustainable development goals, to introduce new technologies, to pay attention to employee development and their social security in order to successfully achieve sustainable development goals.

Keywords: sustainable development, ESG practices, factors of ESG practices implementation, industrial companies, environmental, social and managerial practices.

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Introduction

Currently, the theme of sustainable development (SD) is one of the most popular and cited in the research literature. In practice, over time, more and more companies follow the principles of sustainable development and implement ESG practices in corporate strategies. At the same time, according to a study by Accenture[1], 34% of Russian companies do not set goals for the transition to sustainable development, and another three-quarters do not understand how to work on the implementation of sustainable development practices. At the same time, companies point to such barriers as lack of internal competencies in the field of SD (61%), lack of support from the state (57%), lack of demand from the market and consumers (45%), complexity of transformation processes (44%)[2].

[1] Heading towards sustainability: how Russian business becomes responsible. Sustainability Research 2021 // *Accenture*. URL: https://www.accenture.com/ru-ru/insights/strategy/sustainability-research.
[2] Id.

At the same time, there are many studies confirming a positive correlation between companies' investments in ESG practices and financial performance (see, for example, [Amba, 2014; Ararat et al., 2017; Alshehhi et al., 2018]).

In addition, studies by other authors show that companies that implement ESG practices are (1) much more competitive [Byus et al., 2010; Duque-Grisales, Aguilera-Caracuel, 2019], (2) have more resources for development in the long term [Endrikat et al., 2014; Flammer, 2015], (3) have more efficient operational strategies [Garcia et al., 2017].

Thus, the relevance of the topic of sustainable development is in the focus of attention of researchers and practitioners, but at the same time, there are very few works devoted to the study of the development and impact of ESG on a particular industry. For example, there are no Russian studies showing what factors encourage companies to implement ESG practices.

The purpose of this work is to study what factors influence the implementation of management in accordance with the principles of ESG in industrial companies.

This work sets the following tasks:

1) to analyze studies on the influence of factors on the implementation of ESG practices for industrial companies;
2) to study the implementation of ESG practices in Russian industrial companies and identify the main difficulties and opportunities in achieving their competitiveness;
3) to formulate hypotheses for analyzing the impact of ESG practices implementation factors on the competitiveness of industrial companies and propose a model for analyzing this relationship.

1. Theoretical review of the literature

In the foreign literature, unlike the Russian one, a lot of empirical studies of the factor influence on the implementation of ESG practices have been accumulated.

Earlier studies [Ozcelik et al., 2014; Kara et al., 2015; Rizwan et al., 2016; Miroshnychenko et al., 2017] tested the relationship between the implementation of ESG practices and the financial performance of companies, and most of the results showed a positive impact. Also, a study conducted by Bank of America[3], shows that between January 2007 and August 2019 alone, the ratio of capitalization and profits of American and Western European companies that follow the principles of sustainable development has doubled. The financial performance of European companies that adhere to the principles of SD improved by 20% compared to others[4].

Studies over the past three years point to the increased importance of non-financial factors, such as an increase in the market share of companies [Xie et al., 2019], an increase in brand value (goodwill) [Miralles-Quir et al., 2018], an increase in the value of intangible assets [Saygili et al., 2018]. In addition, studies [Alshehhi et al., 2018; Duque-Grisales, Aguilera-Caracuel, 2019] show that companies with low ESG risks become more attractive to investors, improve financial performance and competitiveness [Garcia, Orsato, 2020]. It has been proven that the trend towards socially responsible investment affects the increase in stock returns [Verbeeten et al., 2016].

In addition, a relationship was found between the degree of disclosure of information about a company's sustainable development and its value in the market [Velte, 2017]. In [Hussain et al., 2018], data from Australian companies show the impact of implementing ESG practices on financial indicators such as ROA and ROE.

However, there are a number of studies that do not confirm this relationship. For example, [Qiu et al., 2016] did not reveal the relationship between ESG performance and market value, while [Rahdari, 2016] recorded the negative impact of ESG on financial performance. However, most research confirms that there is a positive relationship between ESG scores and financial performance, not a negative one.

Thus, these studies show a positive relationship between the implementation of ESG practices and production (operational) performance and market value.

In the scientific literature and among practitioners, a clear understanding is being created that sustainable development is expedient not only to achieve the goals of the state, society and individual companies, but also necessary for the harmonious development of man and nature. However, in Russian research there is a gap on the factors behind the implementation of ESG practices in companies in specific industries.

The main purpose of this study is to empirically test the drivers for the adoption of ESG practices by industrial companies.

2. Research methodology

2.1. Sample Description

The empirical analysis is based on the study of the data collected between January and May 2021.

For the analysis, 548 public enterprises of industrial sectors with more than 250 employees were selected, having in their strategies the achievement of sustainable development goals. Questionnaires were tested during in-depth interviews with representatives of 18 industrial enterprises in order to clarify the ambiguous interpretation of the checklists. Further, electronic questionnaires were sent to the selected enterprises. The respondents were senior management and those responsible for strategic development. A total of 184 respondents from 167 companies gave answers, the response was 30.5% (167/548).

The companies included in the sample belong to the following industries: food industry - 12%, chemical and petrochemical industry - 17%, production of building materials - 21%, ferrous and non-ferrous metallurgy - 13%, mechanical engineering - 10%, forestry, woodworking and pulp and paper industry - 8%, light industry - 7%, others - 12%. More than half of the surveyed companies have been

[3] How trade finance can join the dots on ESG. Bank of America. URL: https://business.bofa.com/content/dam/boamlimages/documents/articles/ID21_0612/trade_finance_ESG.pdf.
[4] Id.

operating in the market for more than 10 years, the age of the sample companies varies from 6 to 54 years and averages 24 years.

2.2. Research variables

Due to the fact that the main goal of the study is to assess the influence of factors on the implementation of ESG practices, it was decided to use the indicators of the implementation of the most significant initiatives for companies - environmental, social, and managerial - as a dependent variable.

At the same time, an assessment was made of the number of references to the initiatives introduced into the practice of companies (Table 1).

As can be seen from the table, the most frequently used practices are aimed at reducing emissions into the atmosphere (36%), reducing waste generated (38%), developing their staff (44%), improving employee welfare (38%), ensuring health and safety of company employees (37%), implementation of CSR principles 36%), anti-corruption and development of a culture of ethical business conduct (32%).

To analyze various aspects of the implementation of ESG practices in the activities of industrial companies, the following indicators were used, the choice of which is determined by the previously reviewed studies:

- company size (x_{1t}) – studies show both positive and negative impact on innovation activity. Large companies have better access to resources, including financial ones, and therefore have more opportunities to finance sustainable development projects. Smaller companies are more agile to market and consumer demands and can outperform large companies in creating value based on the achievement of the sustainable development goal (measured as the logarithm of the number of employees);
- the company's age (x_{2t}) – just like size, it can have both positive and negative effects. The age of the company reflects the experience and well-established business processes, which facilitates the implementation of ESG practices. At the same time, young companies have fresh ideas, have flexibility and are able to take a leading position in achieving ESG goals through innovation (measured as the logarithm of the number of years the company has been in operation);
- having its own division responsible for the implementation of projects related to the achievement of ESG goals (x_{3t}),– own division or person responsible for the implementation of ESG projects conduct research aimed at finding solutions to achieve ESG goals and develop the competencies of employees. The results of successful projects stimulate further investment in sustainable development (dummy variable equal to 1 if the company has its own divisions or a responsible person, and 0 if not);

Table 1
ESG practices implemented by industrial companies, %

	Questions about the implementation of ESG practices by industrial companies	Percentage of mentions
	Ecological initiatives (E)	
1	The company cares about reducing emissions into the atmosphere	36
2	The company reduces the waste produced and moves to a circular economy model	38
3	The enterprise reduces resource consumption	22
4	The company uses clean energy	2
5	The company is looking for solutions in the field of climate resilience	3
	Social initiatives (S)	
1	The company uses advanced labor practices	21
2	The company educates its employees	44
3	The company aims to improve the social security of employees	38
4	The company cares about ensuring the health and safety of all employees.	37
5	The company participates in charitable programs and the development of social entrepreneurship	9
	Managerial initiatives (G)	
1	The company implements CSR principles in its activities	35
2	The enterprise is aimed at combating corruption and developing a culture of ethical business conduct	32
3	The company implements a policy of responsible attitude to procurement not only in the company, but also together with suppliers	8

Source: compiled by the author.

- investment attractiveness of the company (x_{4t}) – investors not only choose sustainable companies, but are also ready to invest in green projects, provide transitional bonds (dummy variable equal to 1 if the company has investments due to its transition to sustainable development, and 0 if not);
- total costs of current activities (x_{5t}) – this indicator is related to the financial capabilities of the company, which also affects the implementation of ESG practices in the company's activities (measured as the logarithm of the volume of current investments);
- costs of acquiring new technologies to achieve sustainable development goals (x_{6t}),– the acquisition of new technologies contributes to the achievement of goals, especially in the field of environmental initiatives (measured as the logarithm of the costs connected with acquiring such technologies);
- consumer demand and expectation (x_{7t}) – consumers believe that companies should be involved in solving social and environmental problems faced by society. This judgment is especially widespread among representatives of generation Z, 94% of whom believe in responsible business. This also affects their consumer habits – 81% plan to buy more environmentally friendly products over the next five years. According to Harvard Business Review, citing a study by the Stern Business School at New York University[5], from 2013 to 2018, sales of "ethical goods" grew five times faster than sales of ordinary goods (measured as the logarithm of sales of "ethical goods");
- the behavior of competing companies (x_{8t}) – leading companies set the pace for the market, taking their business to a new level and meeting the expectations of stakeholders, which affects the strategies of other companies in the industry (dummy variable equal to 1 if the company is under pressure from competitors, forcing it to sustainable development, and 0 if not);
- international activity (x_{9t}) – studies show the positive impact of the company's international activities on setting and achieving sustainable development goals, which is explained by the current trend and high competition in international markets (dummy variable equal to 1 if the company has export earnings, and 0 otherwise);
- requirements of Russian and international regulators (x_{10t}) – more and more countries introduce regulatory restrictions in order to reduce the negative impact on the environment and solve accumulated social problems (a dummy variable estimating regulatory pressure on a company equal to 1 if the company experiences such pressure, and 0 - if not);
- Improvement in operational efficiency (x_{11t}) – studies identify such effects for improving operational efficiency as cost reduction through the creation of sustainable supply chains, cost reduction through more careful use of resources and the transition to a circular economy (dummy variable equal to 1 if the company aims to achieve operational efficiency by achieving sustainable development goals, and 0 otherwise);
- employee expectations (x_{12t}) – research shows that most employees are more likely to choose working for a company with a strong sustainable agenda (a dummy variable equal to 1 if the company aims to meet employee expectations by achieving sustainable development goals, and 0 in otherwise);
- joining the United Nations Global Compact (x_{13t}) – – joining the UN GC means that the company will support human rights, integrate sustainable development goals into business and implement ambitious initiatives to achieve them. The UN Global Compact is currently the largest international sustainability initiative with over 9,500 participating companies (dummy variable of 1 if a company aims to join the UNGC and 0 otherwise);
- introduction of a carbon cross-border tax (x_{14t}) – companies that believe that they will be affected by the introduction of a carbon cross-border tax from 2023 by the EU and will lead to a decrease in profits (dummy variable equal to 1 if the company believes that the introduction of a carbon cross-border tax will affect its activities, and 0 otherwise);
- stakeholder expectations – studies show that companies which achieve sustainable development goals and implement ESG practices meet the expectations of key stakeholders better and more easily achieve the company's strategic development goals (dummy variable equal to 1 if a company implements ESG practices to better interact with stakeholders in the process of their development, and 0 if not). The following stakeholders are highlighted and analyzed:
  - consumers (x_{15t}),
  - suppliers (x_{16t}),
  - partners (x_{17t}),
  - state-owned companies and development institutions (x_{18t}),
  - universities and scientific organizations (x_{19t});
- operating profitability (x_{20t}) – many studies show that companies implementing ESG practices are more profitable and have higher financial performance (dummy variable equal to 1 if the company believes that the implementation of ESG practices allows it to achieve more high financial results, and 0 otherwise).

The performance of enterprises can vary significantly depending on the affiliation to a particular industry, so the indicator of industry affiliation was used as a control variable. To take into account differences in industry affiliation, binary variables were used that indicate the affiliation of an enterprise to a particular industry sector (1 - belongs, 0 - does not): food industry, chemical and petrochemical industry, production of building materials, ferrous and non-ferrous metallurgy, mechanical engineering, forestry , woodworking and pulp and paper, light industry, others.

2.3. Data analysis procedure

To assess the reliability, Cronbach alpha coefficients were calculated, which corresponded to the recommended level of at least 0.75 (Table 2). Next, a factor analysis was

[5] Actually, consumers do buy sustainable products: Research. *Harvard Business Review*.

Table 2
Factor analysis: questionnaire questions, factor load and reliability check (Cronbach's alpha coefficient)

	Questionary	Sum of squared factor loadings	Model 1 for ecological initiatives (E)	Model 2 for social initiatiatives (S)	Model 3 for managerial initiatives (G)
	Factors (Cronbach alpha coefficient = 0.86)				
1	Our company has its own division responsible for the implementation of projects related to the achievement of ESG goals	0.723	0.726	0.721	0.673
2	Our enterprise implements ESG practices in order to increase attractiveness for potential investors	0.694	0.638	0.664	0.796
3	Our company introduces new technologies that contribute to the achievement of sustainable development goals	0.724	0.733	0.129	0.247
4	Our company's customers expect us to achieve sustainability goals	0.725	0.521	0.441	0.546
5	Our company's competitors are adopting ESG practices, so we have to follow these trends to stay competitive	0.719	0.198	0.124	0.298
6	Our company operates in the international market, and in order to remain competitive, we need to implement ESG practices	0.783	0.737	0.289	0.367
7	Our company must implement ESG practices in order to comply with the requirements of Russian and international regulators	0.741	0.754	0.218	0.192
8	Our company plans to join the UNGC, which means that the company will support human rights, integrate sustainable development goals into business and implement ambitious initiatives to achieve them	0.698	0.214	0.271	0.233
9	Our company will be affected by the introduction of the EU carbon cross-border tax from 2023 and will lead to a decrease in profits, in this regard, we already need to implement ESG practices	0.732	0.363	0.259	0.195
10	For our company, it is important to meet the expectations of stakeholders in achieving sustainable development goals				
10.1	○ consumers	0.569	0.215	0.262	0.321
10.2	○ suppliers	0.553	0.173	0.309	0.307
10.3	○ partners	0.548	0.204	0.251	0.166
10.4	○ state companies and development institutions	0.563	0.173	0.302	0.307
10.5	○ Universities and scientific organizations	0.571	0.104	0.151	0.166
11	The introduction of ESG practices contributes to an increase in the financial performance of our company	0.734	0.722	0.599	0.691
	Resulting indicators				
12	Ecological indicators (Cronbach alfa coefficient = 0.73)				
12.1	Reduction of emissions into the atmosphere	0.829	0.804	0.251	0.478
12.2	Waste reducing and moving to a circular economy	0.793	0.621	0.239	0.564
12.3	Reducing resource consumption	0.814	0.793	0.303	0.383
13	Social initiatives (Cronbach alpha = 0.78)				
13.1	Employee development programs	0.748	0.824	0.311	0.676
13.2	Improving social security	0.884	0.728	0.254	0.896
13.3	Ensuring the health and safety of employees	0.821	0.733	0.329	0.747
14	Manerial initiatives (Cronbach alpha = 0.76)				
14.1	Implementation of CSR principles	0.649	0.587	0.473	0.528
14.2	Anti-Corruption and developing a culture of ethical business conduct	0.704	0.624	0.388	0.692

Source: compiled by the author.

carried out using the method of principal components (varimax) for fifteen questions describing eleven factors. The analysis confirmed the presence of eleven factors with values above one in accordance with the Kaiser criterion. In general, the presented factors explain 74.3% of the variation in the answers to the questions (this result corresponds to the recommended value of at least 70%) (Table 2). Similarly, factor analysis was used by the method of principal components (varimax) for indicators of the implementation of ESG practices - environmental, social and managerial. The analysis confirmed these three initiatives, which in general described 71.9% of the variation in questions (Table 2).

The values of the obtained factors for the implementation of ESG practices and the effectiveness of ESG initiatives on industrial enterprises were further used in the regression analysis with the use of a mathematical model:

$$Y_{ik} = \beta_0 + \beta_i X_{ij} + \ldots + \beta_i IND_i + \varepsilon i \quad (1),$$

where Y_{1k} is the implementation of environmental initiatives, Y_{2k} is the implementation of social initiatives, Y_{3k} – implementation of management initiatives, X_{ij} – implementation factors of ESG practices; IND_i is the branch of industry.

Standardized and non-standardized coefficients were obtained using the maximum likelihood method, while the standardized coefficients were used to determine the influence of factors on the resulting indicator, and the non-standardized coefficients were used to test the research hypotheses.

3. Research results

Table. 3-5 shows the results of the regression analysis, reflecting the influence of various factors on the implementation of ESG practices: environmental, social and managerial for industrial enterprises. Models based on equation (1) were able to explain 35% of the variations in environmental initiatives, 42% in social initiatives, and 28% in managerial ones.

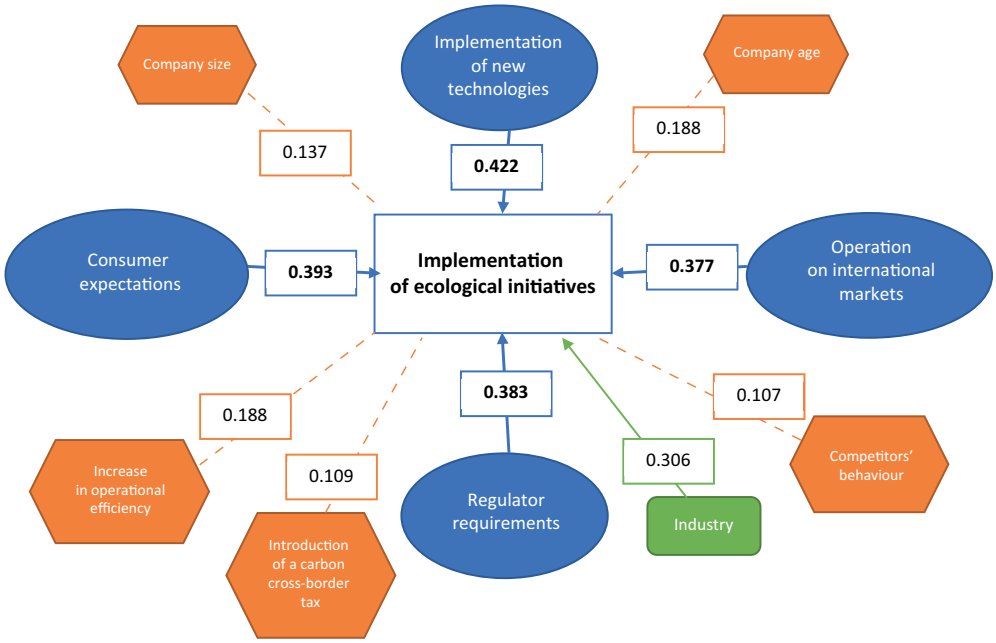
When analyzing the factors for the implementation of environmental initiatives by industrial companies (Table 3), it turned out that the transition of an enterprise to new technologies (β = 0.422, p < 0.01), demand and consumer expectations (β = 0.398, p < 0.01), the total

Table 3
The influence of various factors on the implementation of environmental initiatives by industrial enterprises

Independent indicators	Non-standardized coefficients	Standardadized coefficients
Constant (β_0)	0.615 (0.113)	
Company size (x_{1t})	0.137*** (0.025)	0.126***
Company age (x_{2t})	0.188** (0.066)	0.175**
Availability of a unit (manager) responsible for achieving sustainable development goals (x_{3t})	0.217*** (0.082)	0.214***
Investment attractiveness of the company (x_{4t})	0.269** (0.091)	0.278**
Total costs for current activities (x_{5t})	0.327*** (0.094)	0.324***
Costs for the acquisition of new technologies aimed at achieving sustainable development goals (x_{6t})	0.422** (0.167)	0.438**
Consumer demand and expectations (x_{7t})	0.393*** (0.068)	0.404***
Behavior of competing companies (x_{8t})	0.107** (0.016)	0.124**
International activities (x_{9t})	0.377*** (0.075)	0.369***
Requirements of Russian and international regulators (x_{10t})	0.383** (0.059)	0.381**
Improving operational efficiency (x_{11t})	0.159*** (0.048)	0.162***
Employee expectations (x_{12t})	0.092** (0.047)	0.098**
Accession of the company to the UN global compact (x_{13t})	0.083** (0.047)	0.098**
Introduction of a carbon cross-border tax (x_{14t})	0.109*** (0.014)	0.104***
Stakeholder expectations:		
○ consumers (x_{15t})	0.023*** (0.009)	0.026***
○ suppliers (x_{16t})	0.048** (0.029)	0.035**
○ partners (x_{17t})	0.062** (0.037)	0.068**
○ state companies and development institutions (x_{18t})	0.139*** (0.012)	0.141***
○ universities and scientific organizations (x_{19t})	0.004** (0.107)	0.008**
Profitability of the enterprise (x_{20t})	0.073** (0.029)	0.082**
Industry (IND_i)	0.306** (0.049)	0.308**
Adjusted R^2	0.35	
Number of observations	184	

Note. * – p < 0,10, ** – p < 0,05, *** – p < 0,01. Standard errors are given in parentheses.
Source: compiled by the author.

Fig. 1. Factors of implementation of environmental initiatives by industrial companies



Source: compiled by the author.

costs of the enterprise for current activities ($\beta = 0.327$, $p < 0.01$), the company's work in international markets ($\beta = 0.377$, $p < 0.01$) and the requirement of Russian and international regulators ($\beta = 0.383$, $p < 0.01$). influence positively. In addition, factors of possible investment attractiveness ($\beta = 0.269$, $p < 0.01$) and the presence of a subdivision and/or manager responsible for achieving sustainable development goals ($\beta = 0.217$, $p < 0.01$) have an influence.

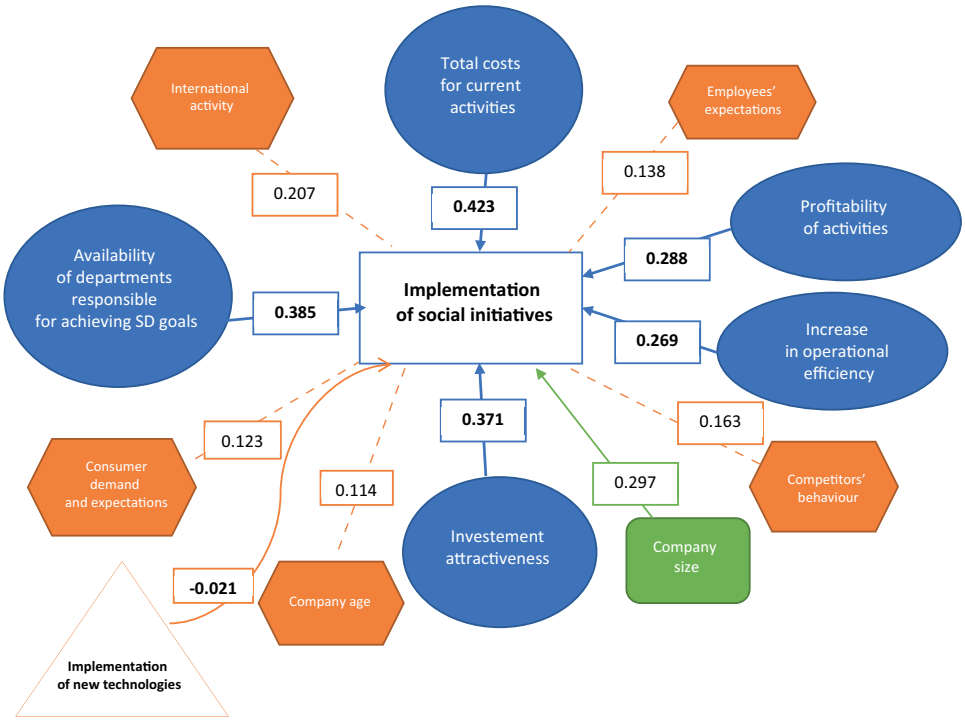
Factors such as company size ($\beta = 0.137$, $p < 0.01$), age ($\beta = 0.188$, $p < 0.01$), competitor behavior ($\beta = 0.107$, $p < 0.01$), introduction of a carbon cross-border tax ($\beta = 0.109$, $p < 0.01$), increased operational efficiency ($\beta = 0.159$, $p < 0.01$), have a very weak impact on the implementation of environmental initiatives by Russian industrial enterprises, unlike foreign ones.

Stakeholder expectations and profitability factors do not have a significant impact on the implementation of environmental initiatives by Russian industrial enterprises.

Industry variables ($\beta = 0.306$, $p < 0.05$) significantly affect the implementation of environmental initiatives by enterprises: the most active enterprises were engineering, chemical and petrochemical industries, ferrous and non-ferrous metallurgy. Thus, new technologies, consumer expectations, the work of companies in international markets, the requirements of the regulator are the key factors in the implementation of environmental practices by companies in the sample studied (Fig. 1).

An analysis of the factors for the implementation of social initiatives by industrial companies (Table 4) showed that such factors as the total costs of current activities ($\beta = 0.423$, $p < 0.05$), the presence of a subdivision and/or a manager responsible for achieving goals in the field of sustainable development ($\beta = 0.385$, $p < 0.05$), investment attractiveness ($\beta = 0.371$, $p < 0.05$), profitability of operations ($\beta = 0.288$, $p < 0.05$) and increase in operational efficiency ($\beta = 0.269$, $p < 0.01$). have more influence. In addition, the larger the enterprise, the more likely it will implement social initiatives ($\beta = 0.297$, $p < 0.01$). Factors of international activity ($\beta = 0.207$, $p < 0.01$), behavior of competing companies

Fig. 2. Factors of introduction of social initiatives by industrial companies



Source: compiled by the author.

Table 4
The influence of various factors on the implementation of social initiatives by industrial enterprises

Independent indicators	Non-standard coefficients	Standardized coefficients
Constant (β_0)	0.459 (0.086)	
Company size (x_{1t})	0.297*** (0.055)	0.296***
Company age (x_{2t})	0.114** (0.032)	0.115**
Availability of a unit (manager) responsible for achieving sustainable development goals (x_{3t})	0.385*** (0.033)	0.384***
Investment attractiveness of the company (x_{4t})	0.371** (0.063)	0.374**
Total costs for current activities (x_{5t})	0.423*** (0.087)	0.424***
Costs for the acquisition of new technologies aimed at achieving sustainable development goals (x_{6t})	–0.021** (0.007)	–0.018**
Consumer demand and expectation (x_{7t})	0.123*** (0.028)	0.124***
Behavior of competing companies (x_{8t})	0.163** (0.022)	0.164**
International activities (x_{9t})	0.207*** (0.052)	0.209***
Requirements of Russian and international regulators (x_{10t})	0.013** (0.008)	0.011**
Improving operational efficiency (x_{11t})	0.269*** (0.055)	0.264***
Employee expectations (x_{12t})	0.138** (0.041)	0.136**
Accession of the company to the UN Global Compact (x_{13t})	0.083** (0.047)	0.098**
Introduction of a carbon cross-border tax (x_{14t})	0.007*** (0.004)	0.003***
Stakeholder expectations:		
○ consumers (x_{15t})	0.023*** (0.009)	0.026***
○ suppliers (x_{16t})	0.048** (0.029)	0.035**
○ partners (x_{17t})	0.062** (0.037)	0.068**
○ state companies and development institutions (x_{18t})	0.124*** (0.023)	0.131***
○ universities and scientific organizations (x_{19t})	0.004** (0.107)	0.008**
Profitability of the enterprise (x_{20t})	0.288** (0.047)	0.287**
Industry (IND_i)	0.103** (0.049)	0.108**
Industry R^2	0.42	
Number of observations	184	

Note. * – $p < 0.10$; ** – $p < 0.05$; *** – $p < 0.01$. Standard errors are given in parentheses.
Source: compiled by the author.

($\beta = 0.163$, $p < 0.05$), employee expectations ($\beta = 0.138$, $p < 0.05$), demand and consumer expectations ($\beta = 0.123$, $p < 0.01$), company age ($\beta = 0.114$, $p < 0.05$) have less influence.

It is noteworthy that, unlike environmental practices, the introduction of new technologies has a negative impact on the introduction of social practices ($\beta = –0.021$, $p < 0.05$). Probably, this effect can be explained by the limited financial resources and the choice between investments in new technologies or social initiatives.

Just as in the case of the introduction of environmental practices, the following factors did not influence the introduction of social practices: the company's accession to the UN Global Compact ($\beta = 0.083$, $p < 0.05$), stakeholder expectations, the introduction of a carbon cross-border tax ($\beta = 0.007$, $p < 0.05$), requirements of Russian and international regulators ($\beta = 0.013$, $p < 0.05$).

The industry sector ($\beta = 0.103$, $p < 0.05$) does not have a significant impact on the introduction of social practices (Fig. 2).

And, finally, the analysis of the factors for the implementation of management initiatives (Table 5) showed that the presence of a unit and / or manager responsible for achieving sustainable development goals ($\beta = 0.424$, $p < 0.01$), the total costs of current activities ($\beta = 0.423$, $p < 0.01$), investment attractiveness ($\beta = 0.371$, $p < 0.01$), consumer demand and expectation ($\beta = 0.336$, $p < 0.01$), behavior of competing companies ($\beta = 0.369$, $p < 0.01$) and international activities ($\beta = 0.377$, $p < 0.10$) positively influence the implementation of management practices by industrial companies.

Factors such as the cost of acquiring new technologies aimed at achieving sustainable development goals ($\beta = 0.223$, $p < 0.05$), increasing operational efficiency ($\beta = 0.283$, $p < 0.05$), requirements of Russian and international regulators ($\beta = 0.153$, $p < 0.05$), company size ($\beta = 0.264$, $p < 0.05$) and stakeholder expectations, have a less significant impact on the implementation of management practices. Factors such as company age ($\beta = 0.122$, $p < 0.05$), employee expectations ($\beta = 0.119$, $p < 0.05$), company accession to the UN Global Compact ($\beta = 0.065$, $p < 0.05$), the introduction of a carbon cross-border tax ($\beta = 0.029$, $p < 0.05$),the profitability of an enterprise ($\beta = 0.174$, $p < 0.05$)and the industry ($\beta = 0.134$, $p < 0.05$), do not have a significant impact on introduction of management initiatives by industrial companies (Fig. 3).

Thus, the presence of subdivisions responsible for achieving sustainable development goals, consumer expectations, the work of companies in international markets, investment attractiveness and costs for current activities are the key factors

Table 5
The influence of various factors on the implementation of management initiatives by industrial enterprises

Independent indicators	Non-standardized coefficients	Standardized coefficients
Constant (β_0)	0.319 (0.073)	
Company size (x_{1t})	0.264*** (0.055)	0.266***
Company age (x_{2t})	0.122** (0.032)	0.119**
Availability of a unit (manager) responsible for achieving sustainable development goals (x_{3t})	0.424*** (0.029)	0.384***
Investment attractiveness of the company (x_{4t})	0.371** (0.063)	0.374**
Total costs for current activities (x_{5t})	0.423*** (0.087)	0.424***
Costs for the acquisition of new technologies aimed at achieving sustainable development goals (x_{6t})	0.223** (0.035)	0.219**
Consumer demand and expectations (x_{7t})	0.336*** (0.028)	0.338***
Behavior of competing companies (x_{8t})	0.369** (0.022)	0.367**
International activities (x_{9t})	0.377*** (0.048)	0.379***
Requirements of Russian and international regulators (x_{10t})	0.153** (0.039)	0.151**
Improving operational efficiency (x_{11t})	0.283*** (0.038)	0.294***
Employees' expectations (x_{12t})	0.119** (0.043)	0.124**
Accession of the company to the UN Global Compact (x_{13t})	0.065** (0.032)	0.068**
Introduction of a carbon cross-border tax (x_{14t})	0.029*** (0.011)	0.023***
Stakeholder expectations:		
○ consumers (x_{15t})	0.223*** (0.032)	0.226***
○ suppliers (x_{16t})	0.241** (0.029)	0.236**
○ suppliers (x_{17t})	0.192** (0.029)	0.198**
○ state companies and development institutions (x_{18t})	0.244*** (0.038)	0.241***
○ universities and scientific organizations (x_{19t})	0.154** (0.107)	0.159**
Profitability of the enterprise (x_{20t})	0.174** (0.042)	0.181**
Industry (IND_i)	0.134** (0.049)	0.137**
Adjusted R^2	0.28	
Number of observations	184	

Note. * – $p < 0.10$; ** $p < 0.05$; *** – $p < 0.01$. Standard errors are given in parentheses.
Source: compiled by the author.

in the implementation of management practices by industrial companies in the studied sample.

Conclusion

Sustainable development has now become a key condition for the effective functioning of companies. Companies wishing to be competitive transform their business models and incorporate sustainable development goals into their strategies. At the same time, most Russian companies are still experiencing difficulties in implementing ESG practices, which requires a comprehensive study of the factors influencing the implementation of environmental, social and management initiatives.

In the work, a comprehensive study of the influence of various factors on the implementation of environmental, social and management practices was carried out based on a study of 167 industrial enterprises.

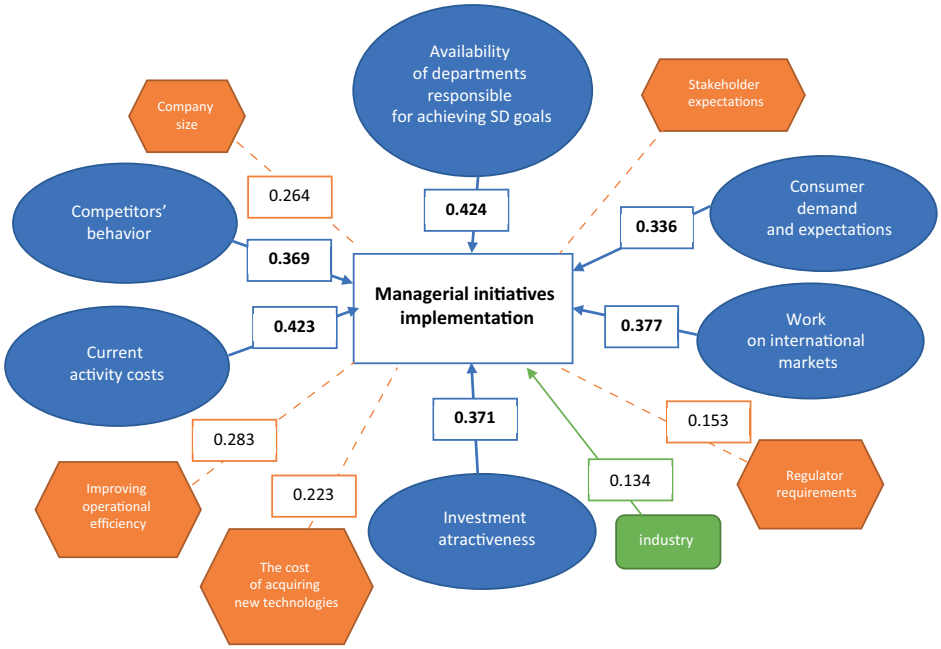
The survey made it possible to identify initiatives that industrial enterprises are working on:

- environmental, including projects to reduce emissions into the atmosphere, reduce waste and transition to a circular economy model, reduce resource consumption;
- social, including projects for the development of its employees and their social security, labor protection, health and safety of all employees;
- managerial, including the introduction of CSR principles into the company's activities, combating corruption and developing a culture of doing business.

At the same time, initiatives such as the use of clean energy, the search for solutions in the field of climate resilience, participation in charitable programs and the development of social entrepreneurship, the policy of responsible purchasing not only in the company, but also together with suppliers, are significantly underestimated by the respondents.

Econometric analysis confirmed that the implementation of ESG practices is influenced by various factors. Thus, the respondents most often associated the introduction of environmental practices with the introduction of new

Fig. 3. Factors of implementation of management initiatives by industrial companies



Source: compiled by the author.

technologies, the desire to meet consumer expectations, the company's work in international markets, and the need to comply with the requirements of the regulator.

As part of the introduction of social practices, the most important are the costs of enterprises for current activities, the presence of a unit and / or manager responsible for achieving sustainable development goals, investment attractiveness, profitability of operations and improving operational efficiency.

The introduction of management practices is most influenced by the presence of departments responsible for achieving sustainable development goals, consumer expectations, the work of companies in international markets, investment attractiveness and the costs of current activities.

Low scores in the implementation of all types of ESG practices were received by the factors of employee expectations, the company's accession to the UN Global Compact, and the introduction of a carbon cross-border tax.

Thus, depending on the goals that the enterprise sets for itself, it is possible to combine investments in certain types of ESG practices and thereby achieve the goals set.

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