SCIENTIFIC
AND PRACTICAL
REVIEWED JOURNAL

ISSN 2618-947X (Print)
ISSN 2618-9984 (Online)

strategic & risk decisions & management

Vol. 12, № 2/2021

16+

Strategic Decisions and Risk Management

Published since 2010

SCIENTIFIC AND PRACTICAL REVIEWED JOURNAL

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ISSN 2618-9984 (Online)

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DOI: 10.17747/2618-947X-2021-2

Decisions and management risks-management «Decisions and management risks-management»
Journal Is registered by Federal Service for Supervision in the sphere of communication, information technologies and mass communications (Roscomnadzor). Certificate ПИ № ФС 77–72389 dated 28.02.2018

Periodicity – 4 times per year

Founder – The Finance University under the Government of the Russian Federation (Finance University), Real Economy Publishing House

Publisher – Real Economy Publishing House

Aims and Scope – "Strategic Decisions and Risk Management" is an international peer-reviewed journal in the field of economics, business and management, published since 2001.

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"Tipografiia Litas+" LLC, 3 Lifliandskaia street, 190020, St. Using the materials it is obligatory to include the reference to "Decisions and management risks-management"
Circulation of 1900 copies.

Subscription through the editors or the Agency "Rospechat", the directory of Newspapers.

- Agency "ARZI", the catalog "Press of Russia" – subscription index 88671
- LLC agency "Ural-press" in all regions of the Russian Federation www.uralpress.ru
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CONTENTS

DOI: 10.17747/2618-947X-2021-2-114-126

Project success and individual entrepreneurial orientation of project managers: Russian context

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Abstract

Projects implemented in conditions of high uncertainty are sometimes called entrepreneurial projects. Success in such projects is more difficult to achieve. To successfully manage entrepreneurial projects, project managers should have entrepreneurial skills. The article explores two issues related to project success, entrepreneurial characteristics, and project uncertainty. First, the article tries to find out whether the increase in the entrepreneurial nature of the project, manifested in the increase in project goals and methods uncertainty, is accompanied by a decrease in project success. Second question is – does the entrepreneurial orientation of project managers affect project success and the relationship between the projects' success and their entrepreneurial features. To answer these questions, data were collected from Russian project managers assessing the entrepreneurial nature of projects, project success and the individual entrepreneurial orientation of project-managers. The collected data were examined using factor and regression analysis. The findings indicate that there is a negative relationship between the entrepreneurial nature and such indicators of project success as internal efficiency, preparation for the future, and results for clients. Some indicators of success were positively associated with such indicators of entrepreneurial orientation as proactivity and risk taking. As uncertainty increased, some measures of individual entrepreneurial orientation of project managers can positively compensate negative impact on project success from uncertainty associated with projects' entrepreneurial nature.

Keywords: project success, project management, entrepreneurship, entrepreneurial orientation, entrepreneurial projects.

For citation:

Titov S.A., Pathak R.D., Tsymbal A.A. (2021). Project success and individual entrepreneurial orientation of project managers: Russian context. *Strategic Decisions and Risk Management*, 12(2): 114-126. DOI: 10.17747/2618-947X-2021-2-114-126. (In Russ.)

1. INTRODUCTION

The current business environment is characterized by high uncertainty, complexity and dynamism, which leads to poor project outcomes. According to a well-known review by the Standish Group, within the period of 2015-2020, only about a third of projects was successfully completed [CHAOS 2020.., 2020]. A review by the Project Management Institute "Pulse of the Profession" also notes that the content of modern projects is becoming more complex [Pulse of the profession.., 2021]. Today, projects are implemented not only to develop and create products, but also to introduce complex initiatives, such as digital transformation and business development. In such an environment, project management can improve performance by learning entrepreneurial practices. After all, entrepreneurship is realized in similar conditions and has developed a number of attitudes and approaches for management in situations of increased uncertainty and complexity.

A number of authors note the expediency of mastering entrepreneurial practices in order to increase innovation, creativity, proactivity and willingness to take risks [Rauch et al., 2009; Wales et al., 2021]. In particular, the positive impact of the entrepreneurial orientation of companies on their performance has been studied well [Martens et al., 2016], including the evidence that entrepreneurial orientation is especially useful in turbulent conditions [Kraus et al., 2012]. [Martens et al., 2018] proved that the entrepreneurial orientation of companies has a positive effect on the success of projects, whereas in the scientific literature, the question of the relationship between the entrepreneurial orientation of project managers and the success of projects remains relatively unexplored. This issue seems to be quite important from a practical point of view, since project managers have

a direct impact on the success of the project, and the use of entrepreneurial practices in project management depends on their entrepreneurial skills. The question is also interesting from a theoretical point of view, because the concept of individual entrepreneurial orientation in relation to empirical research has not yet been applied in project management.

Thus, the present study seeks to find out how the entrepreneurial behavior of project managers, viewed through the prism of the concept of individual entrepreneurial orientation, correlates with the success of projects that, to varying degrees, embody the uncertainty inherent in entrepreneurial activity. The study is structured as follows. The relationship between entrepreneurship, project management and uncertainty is first explored on the basis of available research results. According to these results, questions for the present study are specified. The third section analyzes the scientific literature to identify concepts that can be used to evaluate project success and the entrepreneurial behavior of project managers. Next, the research methodology is described, which consists of collecting primary data using selected measurement models and their quantitative analysis by building correlation-regression models. The coefficients of the independent variables of these models act as the key results of the study. The sixth section interprets the results and conforms them with the available scientific and practical ideas. Finally, the conclusion contains the key findings of the study, its limitations, and directions for further research.

2. ENTREPRENEURSHIP, PROJECT MANAGEMENT, UNCERTAINTY

The development of the theory and practice of project management is accompanied by interaction with other practical and theoretical disciplines. One of the interesting manifestations of this cross-disciplinary development of project management is its interaction with entrepreneurship. [Kuura et al., 2014; Fonrouge et al., 2019] review this interaction and conclude that both disciplines have much in common in practical terms, but there is very little theoretical and methodological mutual enrichment. Nevertheless, it is implemented, including the adaptation of theoretical concepts and practical approaches of entrepreneurship in project management.

Some authors argue that entrepreneurship is most in demand in project management in conditions of increased uncertainty. So, in [Cooke-Davies et al., 2009] a special type of project management system is distinguished, which arises when it is necessary to increase the differentiation of the created results and improve the economic indicators of processes. The authors characterized this type of system as entrepreneurship. This system strives to be both innovative and internally effective at the same time. In this context, "project managers must act as entrepreneurs who identify and seize market opportunities." They play more the role of business leaders and self-employed entrepreneurs and should have the appropriate skills and qualities.

The authors emphasize that such a context is characterized by a high degree of complexity and uncertainty.

Following the logic of the model from [Cooke-Davies et al., 2009], [Kuura et al., 2014] the concept of an entrepreneurial project is proposed as a special variant, which is characterized by two types of uncertainty at the same time - uncertainty in goals and uncertainty in methods. According to the framework of the model developed by the authors (Fig. 1), the higher the uncertainty in these measurements is, the more the project has an entrepreneurial nature.

As examples of entrepreneurial projects, these authors cite the development and production of innovative products, the development of complex socio-technical systems that involve significant adaptation of dynamic organizational processes, and in particular projects for the creation of new business units, research and development projects. These projects, implemented in conditions of high uncertainty, are indeed the most similar to entrepreneurial activity. They are of little success, but at the same time, the use of entrepreneurial abilities by project managers can improve success rates.

Thus, the following research questions can be formulated:

1. Is a more pronounced entrepreneurial nature of projects (which manifests itself in an increasing uncertainty of methods and goals) accompanied by a decrease in the success of projects?
2. Does the entrepreneurial behavior of project managers increase their success while the entrepreneurial nature (and accordingly uncertainty) of projects increases?

Since the questions posed involve such complex concepts as project success and entrepreneurial behavior, it is necessary to review scientific theory and develop systems for evaluating these concepts in order to determine the research methodology.

3. LITERATURE REVIEW

The ideas about project success indicators have developed quite dynamically in the context of the development of the very concept of project success [Jugdev, Müller, 2005; Ika, 2009]. The iron triangle triad (timing, budget, quality) that had dominated until the 1980s was actively supplemented by such indicators as customer and end user satisfaction, results for the team, business results for the company, achievement of strategic goals, contribution to the development of organizational capabilities and etc. At present, the Shenhar and Dvir model [Shenhar, Dvir, 2007] can be singled out as the most holistic, covering various aspects of project success.

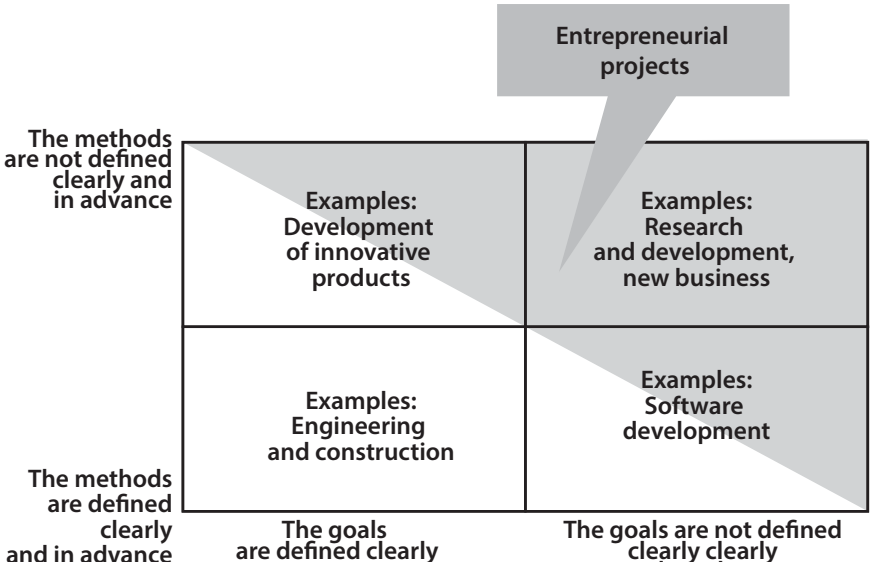
In their model of project success indicators, A. Shenhar and D. Dvir identify five different dimensions. This is directly the internal efficiency of the project, which is manifested in meeting deadlines, budgets, creating the required results and achieving other formal indicators within the framework of the project. Further, they are: results for the team (motivation, high morale, interest, personal and professional growth, loyalty to the company), results for the client (achievement

of their requests, degree of satisfaction, loyalty and willingness to repeat contracts), results for the company (profit , increasing profitability, increasing market share, value for owners) and future-oriented results (contributing to the success of subsequent projects, creating new products, markets, technologies, competencies). Entrepreneurship is traditionally perceived as an activity aimed at creating business results that go beyond short-term indicators.

Therefore, it can be assumed that the use of entrepreneurial approaches will be accompanied by a positive effect to a greater extent on long-term and business results for both the contractor and the customer.

However, according to [Cooke-Davies et al., 2009], an entrepreneurial approach to project management should combine both innovative performance and process efficiency. Therefore, entrepreneurial approaches should improve the internal results of projects as the uncertainty of the context increases. Nevertheless, it can be assumed that the entrepreneurial characteristics of project managers will influence different measures of success to varying degrees.

Fig. 1. Project typology model with entrepreneurial projects



The source: adapted from [Kuura et al., 2014].

Entrepreneurial behavior is multifaceted. As a part of the study of entrepreneurial behavior, the concepts are as follows:

- entrepreneurial intentions (about 2000 scientific publications in the Scopus database since 1993, the three most famous publications have citations of 2201, 1230 and 1132) [Fayolle, Liñán, 2014];
- entrepreneurial process (about 1050 scientific publications in the Scopus database since 1979, the three most famous publications have citations of 1903, 1535 and 964) [Acs, Audretsch, 2005];
- attitude to entrepreneurship (entrepreneurial attitude, about 580 scientific publications in the Scopus database since 1976, the three most famous publications have citations of 1290, 992 and 505) [Harris, Gibson, 2008];
- effectuation (about 460 scientific publications in the Scopus database since 2001, the three most famous publications have citations of 2356, 1568 and 816) [Sarasvathy, 2001];
- entrepreneurial self-efficacy [Chen et al., 1998], entrepreneurial self-efficiency [Baker, Nelson, 2005].

The most developed is the concept of entrepreneurial orientation (about 2470 scientific publications in the Scopus database since 1971, the three most famous publications have citations of 4359, 1464 and 1436), which allows you to analyze how the organization shows the characteristics inherent in entrepreneurial structures, and to what extent it is entrepreneurial [Wales et al., 2021]. The analysis and evaluation of a company's entrepreneurial orientation usually use such dimensions as innovation, risk taking, proactivity, competitive aggressiveness, and independence (autonomy) [Martens et al., 2018].

The concept of entrepreneurial orientation is predominantly applied at the level of individual organizations. Nevertheless, some authors have begun using entrepreneurial orientation towards the team level [Covin et al., 2020] and the individual level [Bolton, 2012; Bolton and Lane, 2012]. With the help of individual entrepreneurial orientation, these authors understand the behavioral characteristics displayed by an individual that bring him closer to the behavior of an entrepreneur. This concept seems to be successful for this work, as it allows you to explore the entrepreneurial behavior of project managers. To measure and evaluate individual entrepreneurial orientation, a scale was developed and tested, which involves the study of three aspects - willingness to take risks, proactivity and innovativeness. All three aspects are indeed associated with entrepreneurial activity. D. Bolton and M. Lane [Bolton, Lane, 2012] showed that three evaluations of individual entrepreneurial orientation correlate with individuals' intentions to engage in entrepreneurial activity. Based on this, the concept of individual entrepreneurial orientation can be used to analyze and assess the entrepreneurial behavior of project managers.

The relationship between entrepreneurial orientation and improvement in company performance has been extensively researched. [Rauch et al., 2009; Wales et al., 2021] conclude that most studies show a positive correlation between company performance and entrepreneurial orientation. A number of studies examine the role of entrepreneurial orientation in the activities of project-oriented companies and the results of their projects. Thus, [Martens et al., 2018], using the Shenhar and Dvir project success model, shows the positive impact of the entrepreneurial orientation in companies on the success of their projects, on the maturity of project management. [Sabahi, Parast, 2020] found that project results are positively associated with only one

dimension of entrepreneurial orientation, namely proactivity. These studies did not assess the individual entrepreneurial orientation of project managers, but their results suggest that it positively correlates with project success rates.

It can also be expected that individual entrepreneurial orientation has a greater impact on project success in conditions of high uncertainty. [Garcia et al., 2021] demonstrated that the entrepreneurial orientation of companies contributes to the adaptation of agile project management methods, which are successfully applied mainly in conditions of high uncertainty. [Kraus et al., 2012] found a positive impact of entrepreneurial orientation on company performance in the face of uncertainty and turbulence in the external business environment.

Based on the literature review, it can be concluded that:

- the concept of individual entrepreneurial orientation can reasonably act for the analysis and evaluation of the entrepreneurial behavior of project managers;
- both entrepreneurial orientation and project success are multidimensional concepts and involve assessment systems with several dimensions, respectively, and it makes sense to consider the research questions posed in a differentiated way, that is, in the context of various dimensions of individual entrepreneurial orientation and project success, rather than to reduce them to aggregate variables ;
- The Bolton and Lane model is suitable for the study of individual entrepreneurial orientation of project managers, and the Shenhar and Dvir model seems to be preferable for assessing project success rates.

4. RESEARCH METHODOLOGY

Based on the review of the theory, in order to address the research questions raised, a primary study of data was conducted to assess the entrepreneurial nature of projects, the success of projects, and the individual entrepreneurial orientation of project leaders. The entrepreneurial nature of the projects was measured by the indicators of uncertainty in objectives and methods derived from the model and then aggregated into one indicator [Kuura et al., 2014]. Project success was assessed with the use of five variables according to the Shenhar and Dvir model. The individual entrepreneurial orientation of project managers was measured by three variables according to the Bolton and Lane individual entrepreneurial orientation model. To assess the entrepreneurial nature, the success of the project and the individual entrepreneurial orientation of project managers, measurement models were developed or adapted, in which primary data were collected in the course of the survey. All ratings were given on a five-point Likert scale. The data were collected from project managers of Russian companies in 2021. Consistency and validity of data collected were analyzed using Cronbach's alpha and confirmatory factor analysis, highlighting the number of factors implied by theoretical models.

Based on the data obtained, five correlation-regression models were built for each project success variable. In the models, the outcome variables were project success indicators, and the independent ones were of entrepreneurial nature and three individual entrepreneurial orientation variables of project managers.

Table 1
Questions to assess project entrepreneurial nature

Estimated indicator of project entrepreneurial nature	Estimating indicator (question) (on a 5-point scale, where 1 point is the lowest score, 5 points is the highest)	Abbreviation used in the analysis
Goal uncertainty	Project goals were clearly articulated at start of the project (as part of the analysis, the scores were inverted, that is, 1 point became 5, 2 – 4 etc.)	GFB
	Project goals were unambiguously and equally understood by the stakeholders of the project known to you (estimates were inverted)	GSS
	Project goals were transformed during the implementation of the project	GTP
Method uncertainty	At the beginning of the project, the methods and technologies for its implementation were clearly defined (estimates were inverted)	MFB
	Methods and technologies for project implementation were known to the main project contractors (estimates were inverted)	MSS
	Project implementation methods and technologies changed during the project delivery	MTP

Also, the models contained elements that reflect the interaction of project entrepreneurial nature with the three dimensions of individual entrepreneurial orientation. In correlation-regression models, the coefficients for each independent variable, their p-values, R2 indicators and p-values for the models as a whole were calculated. The resulting coefficients (taking into account p-values) were interpreted as indicators reflecting the relationship between various indicators of project success, on the one hand, as well as the entrepreneurial nature and individual entrepreneurial orientation of project managers.

Primary data were collected by means of survey forms prepared in MS Forms. Preliminary processing of data from survey forms was carried out in MS Excel. All calculations were carried out using the R language in the RStudio environment.

To analyze the entrepreneurial nature of the project, we used the scheme proposed by [Kuura el al., 2014] which based on the matrix of goals and methods [Turner, Cochrane, 1993] (Fig. 1). Each of the dimensions was assessed by three questions prepared by the authors of this article (Table 1).

To assess the success of projects, a success assessment scale of five indicators and twenty-seven indicators (four to six indicators in each indicator) was used, developed by [Martens et al., 2018] on the basis of the Shenhar and Dvir model (Table 6). For each indicator, respondents gave ratings on a five-point scale. When assessing the success of the project, self-assessment of projects by their project managers (self-report) was used. The possibility of self-assessment in studies of the relationship between entrepreneurial orientation and project success is explained by [Rauch et al., 2009; Kraus et al., 2012]. Projects implemented in the previous year with the direct and full participation of respondents were subject to evaluation. Respondents in the questionnaire provided additional data about the project to make sure that they remember well the circumstances of this project.

To assess the individual entrepreneurial orientation of project managers, a three-part scale proposed by Bolton and Lane (Table 7) was used, which evaluates individual entrepreneurial orientation in the context of three indicators: risk orientation,

Table 2
Respondents' demographic and professional structure

Indicator	Content	Number	Percent
Sex	Male	54	52
	Female	50	48
Age (years old)	Up to 30	17	16
	31–50	63	61
	From 51	24	23
Project manager experience (years)	Up to 5	17	16
	5–15	53	51
	From 15	34	33
Educational level	Academic degree	17	16
	Master's program/ MBA	30	28
	Bachelor's program/ Specialist program	57	56

Table 3
Respondents' companies by size, age, industry

Indicator	Content	Number	Percent
Headcount	Up to 50	39	37
	51–300	31	30
	301–1000	7	7
	1001–5000	15	14
	From 5001	12	12
Company's age (years old)	Up to 5	24	23
	6–15	24	23
	16–30	31	30
	From 31	24	23
Enlarged industry affiliation	Industry	31	30
	Innovative and technological cluster	34	33
	Services	39	37
Organizational structure of management	Design target	27	26
	Matrix	27	26
	Linear-functional	17	16
	Nerwork	12	12
	Not sure	22	21

Table 4
Respondents' projects by size, duration and methodology

Indicator	Content	Number	Percent
Project duration (months)	up to 6	41	40
	7–12	29	28
	from 13	34	33
Headcount in a project	up to 5	17	16
	6–10	34	33
	11–20	29	28
	from 21	24	23
Basic project management methodology	Flexible	24	23
	Linear (predictive)	22	21
	Hybrid	22	21
	Spontaneous	36	35

innovativeness and proactivity, each of which was assessed by three to four indicators. This rating scale was successfully used in the study of [Popov et al., 2019] in the Serbian cultural context, which can be considered as close to the Russian one.

The collection of data on the assessment of the entrepreneurial nature of projects, their success and individual entrepreneurial orientation was carried out through an online survey of the members from the Project Management journal group on Facebook. The appeal was sent to 200 out of 11400 randomly selected subscribers. Answers were received from 108 people, 4 answers were incomplete. The demographic and professional structure of the respondents is shown in Table. 2.

The distribution of respondents by companies in terms of their number, age, management organizational structure and industry affiliation is shown in Table. 3.

The distribution of projects assessed by respondents according to the number of personnel involved, duration and basic project management methodology is presented in Table. 4.

Dispersion analysis in the context of independent variables used in analytical models (formula (1), Table 8) did not reveal a statistically significant difference in the data of different groups of respondents, projects and organizations.

5. RESEARCH RESULTS

The results of the factor analysis of data according to the estimates of the project entrepreneurial nature are shown in Table. 5. The factor load indicator reflects the degree of indicator belonging to the factor. Values less than 0.3 are excluded from the presentation. Problem indicators are highlighted (the maximum factor load is less than 0.5, or the second load is greater than 0.3, or the commonality is less than 0.5). A practically significant factor load value is 0.5, and a value of 0.7 indicates a good indicator belonging to the factor [Hair et al., 2010]. The correlation between the factors is 0.56 (below 0.85), which means that the factors evaluate relatively different dimensions of the same phenomenon [Brown, 2015].

The structure of indicators and factors turned out to be practically significant. No cases of cross factor affiliation were found out. Yet, the structure is not entirely consistent with the theoretical model, since one factor with three indicators of uncertainty by goals (*GFB*, *GSS* and *GTP*) included an indicator from the groups of uncertainty by methods (*MTP*). In addition, the low level compared with the recommended (0.5) one of the generality index (h2) of the *GTP* (0.411) and *MTP* (0.422) indicators attracts attention. The commonality score can be interpreted as R^2 in regression models. It shows the proportion of indicator variance explained by the factor. Due to these circumstances, the *GTP* and *MTP* indicators were excluded

Table 5
Factor analysis of project entrepreneurial nature indicators

Indicators	Factors		Common character indicator (h2)
	Factor 1 «Goal uncertainty»	фактор 2 «Method uncertainty»	
GFB	0.543		0.539
GSS	0.914		0.781
GTP	0.649		0.411
MFB		0.984	0.930
MSS		0.588	0.584
MTP	0.513		0.422
Cronbachs alpha	**0.701**	**0.710**	

from the system that assesses the entrepreneurial nature of projects. It can be assumed, that the indicators of uncertainty in terms of objectives and methods arising during the project are not very consistent with the indicators of uncertainty inherent in the project at its beginning. The final system of indicators of the entrepreneurial nature of projects used in further analysis is shown in fig. 2. Here are the factor loadings and the correlation between the factors obtained after the exclusion of the two indicators presented above.

The results of the factor analysis of data on the success of the project are given in Table. 6. Problematic indicators that were excluded during

Fig. 2. Indicators structure from factor analysis of project entrepreneurial nature

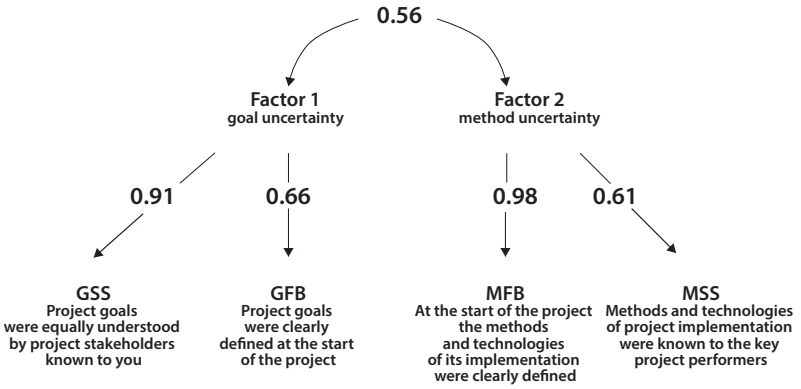


Table 6
Factor analysis of project success indicators

Indicator group (indicators)	Indicators	Factors					General character indicator (h2)
		factor 1	factor 2	factor 3	factor 4	factor 5	
Internal project efficiency (*PSEF*)	The project is completed in time or earlier (*PSEF_1*)					0.539	0.559
	The project is completed with budget performance or economy (*PSEF_2*)					0.790	0.637
	The project is completed in compliance with all the requirements for the results (*PSEF_3*)				**–0.341***	**0.353***	**0.313***
	The project completed with meeting other targets (*PSEF_4*)					0.532	0.582
Team results (*PSIT*)	The project team was satisfied and motivated (*PSIT_1*)		0.805				0.745
	The team was loyal to the project (*PSIT_2*)		0.564				0.763
	The team had high morale and energy (*PSIT_3*)		0.789				0.792
	The team was interested in working on the project (*PSIT_4*)		0.917				0.802
	Team members experienced personal or professional growth (*PSIT_5*)		**0.352***	**0.434***			0.680
	Team members did not try to leave the project/company (*PSIT_6*)		**0.396***	**0.361***			0.566
Preparation for the future (*PSPF*)	The project contributed to the success of subsequent projects (*PSPF_1*)		**0.441***				0.661
	The project led to the creation of new products (*PSPF_2*)			0.744			0.633
	The project contributed to the development of new markets (*PSPF_3*)			0.752			0.656
	The project created new technologies (*PSPF_4*)	**0.338***		**0.462***			**0.454***
	The project contributed to the emergence of new business processes/ models (*PSPF_5*)			0.808			0.692
	The project contributed to the development of managerial competencies (*PSPF_6*)			0.647			0.596
The results for the company (*PSBD*)	The project was economically successful (*PSBD_1*)				0.631		0.824
	The project helped increase the company's profitability (*PSBD_2*)		**0.323***		**0.452***		0.518
	The project had a positive ROI (*PSBD_3*)				0.799		0.728
	The project helped increase the company's market share (*PSBD_4*)				0.726		0.753
	The project created value for the owners (*PSBD_5*)				**0.523**	**0.318***	**0.536**
	The project directly contributed to improving company performance (*PSBD_6*)		**0.399***		**0.358***	**0.361***	0.583
The results for the client (*PSIC*)	The project contributed to the improvement of customer results (*PSIC_1*)	0.855					0.835
	The clients were satisfied (*PSIC_2*)	0.826					0.741
	The project met clients' requirements (*PSIC_3*)	0.771					0.605
	The customer started using the created results (*PSIC_4*)	0.641					0.518
	The customers will return to the company (*PSIC_5*)	0.658					0.523
Cronbachs alpha for the factors (for the final version)		**0.914**	**0.867**	**0.702**	**0.818**	**0.876**	

optimization are highlighted. According to them, indicators are given before optimization. The structure of factors obtained after optimization is characterized by high factor loading (not lower than 0.5), the absence of cross-factoriality, and good generality. Correlations above 0.85 between the factors are not found. Cronbachs alpha for all factors is above 0.7. The structure of the data (after excluding eight problematic ones) is consistent with the theoretical structure of the chosen model.

The results of the factor analysis of individual entrepreneurial orientation of project managers are given in Table. 7. The resulting structure is characterized by good belonging to the factors, high generality, and the absence of a significant correlation between the factors. Cronbachs alpha is greater than 0.7. Based on this fact, all the data for all indicators were used to calculate the indicators of individual entrepreneurial orientation.

As a part of the research questions, five correlation-regression models were formed. The general view is presented below:

$$PSEF = b_0 + b_1\ ENP + b_2\ RISK + b_3\ INN + b_4\ PROA + \\ + b_5\ ENP{:}RISK + b_6\ ENP{:}INN + b_7\ ENP{:}PROA, \quad (1)$$

Where b_i are the regression coefficients of the model elements, *PSEF* is the assessment of the internal efficiency of the project, *ENP* is the assessment of the entrepreneurial nature of the project, *RISK* is the assessment of the attitude to risk as a component of an individual entrepreneurial orientation, *INN* is the assessment of innovativeness as a component of an individual entrepreneurial orientation, *PROA* is the assessment of proactivity as a component of individual entrepreneurial orientation, *ENP:RISK* is the interaction of the entrepreneurial nature of the project and the attitude to

Table 7
Factor analysis of project managers' individual entrepreneurial orientation indicators

Indicator group (indicators	Indicators	Factors			General character indicator (*h2*)
		factor 1	factor 2	factor 3	
Positive attitude to risk (*RISK*)	I tend to take decisive action when doing something in the face of uncertainty (*RISK_1*)			0.815	0.766
	I am willing to invest a lot of time and/or money in something that can bring high returns, even with high risk (*RISK_2*)			0.755	0.519
	I tend to act boldly and decisively in risky situations (*RISK_3*)			0.816	0.673
Innovativeness (*INN*)	I often try new and unusual activities, atypical in most cases, but not necessarily risky (*INN_4*)	0.686			0.619
	In general, I prefer to focus on unique, one-of-a-kind approaches, rather than to improve on proven and common methods (*INN_5*)	0.784			0.702
	I prefer to try my own unique approaches when I'm learning something new rather than to do it like everyone else (*INN_6*)	0.922			0.744
	I like experimentation and new approaches to solve problems, rather than widely used methods (*INN_7*)	0.673			0.640
Proactivity (*PROA*)	I usually act in anticipation of problems, needs and changes in the future (*PROA_8*)		0.919		0.837
	I tend to plan projects ahead of time (*PROA_9*)		0.877		0.692
	I prefer taking on problem solving and project work myself rather than waiting for someone to tell me what to do (*PROA_10*)		0.729		0.791
Cronbachs alpha for the factors		**0.830**	**0.885**	**0.898**	

risk (how much the relationship between the attitude to risk and the internal efficiency of the project will change with an increase in the indicator of entrepreneurial nature), similarly for *ENP:INN* and *ENP:PROA*.

In the other four models, outcome variables were Team Outcomes (*PSIT*), Company Outcomes (*PSBD*), Client Outcomes (*PSIC*) and Preparation for the Future (*PSPF*).

As can be seen from formula (1), the models also implied an analysis of the interaction between the entrepreneurial nature of the project and individual project nature indicators. The interaction of independent variables allows you to identify how one of the independent variables can affect the relationship of another independent variable with the resulting variable.

The results of the correlation-regression analysis in the context of the five generated models are presented in Table 8.

Looking at the statistically significant results (*p*-value less than 0.1 and 0.05), it can be found that the entrepreneurial nature of the project (*ENP*) is negatively correlated with success measures such as internal efficiency (*PSEF*), results for the company (*PSBD*) and outcomes for the client (*PSIC*). Moreover, the coefficient b_1 in all cases is greater than 1 to modulo. Projects with a greater entrepreneurial component are characterized by less success by these indicators, without considering the impact of other factors.

The direct relationship between project success and the individual entrepreneurial orientation of project managers is multidirectional. An improvement in risk attitude (*RISK*) is accompanied by an improvement in the future preparedness score (*PSPF*) (b_2 = 0.68). Project managers' innovativeness (*INN*) is negatively correlated with team outcomes (*PSIT*) (b_3 = –0.59 at *p*-value = 0.06). Proactivity (*PROA*) is positively associated with team outcomes (*PSIT*) (b_4 = 0.60, *p*-value = 0.07) and negatively with client outcomes (*PSIC*) (b_4 = –0.89).

The interaction of independent variables is also ambiguous. The improvement in risk attitude is accompanied by a weakening negative correlation between success and entrepreneurial nature. Thus, in the case of the internal efficiency index (*PSEF*) a 1% % increase in the risk ratio leads to a decrease in the coefficient b_1 (*ENP*) by 0.25% to modulo – from –1.66 to 1.31%. Thus, the attitude towards risk, as the entrepreneurial nature of the project increases, can improve the internal efficiency of projects. An improvement in the attitude towards risk in the conditions of high uncertainty inherent in projects with a high entrepreneurial nature is accompanied by an improvement in internal efficiency.

Similarly, project managers' innovativeness (*INN*) improves team outcomes (*PSIT*) as entrepreneurial nature increases (b_6 is positive and equals 0.32), and project managers' proactiveness (*PROA*) increase reduces the negative impact of entrepreneurial nature (*ENP*) on client outcomes (*PSIC*) (b_7 = 0.25).

6. INTERPRETATION OF THE OBTAINED RESULTS

The results provide incomplete and sometimes contradictory answers to the research questions posed. In the context of the first question, it can be seen that the entrepreneurial nature is indeed associated with lower project success rates. Nevertheless, this does not concern all the indicators. With the increased uncertainty inherent

Table 8
Regression analysis of the relationship between project success, entrepreneurial nature and individual entrepreneurial orientation

Model elements	*PSEF*		*PSIT*		*PSPF*		*PSBD*		*PSIC*	
	bi	***p***	***bi***	***p***	***bi***	***p***	***bi***	***p***	***bi***	***p***
b_0 (*intercept*)	**7.39**	**0.00****	1.87	0.10	–1.24	0.17	**5.23**	**0.00****	**7.15**	**0.00****
b_1 (*ENP*)	**–1.66**	**0.00****	–0.33	0.36	0.36	0.21	**–1.01**	**0.00****	**–1.53**	**0.00****
b_2 (*RISK*)	–0.91	0.02	0.10	0.80	**0.68**	**0.04****	–0.37	0.21	–0.30	0.36
b_3 (*INN*)	0.07	0.81	**–0.59**	**0.06***	0.31	0.21	0.03	0.88	0.05	0.84
b_4 (*PROA*)	–0.01	0.96	**0.60**	**0.07***	0.18	0.49	–0.22	0.37	–0.89	0.00**
b_5 (*ENP:RISK*)	**0.25**	**0.02****	–0.04	0.75	**–0.18**	**0.06***	0.11	0.18	0.08	0.43
b_6 (*ENP:INN*)	0.06	0.52	**0.32**	**0.00****	0.09	0.30	0.09	0.22	0.12	0.15
b_7 (*ENP:PROA*)	0.08	0.39	–0.09	0.36	0.02	0.77	0.11	0.16	**0.25**	**0.00****
R^2	0.34		0.51		0.64		0.39		0.41	
p-model value	0.00**		0.00**		0.00**		0.00**		0.00**	

Note. bi are the values of the coefficients b_0, …, b_7; *p* – *p*-values of coefficients b_0, …, b_7; * – *p*-value less than 0.10, ** – *p*-value less than 0.05.

in entrepreneurial projects, it is more difficult to achieve measures of internal efficiency (*PSEF*), business results for the company (*PSBD*) and results for the client (*PSIC*). Between the entrepreneurial nature, on the one hand, results for the team (*PSIT*) and results for the future (*PSPF*), on the other hand, no statistically significant relationship is found.

Internal efficiency is facilitated by the stability of both management and project execution processes. The uncertainty inherent in entrepreneurship can indeed conflict with internal efficiency [Cooke-Davies et al., 2009]. In addition, internal results, results for the company and for the client are much more related to the content of the project itself than the results for the team, which can be formed due to socio-psychological factors, and the results for the future, which go far beyond the scope of the project itself [Shenhar and Dvir 2007].

Between internal project outcomes (*PSEF*) and entrepreneurial nature (*ENP*) the coefficient has the highest modulo value (–1.66). This is clear, since uncertainty primarily affects the timing and budget indicators. The smallest ratio arose between the results for the company and the entrepreneurial nature of the project. Indeed, of the three dimensions associated with entrepreneurial nature, the results for the company seem to be the ones that go far beyond the scope of the project itself. Positive margins and increased market share (indicators) can be categorized as business outcomes that often result from entrepreneurial efforts.

Considering the results in the context of the second research question, it can be noted that the relationship between the individual entrepreneurial orientation of managers and the success of projects looks at least ambiguous. We will reveal this connection in the context of individual entrepreneurial orientation measurements.

Attitudes to risk (*RISK*) are directly positively related only to outcomes for the future (*PSPF*), and this is consistent with existing views. The creation of new products, the development of new markets, business models is a rather risky activity. Decisive action is required here, despite high uncertainty. The lack of association between attitude towards risk and future outcomes can partly be consistent with the results of the study [Kraus et al., 2012], which also did not reveal relationships between attitude towards risk and company performance despite non-project context.

The parameters of the relationship between the attitude to risk and the results of the project vary depending on the severity of the entrepreneurial nature (*ENP:RISK*). In the context of internal results (*PSEF*) a positive coefficient is visible (0.25 at the intersection of *ENP:RISK* and *PSEF*). This means that as the entrepreneurial nature of the project increases, the attitude towards risk reduces the negative impact of the entrepreneurial nature on the success of the project.

The attitude to risk proves useful for entrepreneurial projects with high uncertainty in methods and goals. Such a result should be recognized as unexpected, since the adoption of risky decisions is ambiguously reflected in the immediate results of the project.

An even more unexpected result is obtained within the framework of the interaction between the entrepreneurial nature of projects and attitudes towards risk (*ENP:RISK*)in the context of the results for the future (*PSPF*). The results show (although only 0.06 significant) that as entrepreneurial nature (*ENP*) increases, willingness to take risks (*RISK*) only reinforces the negative association of entrepreneurial nature with future outcomes (*PSPF*). The concept of entrepreneurial orientation suggests that a positive attitude towards risk contributes to the effectiveness of entrepreneurial activity, that is, activities carried out under high uncertainty [Lumpkin, Dess, 1996]. But, despite the surprise, these results are consistent with the study [Kraus et al., 2012]. They also found a negative effect of risk attitudes as uncertainty increased.

The category of unexpected results includes the absence of any correlation between the success of the project and the innovativeness of project managers, except for the negative relationship between innovativeness (*INN*) and results for the team (*PSIT*). It could be conceded that innovativeness is not entirely relevant to internal and company outcomes. But it turned out that the propensity for unique approaches, new activities, experimentation are in no way connected with the results of the project, and for motivation, loyalty and interest, innovation looks like a useful component. However, we see negative relationships. It can be assumed that the study deals with the individual entrepreneurial orientation of one person, namely, the project manager. An increase in his personal innovativeness can be negatively perceived by the project team.

The interaction of innovativeness and entrepreneurial nature (*ENP:INN*) with the success of the project does not contradict the established theory. Entrepreneurship and project management studies note - it is innovation that helps project managers cope with uncertainty and complexity [Frederiksen, Davies, 2008]. Mastering this entrepreneurial quality improves the results of project managers in a dynamic environment [Kuura, Lundin, 2019]. But the results obtained cannot be called complete, since they relate to only one indicator of the success of the project - the results for the team. In the context of other indicators, the coefficients of the *ENP:INN* parameter do not have high significance.

And finally, in the context of proactivity (*PROA*) we face with an incomplete and sometimes contradictory picture again. Proactivity, that is, the ability to anticipate problems and deviations arising from the complexity, uncertainty and dynamism of the context, is supposed to improve all indicators of success. Indeed, the results suggest that the improvement in proactivity is consistent with only one measure of success, team outcomes (*PSIT*). The results for the client (*PSIC*) worsen as proactivity increases (*bi* at the intersection of *PROA* and *PSIC* = –0.89). It is difficult to explain, but it can be assumed that the proactivity of the project manager manifests itself as excessive independence and additional communication with clients, which negatively

affects their satisfaction, desire to return to the company and perceived results.

In the context of the entrepreneurial nature of the project, the connection between proactivity and results for the client looks understandable. In more entrepreneurial projects, improved proactivity tends to reduce the negative impact of uncertainty resulting from a pronounced entrepreneurial nature. Being proactive in entrepreneurial projects proves beneficial for results with regard to clients. Thus, an increase in proactivity, besides the entrepreneurial nature, is associated with a decrease in success. In an increasingly entrepreneurial environment, proactivity is associated with favorable outcomes, but this is only in terms of clients. For other indicators of project success, the results do not allow us to draw meaningful conclusions.

7. CONCLUSION

Projects implemented under conditions of high uncertainty are classified as entrepreneurial in the literature on project management. The success of such projects is usually more difficult to achieve. Entrepreneurial project managers are expected to have entrepreneurial abilities in order to successfully manage entrepreneurial projects. This article explores two questions regarding project success, entrepreneurial characteristics, and project uncertainty. First, the authors try to find out whether an increase in the entrepreneurial nature of the project, manifested in an increase in uncertainty about the goals of projects and methods of implementation, is accompanied by a decrease in the success of the project. Second, whether the entrepreneurial orientation of project managers affects the success of projects and the relationship between project success and their entrepreneurial nature.

The data collected during the survey from 104 Russian project managers were subject to quantitative analysis with the construction of five correlation-regression models. The results of the analysis allowed us to draw the following conclusions:

- An increase in the entrepreneurial nature of projects is accompanied by a decrease in project indicators such as internal project efficiency (compliance with deadlines, budgets and other internal indicators), preparation for the future (new products, markets, business models, competencies) and client outcomes (satisfaction, loyalty, compliance with requirements, etc.).
- Willingness to take risks, as a measure of the individual entrepreneurial orientation of project managers, is positively correlated with such an indicator of project success as preparation for the future. An increase in proactivity is accompanied by an improvement in such an indicator as the results for the team (satisfaction, loyalty, interest). At the same time, negative relationships were found between the innovativeness of project managers and results for the team, as well as between proactivity and results for the customer.
- With an increase in the entrepreneurial nature of projects, such indicators of individual entrepreneurial orientation as willingness to take risks (in terms of internal project effectiveness), innovativeness (in terms of the results for the team) and proactivity (in terms of the results for the client) turned out to be able to counteract the negative impact of uncertainty on the success of the project.).

In general, individual entrepreneurial orientation is characterized by a positive relationship with the success of the project, especially in terms of increasing the entrepreneurial nature of projects. However, the study produced some mixed results. In particular, innovativeness, in the absence of the influence of other factors, was negatively associated with results for the team, and proactivity inversely correlated with results for the client. For many links between entrepreneurial orientation and project success, no statistically significant relationships could be identified.

The mixed results may be due to limited character of the study, which includes the following:

- data were collected from only 104 respondents among the readers of one magazine, which makes the sample not completely representative;
- only Russian project managers participated in the survey, and accordingly, the results reflect only the realities of the Russian economy;
- the models used to measure the entrepreneurial nature and success of the project proved to be imperfect, which led to the exclusion of certain indicators from the analysis;
- not all factors capable of having a significant impact on the success of projects were included in the correlation-regression models.

The results obtained indicate a rather complex nature of the interaction between the entrepreneurial orientation of project managers and success indicators, taking into account the influence of the entrepreneurial characteristics of the project. Suggested areas for the further research are:

- clarification of the ideas about the entrepreneurial characteristics of projects and about entrepreneurial projects on the whole as a special category. In particular, in the article the entrepreneurial nature of projects is reduced to two dimensions, but it makes sense to include into consideration, in addition to uncertainty in terms of goals and methods, the complexity of the project or the turbulence of the external environment;
- consideration of mutual influence of different levels of entrepreneurial orientation. In addition to the individual orientation used in the article and the widespread entrepreneurial orientation of the company level, the entrepreneurial orientation of the team can influence the success of projects.

The study of the use of entrepreneurial approaches in project management is presented as an actual direction, which has both theoretical and practical significance..

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The article was submitted on 27.08.2021; revised on 19.09.2021 and accepted for publication on 10.10.2021. The authors read and approved the final version of the manuscript.

DOI: 10.17747/2618-947X-2021-2-127-137
JEL L16, L92
UDC 334.72

Digital twins and their appliance in transport economics

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Abstract

Today digitalization increasingly affects the economy, including the transport industry. The consequence of this is the emergence of digital twins that allow modeling and predicting the behavior of both individual processes and enterprises as a whole.

The aim of the article is to investigate the process of digitalization in the transport industry. The theoretical basis of the article was the universal organizational science of A. Bogdanov.

The article offers a definition of information, and its classification in relation to the economy at three levels: applied information (technological information), information about algorithms of the owners of factors production behavior (behavioral information) and information, with which the impact on the owners of production factors and the real economy in general (directive information). The totality of these levels of information from the macroeconomic point of view forms an information economy, and from the microeconomic point of view – a digital twin of a particular subject of the real economy.

It is proved that the digital economy is a subsystem of the information economy, differs in a binary way of presenting information and is maximally oriented to the management of the real economy.

Information precedes all activity, so the real economy is a product of the information economy. Consequently, the technological division of labor is based on a prior informational division of labor. This theoretically allows us to judge the adequacy of the digital twin through the analysis of individual technological levels of the transport enterprise. This hypothesis was applied to the analysis of the Russian railway transport, which gave reason to consider this approach promising for use at macro- and micro-levels both.

Keywords: real economy, digital economy, digitalization, signal, information, classification, digital twin, efficiency.

For citation:

Rimskaya O.N., Anokhov I.V. (2021). Digital twins and their appliance in transport economics. *Strategic Decisions and Risk Management,* 12(2), 127-137. DOI: 10.17747/2618-947X-2021-2-127-137. (In Russ.)

1. INTRODUCTION

Significant progress in recent decades in the development of digital technologies and processing capacity of computers with a simultaneous reduction in the costs of their use has made digitalization a mass phenomenon that has affected all areas of the society and economy, whereas a digital twin has become an everyday reality.

The term “digital twin” became widespread after the publication of the article [Grieves, 2017] and today it is widespread in relation to virtual models of industrial objects or processes created with the help of information programs.

In our opinion, this term is applicable not only to technical systems, but also to economic ones, as the economy is increasingly becoming digital. In the railway industry, the first digital projects were created in the Soviet days at the Experimental Institute of Communications, the leading research institute of the railway industry (JSC VNIIZHT) [Mazo et al., 2021].

Digitalization has acquired both micro- and macroeconomic character. The Strategy for the Development of the Information Society of Russia until 2030 defines the digital economy as follows: “the digital economy is an economic activity in which the key production factors are digital data, the processing of large volumes and the use of analytical results which, compared to traditional forms of management, can significantly increase the efficiency of various types of production, technologies, equipment, storage, sale, delivery of goods and services[1].

2. LITERATURE REVIEW

In a simplified form, the digital economy can be interpreted as “the economy of goods and services, the development, production, sale or supply of which is completely dependent on digital technologies” [Kling, Lamb, 2000], and its main distinguishing feature can be considered “the implementation of economic and social

[1] Decree of the President of the Russian Federation of May 9, 2017 No. 203 “On the Strategy for the Development of the Information Society in the Russian Federation for 2017–2030”. URL: http://kremlin.ru/acts/bank/41919.

activities via the Internet » [Dahlman et al., 2016]. Indeed, "the interest in the impact of digital technologies on the economy initially arose with the growth of the Internet" [Foster, Azmeh, 2020. P. 1251]. However, in this respect, it is no longer possible to consider, for example, in-house information technologies that operate autonomously from the Internet (for example, software for a machine tool with numerical control) digital.

In this regard, some authors give a wider list of features of the digital economy, including cyber-physical systems [Barbosa et al., 2016], the Internet of things, digital twins, autonomous robots [Foster, Azmeh, 2020. P. 5-6]. Other authors believe that digital economy is also distinguished by specific products, as well as by new ways of production and consumer interaction, for example, in the shared use format [Daviesa et al., 2017].

In recent years, more and more attention has been paid to how digital technologies, services, products, methods and skills are becoming a key aspect of each sector, that is, digitalization, which is defined as "the transition of business to the use of digital technologies, products and services" [Brennen, Kreiss , 2016]. They facilitate the integration of firms into global networks with the participation of states [Sampath, 2018]. These kinds of digital platforms have indeed fundamentally changed the economic landscape, but they have also created a significant asymmetry between enterprises in the real economy and entities that own data and are able to use it (within and across countries) [Srnicek, 2016; Weber, 2017]. A fundamentally new feature of this increased organization is the ability to scale it to the whole world, as a result of which new players find themselves in a worse position than the pioneers [Zhu, Iansiti, 2012]. This explains the "winner takes it all" effects [Kuchinke, 2016] and the total dominance of companies like Amazon, Google, and Facebook. This means that digitalization can radically increase the level of internal organization of a subject, bringing it to a leadership position.

The advantages of the digital economy development according to the World Bank's review "Digital Dividends"[2]:

- growth of labor productivity;
- increase of companies' competitiveness;
- reduction of production costs;
- creation of new jobs;
- overcoming of poverty and social inequality.

Here one could add that in the digital economy, communication costs tend to zero and generate strong network effects [Engel, 2015]. In addition, "digitalization reduces transaction costs in order to combine human capital skills across geographic boundaries and increase the scalability of these skills" [Banalieva, Dhanaraj, 2019. P. 1379]. The scalability and speed of implementation of digital projects are also growing dramatically [Brouthers et al., 2016].

The introduction of digitalization into life in many sectors of the economy, in addition to obvious advantages, also brings a number of following disadvantages for the humanity:

- the risk of cyber threats associated with the problem of protecting personal data – the problem of fraud can be partially solved by introducing the so-called digital literacy;
- "digital slavery" – the use of data about millions of people to control their behavior, for example, to stimulate the growth of sales of goods and services due to massive online advertising;
- increased unemployment in the labor market, as the risk of the disappearance of certain professions and even industries will grow. Thus, many experts seriously believe that the banking system will disappear within the next ten years. This will become possible due to the further spread of information technology and its products: stores with electronic cash registers, customer service bots, unmanned vehicles, etc;
- "digital divide" – a gap in digital education, conditions of access to digital services and products, which leads to a gap in well-being of people living in one country or in different countries.

3. MATERIALS AND METHODS

Each collective subject acting in the economy, in terms of A.A. Bogdanov can be defined as an organized complex, understood by him as "the whole is greater than the sum of its parts".

Such an organized complex creates many different kinds of signals and simultaneously receives them from other subjects. For the transport industry, such signals can be the following: the demand for transportation services, the dynamics of production at key consignors, the state of infrastructure, macroeconomic conditions, changes in tax and credit rates, indexes of optimism of producers, population size, dynamics of final demand, energy supply of the country, etc. Some of these signals are external noise for the transport company, and the other part is recognized among this noise, embedded in cause-and-effect relationships known to the company; it changes its behavior and, as a result, becomes information. In other words, information in this article refers to external signals distinguished by an organized complex among the noise surrounding it and builds into its causal relationships, which allows to adapt its activity to a continuously changing external environment.

Sensitivity to external signals and the ability to distinguish them increase as the organizational structure of the subject develops and becomes more complex. In the course of this, information turns into a universal instrument of ingression (from Bogdanov's point of view), that is, into a tool capable of connecting the activities of extremely diverse areas: the technosphere and human, technology and economics, natural and human sciences, etc.

[2] World Bank Review "Digital Dividends" (2016). URL: https://openknowledge.worldbank.org/bitstream/handle/10986/23347/210671RuSum.pdf.

However, for this, a certain category of signals from these areas must be singled out and brought to uniformity and a common understanding. Such signals in human civilization have become quantitative data, and the main way to recognize and understand them is mathematics, which, according to Bogdanov, is equally applicable "to combinations of astronomical worlds and biological cells, living people and ethereal waves, scientific ideas and atoms of energy" [Bogdanov , 1989. S. 124]. Indeed, mathematics is "defined as the 'science of quantities'. The value is the result of measurement; and the latter means the consistent application of some measure to the measured object and, obviously, proceeds from the prerequisite that the whole is equal to the sum of the parts" [Bogdanov, 1989. P. 124].

It also turned out that the operation of such mathematized, that is, impersonal and universally applicable information allows us to more fully identify causal relationships and use a fundamentally new opportunity: to model reality without the need to set matter and human being in motion each time, overcoming their inertia. For this, mankind in different periods of its existence used various material carriers: the human ability to remember (civilization of memory), available physical objects (wood, birch bark, clay, stone, bundles, etc.), (civilization of images), syllabic and alphabetic writing (civilization of letters), mathematical signs (civilization of numbers), binary signs (civilization of numbers)… Thus, mankind has constantly improved in the use of general, ingressive aspects of the processes and phenomena surrounding it, having achieved amazing success in this.

4. RESEARCH RESULTS

Any separate transport process can be understood as a process of connecting material objects (cargo, rolling stock, infrastructure, etc.) with energy, information and human labor. In this process, the information is applied as the application technology of such a connection and therefore it can be designated as the information of the first level (or application information).

With the accumulation of experience, the carrier, based on the information of the first level, receives the information of the second level (or behavioral information) in the form of understanding and preliminary modeling the behavior of those who own the following objects: cargo, infrastructure, labor, energy and information of the first level. These owners can be called the main subjects of the real economy.

Over time, it turned out that this information modeling system allows you to develop and apply your own tools for influencing the real economy, for example, in the form of a risk-sharing system for shippers, when trading caravans and ships were financed by several merchants together or, later, in the form of shareholding. The influence of such an information tool as money turned out to be the most global, which made it possible to minimize risks, time and transaction costs significantly, and build the longest possible production chains. Thus, it became possible not only to record and predict events and processes in the real economy, but also to determine them in many respects. This kind of digital signals can be called the third-level information (or deterministic, directive information). Such signals can be both formal and informal:

- cash and financial contracts;
- rights to resources,
- planning tasks, estimates, budgets, forecasts;
- equity participation rights;
- access to tangible and intangible objects;
- contracts for future deliveries, services and works;
- personal relationships, position in a small group;
- public reputation and position in the society, political weight.

Thus, with the help of the information, a person gradually received the following opportunities: modeling the combination of factors of production → modeling the behavior of the owners of these factors → predicting the reactions of the owners and controlling their behavior.

From this point of view, the information system in the economy is a system for fixing and processing quantitative signals from the subjects of the real economy, which has the ability to influence the behavior of these subjects with the help of reverse information signals.

If the information of the first level, in fact, is an algorithm for the interaction of subjects of the real economy in a particular situation, then the information signals of the third level launch these algorithms. This, among other things, means that the possibility of predicting and informational regulation of the behavior of subjects of the real economy is in harmony with their autonomy, since the reception of money and other signals actually launches a package of a predetermined algorithm of actions for a particular subject. An information signal is required only to change one algorithm to another, after which the subjects of the real economy act independently. Because of this, the third-level information can be used as flexibly as possible by combining such algorithms into long production chains.

Considering the above mentioned, the goal of the information economy is to increase the ideality of the real economy by eliminating various kinds of losses, risks and unproductive actions. To do this, each real production process is initially tested on information models. Based on the Pareto principle, we can say that the information economy is designed to help the real economy in performing only the productive 20% of activities while eliminating the remaining 80%.

Thanks to its unique advantages, the information economy is now able to manage the real economy, while the real economy cannot manage the information economy. This actually means that the information and real economies are related as a system and a subsystem. This is not accidental, since the state, science, education, upbringing, art and much more refer specifically to the information system.

However, today we see that an information system based on operating with numbers (0, 1, 2, ..., 9) is rapidly turning into a digital system using only two characters: 0 and 1. As a result of this process, for example, the value of a work of art, a movie, a video, a website, a scientific article, and much more today is measured by the number of views, comments, quotes, etc. It is noteworthy that the content of these views, comments, and quotes has ceased to have at least any meaning: a choice was made from two options (looked - did not look, read - did not read, quoted - did not quote, etc.). Thus, information now often turns into an alternation of the simplest and unambiguously interpreted states: yes – no, false – true, "+" and "-", "on" - "off", 0 - 1.

At the same time, the reverse movement of information – from the information system to the real economy – often takes on the same binary form: yes – no, perform – do not perform, permissible – unacceptable, impossible – possible, agreed – not agreed, etc. The same applies to assessments of the activities of the subjects of the real economy: good – bad, acceptable – unacceptable, to support the proposal – not to support, to allocate resources – not to allocate, etc. Having received this kind of binary information, the subjects of the real economy begin to perform one or another algorithm of actions pre-embedded in them.

From this point of view, digitalization is nothing more than a decrease in the sensitivity of the information system, an enlargement of the caliber of perceived signals and a unit of received and transmitted information. It also provides an increase in the stability of governance (just as a QR code is in some cases simpler and therefore more appropriate than an alphanumeric code), as well as an improvement in the predictability of reactions from the real economy.

In our opinion, the information and digital economies exist today in parallel and solve different problems:

- the tasks of the information economy: capturing the signals of the real economy, their formalization and embedding in cause-and-effect relationships to prescribe algorithms for the behavior of the subjects in this real economy;
- the tasks of the digital economy: launching one or another algorithm and fixing feedback signals about their implementation.

A conditional example is the situation when the government of a country, having caught signals about the state of the real economy, develops specific, detailed algorithms to stimulate certain industries (that is, using the tools of the information economy) and decides to launch these algorithms (that is, according to the binary principle, inherent to the digital economy: stimulate – do not stimulate).

In other words, the information economy monitors the state of the real economy and creates algorithm templates for it, while the digital economy launches packages of these templates and receives reports on their implementation.

In this regard, it is not surprising that the digital economy is focused on a binary, digital representation of information, because "a digit is a control signal in information and computer systems" [Katasonov, 2019. P. 65].

The separation of the digital subsystem from the information system is a reaction to the continuous multiplication of the volume of circulating information and the corresponding decrease in the ability of the information system to interpret them. In the most typical areas that do not require immersion in algorithms, the system choses the simplest way of fixing and processing a unit of information, suitable for any information carrier and using extremely simple and general units of measurement, that is, one and zero, which are complete (rather than intermediate) states and not open to multiple interpretations.

5. DIGITAL ECONOMY ON TRANSPORT

Based on the foregoing, the information economy on transport should provide a connection into a single organized complex:

- transportation technologies (the first-level information);
- activities of carriers, consignors and consignees, as well as third parties (banks, insurance companies, the state, etc.) (the second-level information);
- long-term interests of subjects of the real economy (the third-level information).

The information economy can be considered effective if the degree of ideality of this organized complex increases, that is, there is a movement to a state where the function of transportation is performed, and the subject of transportation gradually disappears[3].

To this end, the information economy monitors the control parameters of the real economy and, if necessary, corrects the model. That is why an information specialist (controller, accountant, standardizer, economist, programmer, etc.) has become an obligatory participant in any production process, and the staff of information departments at enterprises is constantly grows in size with a simultaneous increase in salaries.

The information system and the real economy developed simultaneously. Therefore, along with the concept of "technological division of labor" (in the interpretation of A. Smith [Shchedrovitsky, Kuznetsov, 2016]), it is advisable to use such a concept as the information division of labor, which here means the allocation of three levels of information: transportation technology (the first-level information); data on the activities of participants in the transportation process (the second-level information); data on the long-term interests of the subjects of the real economy (the-third level information). Let's consider this point in more detail.

[3] An example of such an ideal system in some cases can be a river (for passing carriers). In the modern economy, they are trying to get closer to this state, for example, by creating unmanned vehicles.

It is hardly necessary to prove the thesis that the larger the activity of an enterprise (for example, the volume of transportation), the more complex its internal structure should be. During the period of its maximum complexity, the structure of a transport company, in addition to the transport departments themselves, also includes supply departments (logistics department, warehouses, terminals, garages, depots, training centers, etc.), economic (accounting, labor and wages department, financial department, etc.), technological (R&D department, legal department, research center, etc.) and political (director's office, board of directors, etc.) divisions. Each of these specialized subdivisions, as the result of a technological division of labor, is based on information of the appropriate level, and arises with a certain, strictly individual for each enterprise volume of transportation and the number of entities involved (Fig. 1).

Figure 1 shows that as the volume of traffic in the real economy grows, the role of relations with external entities increases, which requires the transport company to allocate appropriate specialized units to work with them. This process would be impossible if the information system did not accumulate the relevant information and expand the horizon of understanding the interests of the subjects of the real economy at the transport enterprise. Considering that knowledge precedes conscious action, the presence of an information system is a necessary condition for the subsequent emergence of the technological units related to the real economy. The digital economy in Figure 2 is shown as a direct connection between technological units, which is digital, binary in nature and is aimed at the transfer of orders and reports of their implementation.

Levels of information are shown in horizontal sections, because, for example, in some cases, the development of technology allows the carrier to scale it and achieve an increase in cargo turnover without growing numbers of external entities.

In addition, the model in Fig. 1 shows the situation where the growth in the volume of transportation coincides with the growth in the number of entities involved. However, in practice, a situation is possible when the volume of traffic increases without a significant change in the number of subjects (Fig. 2), or the number of subjects grows with a constant volume of traffic (Fig. 3).

Fig. 3. The model of growth in the number of the involved subjects with the invariable volume of transportation (transactional strategy)

The model in fig. 2 may prevail when the carrier performs a mono function: transportation for the benefit of a limited circle of shippers (for example, as a subsidiary). In this case, all relationships with suppliers and contractors, technology developers, political forces, and government agencies are the task of the parent company. At the same time, the technological levels of the carrier, as a rule, are enlarged.

The model in fig. 3 can take place when the carrier operates in conditions of increasing instability of the external environment, which requires significant transaction costs without increasing freight turnover. To overcome this instability, he is forced to create specialized units that interact with specific external actors. At the same time, the increasing costs of maintaining an overgrown organizational structure are included in the tariff and paid by shippers.

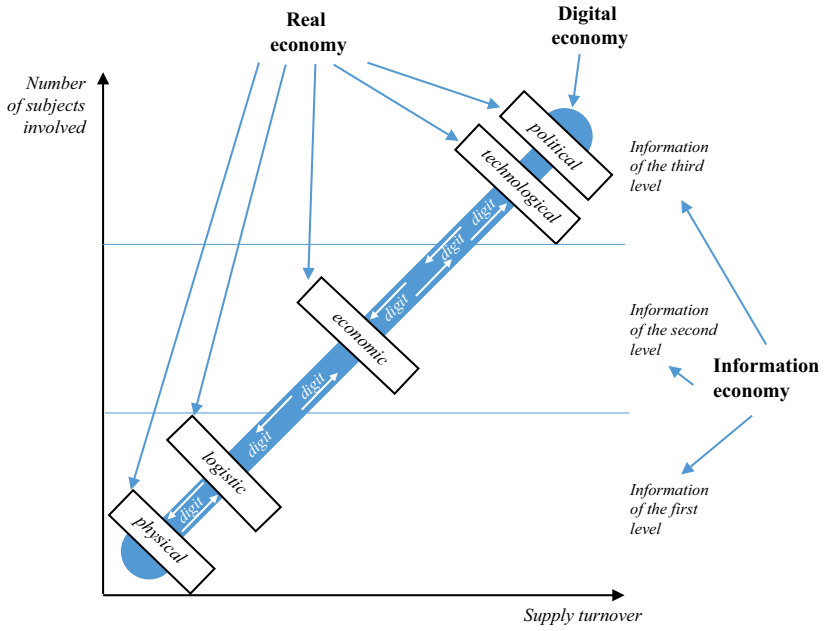
Based on this, the strategy of the transport enterprise corresponding to the model in Fig. 2 can be called conservative (routine), and the strategy of the transport enterprise corresponding to the model in Fig. 3 – transactional.

In addition, in a transport enterprise, some technological levels may be more successful than others. Such unevenness is unique for each enterprise and can be fixed through the analysis of the digital twin of this enterprise. This aspect will be discussed further.

6. ASSESSMENT OF INFORMATION LEVELS

Testing the model shown in Fig. 1 requires internal, specially collected information about the activities of a transport company. Due to the lack of such information in the public domain, publicly available information on the activities of freight rail transport in Russia (mainly data from the State Statistics Committee of Russia) will be used,

Fig. 1. Model of interdependence of information, real and digital economies (balanced strategy)



The source: compiled by the authors.

which makes it possible to judge the digital twin as a first approximation despite the fact it characterizes its activities only indirectly.

Taking into account this fundamental reservation, we will consider all three information levels and try to model the digital twin of Russian railway transport in a binary, digital representation.

6.1. THE FIRST-LEVEL INFORMATION

If we assume that A is the set of actions available to the carrier (regardless of whether he acts in his own interests or in the interests of others), then in this set there is some subset of actions B ($B \subset A$), in which the carrier can connect factors of production for the implementation of the transportation process.

In turn, in this subset B there are several alternative algorithms for connecting factors of production (that is, subsets of the third level, for example, two alternative subset algorithms C and D): from randomly spontaneous to verified in detail. These algorithms differ in the information that underlies them. Each carrier is able to rank these algorithms from best to worst, for example, cargo transportation algorithm C is more productive than algorithm D: $C > D$, since it brings greater physical results from transportation (R_C).

Having chosen the best algorithm, the carrier adheres to it in the future, resulting in a process that Bogdanov called progressive selection [Bogdanov, 1989. p. 202], which manifests itself in the spontaneous consolidation of those actions that improve the technological process. In other words, the carrier improves the algorithm and the consequence of this "is an increase in its activities due to the environment" [Bogdanov, 1989. p. 202]. On the external plane, this manifests itself in a decrease in the number of unproductive actions, as well as losses in time and working capital, which is generally equivalent to an increase in the physical results of the transportation process from optimizing the same algorithm:

$$R_{C1} > R_{C2} > \ldots > R_{Cn}. \quad (1)$$

The efficiency of a transport enterprise in modeling the transportation process is evidenced by the first-level information (applied technology), which should reduce the labor intensity and energy intensity of cargo transportation, reduce transportation time, save rolling stock and track, provide shippers with physical access to increasingly remote areas, etc.

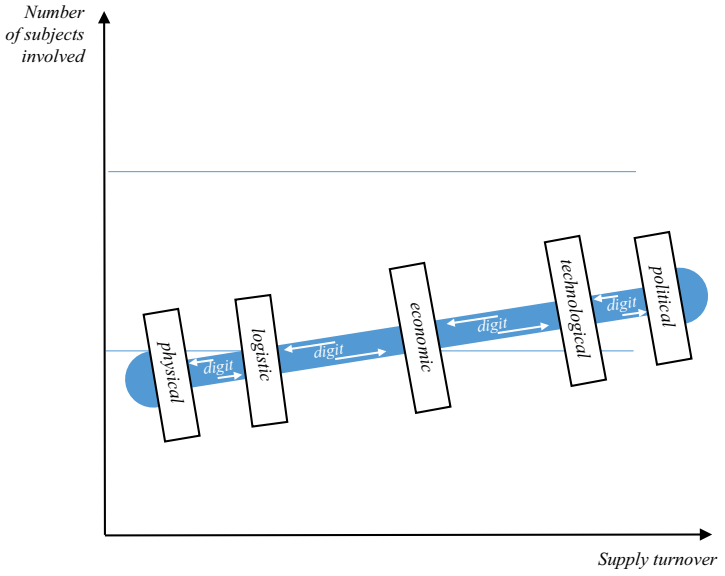
As you can see, in 2019, compared to 2005, there is a significant increase in the performance of railway transport, which positively characterizes the use of practical technologies. An exception is the increase in the number of accidents, which may indicate a weakening control over transportation technology.

On the whole, it can be stated that inequality (1) is satisfied, which means that the railway transport of Russia as a whole works effectively with the information of the first level.

6.2. THE SECOND-LEVEL INFORMATION

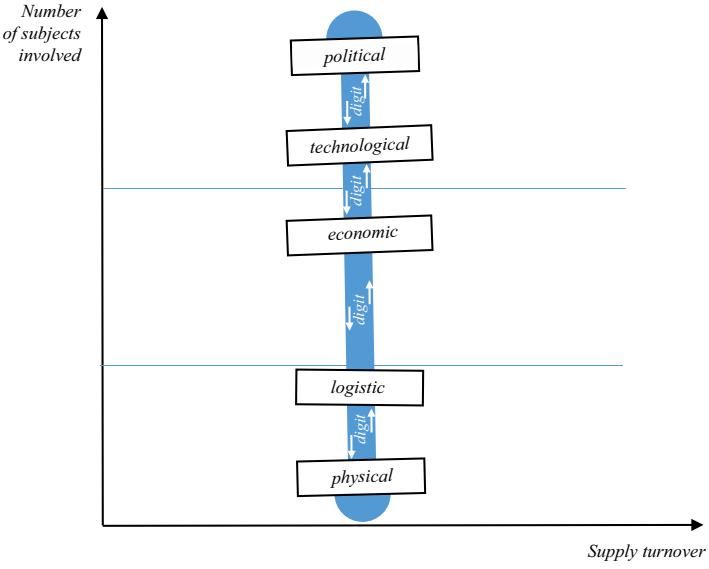
The second-level information of the digital twin should show how effectively transport companies can predict the behavior of their transportation partners, that is, synchronize their activities with those of the main consignors and consignees.

Fig. 2. Model of transportation growth with a limited increase in the number of actors involved (conservative strategy)



The source: compiled by the authors.

Fig. 3. The model of growth of the number of the involved subjects with the invariable volume of transportation (transactional strategy)



The source: compiled by the authors.

Table 1
Parameters of railway transport activity

Indicator	2005	2010	2015	2017	2018	2019
Length of communication lines (thousand km)	…	124	118	123	122	122
Working fleet of loaded railway cars (thousand pieces on average per day)	270	328	388	417	461	473
Operating length of railway tracks (thousand km)	85	86	86	87	87	87
Density of public railway tracks (km per 1000 km^2 of the territory)	5.0	5.0	5.0	5.1	5.1	5.1
Intensity of cargo transportation per 1 km of the length of public railways	21.8	23.5	26.7	28.8	30.0	29.9
Working fleet of loaded railway cars (thousand pieces on average per day)	270	328	388	417	461	473
Freight transported (million tons)	1273	1312	1329	1384	1411	1399
Number of railway accidents	5	1	15	14	10	18

Source: Transport in Russia. 2020: Stat. Sat. M., Rosstat.

If A is the set of possible actions of railway transport, and H is the set of possible actions of consignors, then the subset of jointly performed actions G (Fig. 4, a) increases over time (Fig. 4, b) due to the accumulation of experience, synchronization of their activities and reduction of transaction costs.

Moreover, with the deepening of the division of labor, subsets of the action E and F, become available to them, which were previously inaccessible (Fig. 4, c). This can manifest itself, for example, in the sharing of rolling stock, infrastructure, training centers, etc.

To analyze such processes, it would be advisable to compare the following indicators (which are equally applicable for both the carrier and its partners): the rhythm of the main activity, the level of utilization of fixed assets, the duration of the main production cycles, etc. However, given the publicly available information on the adaptation of the carrier's activities to the activity of its partners (for example, coal mining companies), one can judge indirectly: by the surplus/deficit of cars and the dynamics of production of the main shippers (Fig. 5).

As can be seen from the figure, for the period under review, the dynamics of coal production is in antiphase with respect to the deficit / surplus of cars for its transportation. Meanwhile, hard coal is key for rail transport: it accounts for about a third of the total volume of loading. The same applies to the dynamics of mining of metal ores. This situation has many reasons: from the inelastic supply of railcars and the length of the investment cycle for the renewal of the railcar fleet to the volatility of demand for freight transportation services.

This means that at the second-level information, the activities of railway companies are not sufficiently synchronized with their main partners (at least in the medium term).

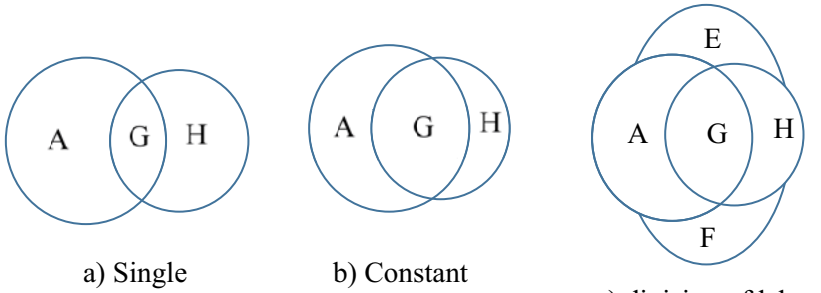
6.3. THE THIRD-LEVEL INFORMATION

The efficiency of a transport enterprise at the third level of information means that it is able to influence other participants in the transportation process, using new technologies and political levers, as well as to harmonize relations with them in the long term. The consequence of this should be the harmonization of their long-term interests and the effectiveness of the main production activities. Of fundamental importance is the emergence of tools for managing the activities of consignors which leads to the set of their possible actions H that become a subset of actions of railway transport A (Fig. 6, b). In other words, shippers become a subsystem of rail transport ($H \subset A$).

With the available information, the situation in Fig. 6 can only be assessed indirectly – through a comparison of the profitability or effectiveness of their activities (Table 2).

From Table. 2, we can conclude that the profitability of the main production activities of shippers (enterprises for the extraction of coal, gas, oil and ores) is several times higher than the profitability of the main production

Fig. 4. Effect of synchronization of railway transport and shippers activities



a) Single shipments b) Constant shipments c) division of labor

The source: compiled by the authors.

activities of railway carriers. Of course, each of these industries has its own market, degree of price control, level of monopolization and taxation, and so on. Nevertheless, rail transport demonstrates less investment attractiveness, insufficient control over the cost of transportation and the economic efficiency of new technologies. Of high importance is the regulatory function of the state which directly and indirectly limits the amount of tariffs. However, the rail freight market is a buyer's (i.e. shipper's) market.

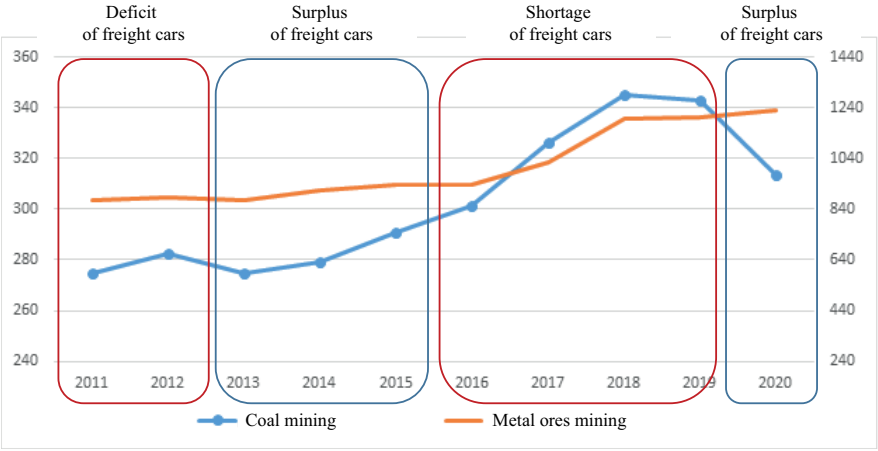
At the same time, in terms of return on assets, rail transport is an absolute leader among those industries presented in Table. 2, which can be explained by the relatively smaller size of such assets in monetary terms.

As a result of this analysis, an image of a digital twin for the railway transport of Russia is formed (Fig. 7).

The right side of Fig. 7 (b) is nothing more than a digital twin of the enterprise, composed of all three types of the information, which provides new instrumental capabilities. Thanks to it, for example, it is possible to judge with greater or lesser accuracy the real economy of the carrier, as well as the efficiency of his work with information.

The image can be different: from that shown in Fig. 5 as generalized as possible to reveal the work of individual divisions of the transport enterprise.

Fig. 5. Surplus/deficit of cars and dynamics of the main cargo shippers' production



Sources: Russia in numbers. 2019: Brief stat. Sat. M.: Rosstat, 2019; [Savchuk, 2020].

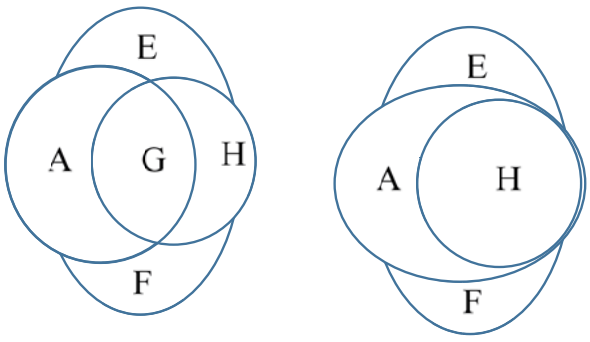
7. DISCUSSION AND CONCLUSION

Information today is a key factor in the economy as a resource, a commodity, a source of added value and a means of employment. The advent of the Internet, the reduction in the cost of access to the global network, the multiplication of computing abilities have become a real digital revolution that has changed our life in general and the economy in particular.

Digitalization has become the most important factor in the activity of all sectors of the economy, including transport. It is clear that modern transport and logistics will require a different management approach that not only takes into account technological aspects, but is also more customer-oriented than ever before. This forms the prerequisites for creating a digital service of the 21st century, a customer-oriented economy on demand in a digital reality.

This is quite clearly realized by both the leaders of transport companies and government officials. Thus, the government decree dated from March 19, 2019 No. 466-r[4]

Fig. 6. Management of cargo shippers activity thanks to the information of the third level of the railway transport



a) b)

The sources: compiled by the authors.

[4] Decree of the Government of the Russian Federation from March 19, 2019 No. 466-r "On Approval of the Development Program of Russian Railways JSC until 2025". URL: http://www.consultant.ru/document/cons_doc_LAW_320741/.

Table 2
Profitability of sold goods, products (works, services) and assets of organizations by types of economic activity (%), 2017–2018

Indicator	2017		2018	
	Profitability of sold goods, products (works, services)	Profitability of assets	Profitability of sold goods, products (works, services)	Profitability of assets
Total	6.7	3.8	12.3	6.4
Extraction of minerals, including:	24.6	10.4	33.6	17.3
Coal minig	28.4	16.1	31.4	11.6
Crude oil and natural gas production	24.1	10.7	35.3	20.4
Mining of metal ores	47.4	11.3	57.3	17.6
Extraction of other minerals	41.5	7.8	50.9	7.6
Railway transport activity: freight transportation	13.6	16.7	18.5	20.2

Source: Russia in numbers. 2019: Brief stat. Sat. M., Rosstat, 2019, 261-263.

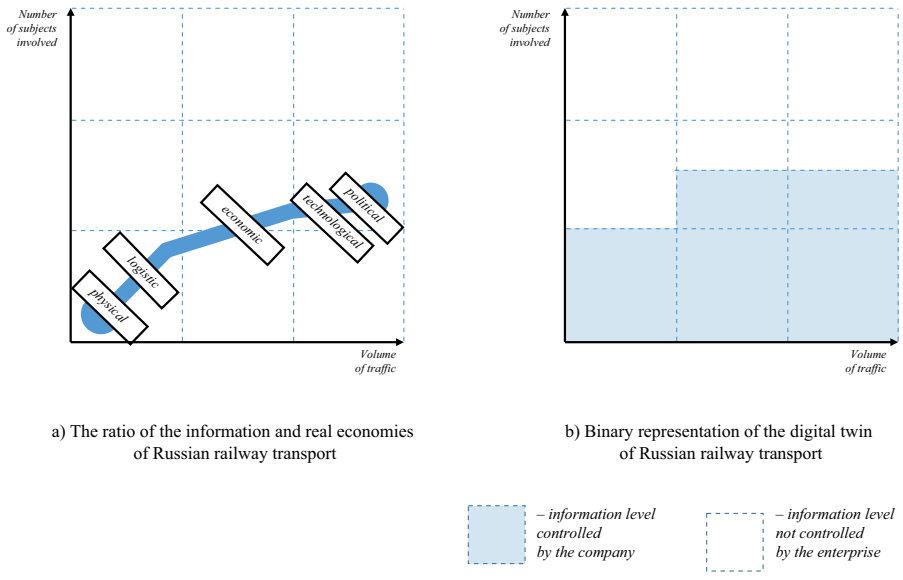
approved the long-term development program of Russian Railways JSC until 2025, which involves the implementation of the Digital Railway project, including:

- Creation of a unified information space for freight traffic and the passenger complex;
- Formation of end-to-end digital technologies for organizing the transportation process in order to improve the efficiency of rail transportation and infrastructure;
- Creation of a unified integrated automated management system, optimization of corporate enterprise management systems, analysis and development of reporting.

By virtue of large-scale digitalization, the presence of a digital twin becomes an integral part of every transport enterprise. This requires clarification of the quantitative relationships between the three levels of information, which allows to calculate automatically all other parameters of the analyzed transport enterprise in case you know one numerical parameter. This issue deserves separate consideration in subsequent articles.

The rapid growth of the importance of the digital twin has obvious disadvantages. So, today we see, for example, that with the accumulation of information capacity, scientometric, abstract bases become almost more important than scientific articles and journals themselves, the collected data on people's

Fig. 7. Image of digital twin for Russian railway transport



a) The ratio of the information and real economies of Russian railway transport

b) Binary representation of the digital twin of Russian railway transport

The source: compiled by the authors.

consumer behavior is more important than each individual, and the ability to generate more and more new digital money is important in comparison to the state of the real economy.

The next stage of digitalization may be the autonomy of individual modules of the digital economy, that is, their ability to initiate and interact with each other while activating certain physical production processes. It is likely that on the basis of the third level information it will be possible to create new first-level information without the direct participation of a person (that is, to invent), as well as to perform legally significant actions (for example, order a transportation service).

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The article was submitted on 9.10.2021; revised on 2.11.2021 and accepted for publication on 10.11.2021. The authors read and approved the final version of the manuscript.

DOI: 10.17747/2618-947X-2021-2-138-149
JEL: M480

Pandemic (COVID-19) effect on financial statements: The role of government and organizations for future prevention

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Abstract

COVID-19 pandemic period impedes business operations and world economic growth. This type of pandemic may happen again in the future. Hence, the objectives of the study are to find out the pandemic effect on items in financial statements; to predict the future effect on items in the financial statements, and to find out the role of government and organizations for future prevention of the adverse effects on financial statements due to the pandemic. The analysis is based on a large number of publicly available sources, including research papers, governmental documents, and reports. The study has taken 8 ratios compared with 80 listed companies around the globe. During the pandemic period the magnitude of adverse effect on business operations depends upon the decision and actions of external bodies (WHO, governments) and internal ones (organizations) parties. The findings revealed that the role of government and organizations for future prevention of 'Pandemic Effect on Financial Statements' is vital to defend against future pandemic situations. This study has added a new discussion to the body of knowledge, i.e. examining pandemic (COVID-19) effect on business operational activities and its financial statements; hence, an approach that is not widely discussed in the previous studies.

Keywords: future prevention, financial statements, government, pandemic, COVID-19.

For citation:

Thottoli M.M. (2021). Pandemic (COVID-19) effect on financial statements: The role of government and organizations for future prevention. *Strategic Decisions and Risk Management*, 12(2): 138-149. DOI: 10.17747/2618-947X-2021-2-138-149.

1. Introduction

Financial statements include income statements, statements of financial position, cash flow statements, and statements of equity shareholders. If there are no accurate, timely and regular financial statements, even if one who believes that the business is doing well, the business could not able to achieve their aim [Adrian, 2019; Mathuva et al., 2019]. Cash and profit are considered the lifeblood of any business [Mazzarol, Reboud, 2020]. Fair financial statements are helpful for stakeholders including managers, shareholders, investors, banks, government, tax inspectors, and so on to make the right decision [Davern et al., 2019; Weetman, 2019]. The preparation of financial statements is compulsory as a legal requirement [Gahlot et al., 2019; Pelekh et al., 2020]. Unqualified audited financial statements ensure the presence of applicable accounting standards (International Accounting Standards – IAS) [Adrian, 2019; Jatmiko et al., 2019] and Generally Accepted Accounting Principles (GAAPs) [Routh et al., 2019]. These statements are used by different stakeholders for different decision-making [Weetman, 2019; Birt et al., 2020]. Concepts and a clear understanding of accounting, financial statements, and budgeting [Reichard, Küchler-Stahn, 2019] helped take the right decision at the proper time in order to direct the business towards its financial success [Birt et al., 2020].

Governments, income tax departments, security exchanges compel companies to prepare their financial statements on a quarterly basis [Mao, Wu, 2019] that might use company management to guide and control future financial requirements [Kajüter et al., 2019]. The COVID-19 pandemic impeded business operations [Koonin, 2020] and economic growth [Barro et al., 2020] around the world and it continues as a universal phenomenon [Crank et al., 2019]. Since the universe has faced many diseases in pandemic scales, it badly affects major business operational activities [Koonin, 2020]. It is obvious that the pandemic, say, novel coronavirus has been controlled by many countries [Wu, McGoogan, 2020], a lot of measures have been taken by both government (external) and business organizations (internal) [Zhang et al., 2020]. The measures taken by both external and internal bodies of such countries as Italy, the United States, Spain, Germany, France, and Iran have not

limited the spread of COVID-19 among citizens [Zhou et al., 2020]. Pandemic leads to lockdowns in many countries that impede business operations [Kruger et al., 2020]. Still pandemic has less affected some businesses like food and pharma industries. This set of nosy challenges calls researchers to study the role of governments and organizations regarding financial statements according to the industry. Hence the objectives of the study are to find out the role of governments and organizations for future prevention, 'pandemic effect on financial statements, based on comparing current quarterly/yearly financial statements with previous ones in industries/organizations; and to predict the future effect on such organizational financial statements. Later, financial statements were compared to the pandemic effect on the economy that highlights the role of governments and organizations for future prevention.

The study has proposed an innovative framework in which it defined four major independent variable measures taken by external bodies (governments, WHO), internal institutions (organizations), scientific and controlled measures, unscientific and uncontrolled measures that affect dependent variables (business operational activities and financial statements). The current study chose these four essential independent elements (factors) to represent the characteristics for certain reasons. These are all the important factors influencing business operations as well as financial statements in general. Hence the following theoretical framework has been developed. The relationship measures taken by external bodies (governments), internal institutions (organizations), scientific and controlled measures, unscientific and uncontrolled measures with business operational activities and Financial Statements are shown in fig. 1.

2. Literature review

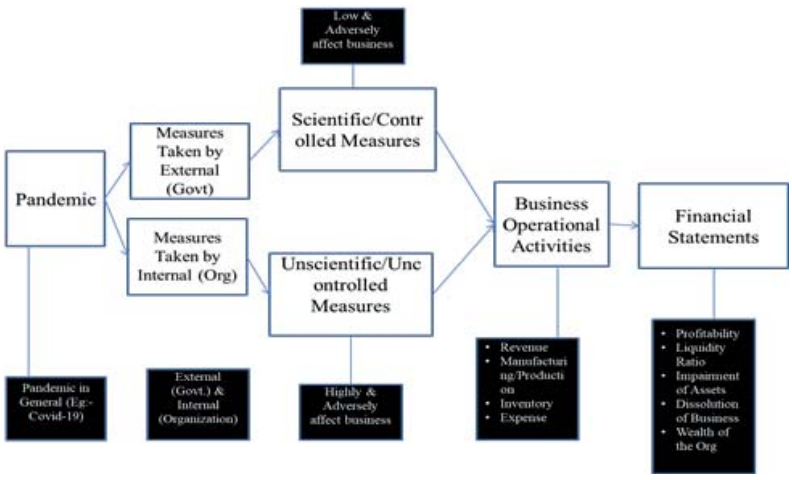
Comparative or common-size income statement and statement of financial position help to understand the causes of differences in operational financial performance between two periods [Dinçer et al., 2018; Salma, Hussain, 2018; Robinson, 2020] and can be used to predict future trend [Chen et al., 2018; Linares-Mustarós et al., 2018; Hosaka, 2019]. Accounting ratios and trend analysis can be used for more threadbare and predicted future analysis [Jayasekera, 2018; Le, Viviani, 2018; Linares-Mustarós et al., 2018; Bateni, Asghari, 2020]. Comparing financial statements with two periods helps to prepare forecasted financial statements [Hasanaj, Kuqi, 2019; Henry et al., 2020; Thottoli, 2021a; 2021b]. An effective analysis of financial statements leads to understanding the value of a business. [Ani, Odo, 2019] analyzed current financial statements to predict the profitability and risk of an organization [Kamar, Fatihah, 2018; Waqas, Md-Rus, 2018; Ali, Puah, 2019; Campbell et al., 2019]. Effective analysis of financial statements helps to assess the quality of the firm's financial statements [Cantele, Zardini, 2018; Muda et al., 2018; Robinson, 2020]. Financial statement analysis helps to understand the operational performance of any company [Marjanović et al., 2018]. Identifying industry and economic characteristics is possible using the analysis of financial statements [Müller et al., 2018]. The interim financial report predicts future effect on organizational financial statements [Nainggolan, 2018].

In normal economic conditions, most successful organizations continue to operate their business the same or better way. It has been found that organizational operational activities are adversely affected during the outbreak of any pandemic, which is now a normal phenomenon in every decade [Bhardwaj, 2020]. Pandemic will negatively affect organizations' operational, financial, and revenue aspects [Williams, Kayaoglu, 2020]. The task of organizations is to take all the necessary measures to prevent pandemic situations, and it depends on the governments and tax authorities' situational decisions/actions through implementing emergency rules/decrees/orders [Di Saverio et al., 2020; Saleh et al., 2020]. The governments with reserve banks may implement supportive financial measures to overcome adverse economic consequences especially during a pandemic such as a Coronavirus disease 2019 [Adams, Walls, 2020]. Since pandemic is a social and communal influential factor, the organization and its employees should also take scientific and controlled measures to eliminate such situations within a short period of time [Alabdullah et al., 2020; Cirrincione et al., 2020; Tan et al., 2020].

2.1. Business operational activities and financial statements

Business operational activities are the core daily routine that an organization needs to pay attention to in order to get revenues. Manufacturing or production, selling, administration, marketing [Thottoli, Thomas, 2021], customer services are some of the operational activities of any organization. Well-planned operational activities help organizations to

Fig. 1. Schematic diagram of research framework



achieve better cash flows and to maintain and/or increase the net income of the business. Financial statements help make smart business move and keep value and reputation [O'Brien, 2019]. Financial statements are the basis to get a loan or attract investors. Thus, it is important for any business to keep an eye on its operational activities much better than before. Operational activities are the principal revenue-producing activities [Hasanaj, Kuqi, 2019; Yosvid, 2020].

2.2. Scientific and controlled measures taken by external (governments and WHO)

Social awareness is considered to be the first step that government has to take as an initiative. Basic facilities such as food, masks, soap, sanitation materials and so on should be provided at the grass root level by the government especially to the underprivileged and downtrodden living in slum areas. Healthcare and adequate testing facilities in every ward in the country need to be provided by the local government or authorities. Governments should take an initiative to identify and isolate violators whenever required using strict policy. After all strict follow-up action against the lockdown, violators are to be followed up. Stay-at-home orders, business closures, and travel restrictions are brought in by heads of health emergencies to counteract the spread of COVID-19. WHO is currently taking precautionary measures/advice to protect people from the spread of COVID-19. Interventions, such as intensive contact tracing followed by quarantine and isolation, can effectively reduce the spread of COVID-19. Under the most restrictive measures, the outbreak is expected to peak within two weeks (since January 23, 2020) with a significantly low peak value. With travel restrictions (no transportation of exposed individuals to Beijing), the number of infected individuals in seven days will decrease by 91.14% in Beijing, compared to the scenario of no travel restriction. Collaborative efforts are required to combat the novel coronavirus, focusing on both persistent strict domestic interventions and vigilance against exogenous imported cases. Community-wide containment is an intervention applied to an entire community, city, or region, aimed at reducing personal interactions, except for minimal interaction to ensure vital supplies. From a policy perspective, understanding whether and how communities respond to government actions is crucial. Socialization of coronavirus in the USA reveals that fear about the pandemic disease has taken initiatives from the governmental side to the society and general people, placing pressure among prospective customers and heading to regulatory reaction and a substantial societal backlash [Andriani, 2020; Brammer et al., 2020]. These measures help return to the normal situation which will, in turn, help increase the turnover of the business. These scientific and controlled measures taken by the governments and WHO can lead to the economic growth in short term. Hence, it is hypothesized that:

H1: During pandemic period scientific and controlled measures taken by external bodies (governments and WHO), adversely affect business operational activities and financial statements.

2.3. Unscientific and uncontrolled measures taken by external (governments & WHO)

Research on China and South Korea shows, that early governmental action and cooperation with the population can slow down the uncontrolled spread of the pandemic. A weak approach of government to control the pandemic may lead to communal spreading. Improper measures at the initial stage by the government may lead to the spreading of the virus in the society. Poorly tested facilities are another inability of the country to control the spreading of the virus. A situational communication/instruction of good health and safety measures during the pandemic period is important to avoid the spread of such viruses. The measures should be taken by local/state/health organizations as soon as possible before spread of the disease in the community. This can be evident that in countries like the UK and the the US, the governments were swift to institute scientific controlled measures to alleviate corporate debt [Amankwah-Amoah et al., 2021]. Hence, it is hypothesized that:

H2: During the pandemic period unscientific and uncontrolled measures taken by external bodies (governments and WHO) adversely affect business operational activities and financial statements.

2.4. Scientific and controlled measures taken by internal institutions (organizations)

To sustain and thrive in uncertain times brought forward by COVID-19, organizations must explore new ways of cooperation. This has placed a spotlight on the need for corporate resilience and the ability to embrace virtual collaboration tools and practices. The researcher has observed that most of the companies have to require digital technologies to reduce office hours. It is not necessary for organizations to operate with a 100 percent presence of employees. They have implemented social distancing and quarantine measures. The staff is working from different locations, either in the office or at home. Staff members who have returned from abroad or who have even mild cold symptoms are working from home for a minimum of 14 days. All business trips are suspended. Digital tools for internal and external meetings are used, and reception of visitors is stopped. Public events and seminars are not organized. This makes the companies remain operational and continue making disbursements to its customers. It is necessary to follow recommendations published by WHO. Ban on lunch breaks to avoid crowds has been introduced. Masks and hand sanitizers should be given to all employees. Close and constant monitoring of international developments, including instructions issued by relevant local and national authorities should be observed. Internal task forces in the areas of operations, business, and general crisis management were formed. This continues to operate a business without much disturbance [Untaru, Han, 2021]. It was found out that the scientific and controlled measures taken by organizations against the COVID-19 virus positively affected both customer safety and business operations. Hence, it is considered that:

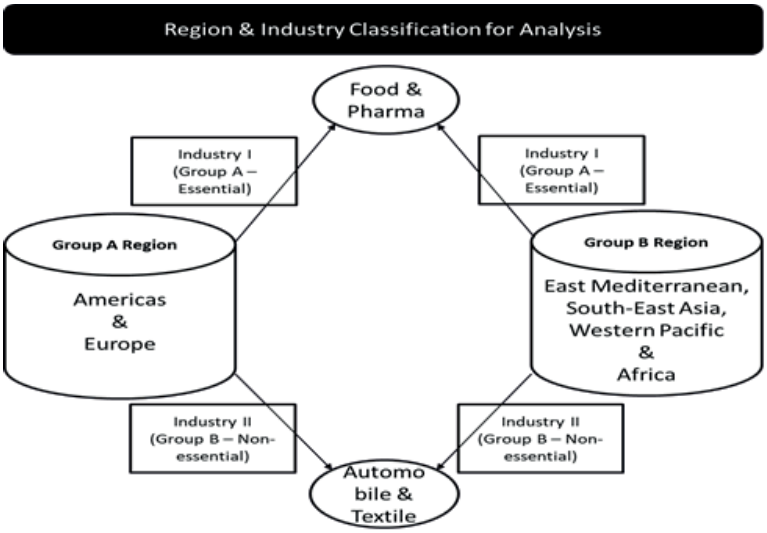
H3: During pandemic period scientific and controlled measures taken by internal (organization), adversely affect business operational activities and financial statements.

2.5. Unscientific and uncontrolled measures taken by internal institutions (organizations)

An effective Business Continuity Management (BCM) program is a critical component of successful business management. Experience shows that typically over 50 percent of businesses without an effective business continuity plan will ultimately fail following a major disruption. Thermal screening is mandatory for all the staff. If there are no strategies using a cost-effective approach, and without taking into consideration key resources or critical activities, people, Information Communication Technology (ICT), supplies, and facilities may adversely affect business operations. Product packing and production information should be looked into if it is necessary. Unreasonable dismissal of an employee who has care-giving obligations related to COVID-19 may spoil business. Not providing employees with adequate resources to work from home is another key area. Many organizations are now requiring their staff to work from home, which can further increase the risk as enterprise network security safeguards are not always available to home-users, and some users may be forced to use their systems at home that may not have the same level of protection. Despite the working conditions, employees must be especially vigilant right now for malicious attacks that attempt to exploit the pandemic and people's fears. This is important for both working in the office and at home. This concept has been supported by [Hu et al., 2021]. The researchers expressed the idea that failure to obey COVID-19 organizational protection measures may jeopardize the health and protection of employees, business operations, and the public. Hence, it is hypothesized that:

H4: During pandemic period unscientific and uncontrolled measures taken by internal institutions (organizations), adversely affect business operational activities and financial statements.

Fig. 2. Region & Industry classification for analysis



3. Methods

The analysis is based on a large number of publicly available sources, including research papers, government documents, and reports. The paper aims to triangulate the validity of the data with multiple sources. The study has taken 8 ratios compared with 80 listed companies around the globe. Further, as a part of the methodology, the current study has used secondary data after considering organizations' current quarterly financial statements with previous ones to reach the predicted financial results. This result has later been cross-compared with pandemic (COVID-19) affected (according to the data of COVID-19 statistics provided by World Health Organization – WHO) economies. Organizations were grouped geographically as well as industry types. During the pandemic period, the magnitude of adverse effect on business operations depends upon the decision and actions of external bodies (WHO, governments) and internal institutions (organizations).

In this study, industries were grouped under essential (Group A) and non-essential (Group B) during the pandemic. Food and Pharma (Industry I) industries are grouped as essential industries whereas Automobile and Textile (Industry II) industries are grouped as non-essential industries

Table 1
List of accounting ratios used as variable

Ratio class	Ratio name	Notation	Formula
Profitability ratios	Gross Profit Ratio	GPR	Gross profit/revenue
	Operating Profit Margin	OPM	Operating profit/revenue
	Net Profit Ratio	NPR	Net profit/revenue
	Return on assets	ROA	Net income/average assets
	Return on Capital Employed	ROCE	Avg. capital employed/net profit
Liquidity Ratio	Current Ratio	CR	Current assets/current liabilities
	Acid Test (Quick) Ratio	ATR	Quick assets/current liabilities

Source: [Olson, Zoubi, 2008].

Table 2
COVID cases comparison (WHO Region)

Group	WHO Region	Confirmed Cases	Percentage (%)	
Group A Region	Americas	3084517	47	81
	Europe	2211148	34	
Group B Region	Eastern Mediterranean	587030	9	19
	Southeast Asia	322863	5	
	Western Pacific	188393	3	
	Africa	121104	2	
	Total	6515796	100	

Sources: calculated by the author as per the data (WHO Coronavirus Disease (COVID-19) Dashboard, Data last updated: 2020/6/5, 10:41 am CEST).

Fig. 3. COVID cases comparison (WHO Region)

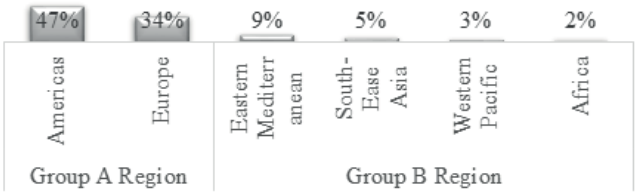
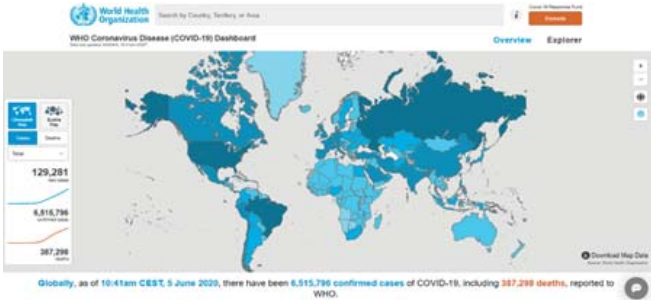
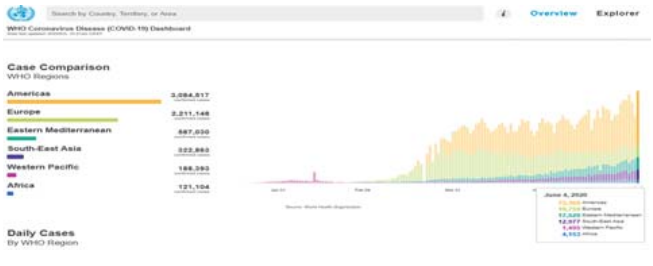


Fig. 4. WHO coronavirus disease (COVID-19) dashboard, Data last updated: 2020/6/5, 10:41 am CEST



Source: https://www.who.int/emergencies/diseases/novel-coronavirus-2019/advice-for-public.

Fig. 5. WHO coronavirus disease (COVID-19) dashboard, Data last updated: 2020/6/5, 10:41am CEST[1])



Source: https://covid19.who.int/?gclid=EAIaIQobChMI_M3Cutrq6QIVCIBQBh2BkQVREAAYASAAEgKSY_D_BwE.

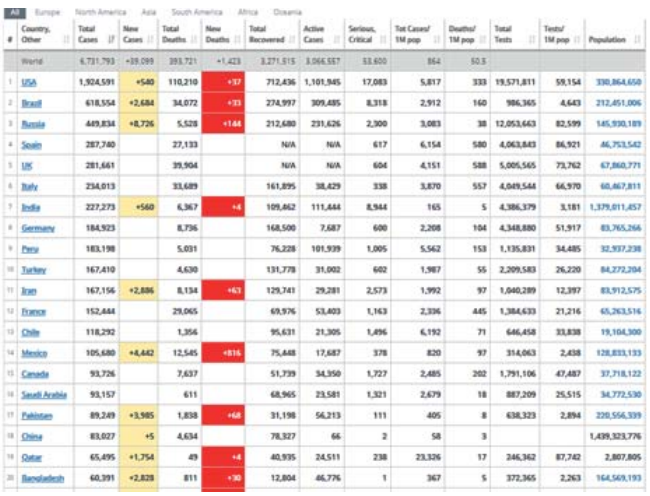
during the pandemic period. For industry sample selection, the regions were segregated according to groupings made by WHO based on COVID-19 confirmed cases (fig. 1 and fig. 2). Americas and Europe appeared as one group, Group A Region, and rest of the region (Southeast Asia, Western Pacific, and Africa) formed another group, Group B Region. The study investigates two industries in each region, where 20 companies in every industry were taken as a sample, and the total number consists of 80 companies. The sample for the study has limited to 80 since there is not enough published financial information during the current study.

3.1. Variables of the research and its measurements

This study has used various measurements (accounting ratios) as variables for assessing the financial performance of any organization (fig. 2 and table 1, list of accounting ratios used for the analysis [Olson, Zoubi, 2008]):

The paper also takes impairment of assets of various selected companies for comparative analysis.

Fig. 6. WHO coronavirus disease (COVID-19) dashboard, Data last updated: 2020/6/5, 10:41 am CEST)



Source: https://covid19.who.int/?gclid=EAIaIQobChMI_M3Cutrq6QIVCIBQBh2BkQVREAAYASAAEgKSY_D_BwE.

[1] https://covid19.who.int/?gclid=EAIaIQobChMI_M3Cutrq6QIVCIBQBh2BkQVREAAYASAAEgKSY_D_BwE. Date of access: 5-6-2020.

4. Results and discussion

As per the WHO COVID-19 dashboard, there are 6,515,796 confirmed cases reported around the world at the time of this study (2020.06.05). Among them, 3,084,517 confirmed cases (which is around 47%) are widespread in Americas and 2,211,148 confirmed cases (which are 34%) exist in Europe. Hence, 81% of confirmed cases are in Group A Region. Whereas remaining 19% confirmed cases are from Group B Region (table 2, fig. 3–6).

Table 3
Group A & Group B, Industry I
Таблица 3
Группы А и В, отрасль I

	Group A, Industry I	Group B, Industry I	Group A, Industry I	Group B, Industry I	Group A, Industry I	Group B, Industry I	Group A, Industry I	Group B, Industry I	Group A, Industry I	Group B, Industry I
Company	Gross Profit Ratio	Gross Profit Ratio	Operating Profit Margin		Net Profit Margin		Return on Assets		Return on Capital Employed	
	(Q1,'19) (Q1,'20)	(Q1,'19) (Q1,'20)	(Q1,'19) (Q1,'20)		(Q1,'19) (Q1,'20)		(Q1,'19) (Q1,'20)		(Q1,'19) (Q1,'20)	
1	44.15 44.14	27.78 19.76	15.59 13.86	27.03 -14.48	11.04 9.73	22.09 -11.79	1.81 1.59	1.62 -1.21	5.24 2.77	2.50 -1.82
2	66.25 69.82	2.35 7.02	24.32 17.67	2.35 7.02	6.78 6.19	0.19 5.64	0.40 0.37	0.03 0.52	0.40 0.37	0.08 1.46
3	39.66 36.54	24.48 23.14	0.67 0.64	4.94 3.23	13.98 11.23	3.08 2.23	1.42 1.18	0.58 0.43	1.42 1.18	1.35 1.18
4	55.74 57.46	4.05 6.64	21.76 18.79	0.56 2.58	15.09 13.51	0.20 1.75	5.74 5.06	0.07 0.46	5.74 5.06	0.08 0.52
5	18.39 17.96	10.12 18.31	1.45 2.78	11.85 26.27	-0.04 -0.05	5.67 10.48	-0.01 -0.01	0.45 1.02	-0.01 -0.01	1.06 2.46
6	17.44 16.82	20.75 39.76	2.17 -1.99	2.70 1.81	1.09 -2.18	22.72 25.41	2.02 -3.52	2.41 2.41	0.79 -1.48	2.58 3.92
7	30.87 29.13	2.16 26.82	8.85 11.28	2.72 13.73	3.61 6.94	0.37 0.45	0.58 0.80	0.06 0.06	0.87 1.86	0.16 0.18
8	2.87 2.50	52.83 41.99	2.87 2.50	7.54 4.42	0.44 0.27	4.53 7.51	0.51 0.27	0.85 1.52	1.83 0.74	2.27 3.98
9	5.07 -2.62	5.41 4.28	5.07 -2.62	0.64 3.15	0.73 -5.42	0.20 3.20	0.21 -1.36	0.07 0.79	0.30 -1.83	0.08 0.94
10	9.51 8.92	6.67 18.28	10.13 8.23	23.71 49.15	3.74 3.19	5.07 4.35	0.67 0.57	0.45 0.42	1.00 0.82	1.06 1.02
11	32.95 32.30	2.80 0.27	29.65 28.35	5.81 -6.51	29.61 28.28	31.11 44.29	2.32 2.04	1.99 4.19	5.62 4.83	3.53 6.84
12	0.00 0.03	3.46 2.55	4.51 3.56	4.75 11.49	92.13 93.93	0.12 6.96	2.19 3.51	0.02 0.84	4.02 6.28	0.05 2.79
13	42.36 43.29	22.60 88.33	44.50 36.10	10.05 2.21	37.27 27.72	4.53 1.10	3.19 2.57	0.83 0.21	4.40 3.47	2.27 0.59
14	44.48 38.22	1.32 9.52	44.48 38.22	0.76 2.83	35.85 29.62	0.19 2.84	3.34 2.96	0.06 0.60	5.44 4.62	0.07 0.84
15	26.32 -35.47	6.38 6.84	26.32 -35.47	24.03 51.44	16.77 -29.52	2.67 22.86	1.54 -3.03	0.22 2.14	1.82 -3.60	0.56 5.37
16	23.25 41.80	2.87 31.87	38.45 41.80	9.39 -0.01	31.37 34.92	11.71 -0.01	2.76 3.30	0.63 0.00	26.06 28.71	1.33 0.00
17	43.06 52.63	0.49 0.26	40.37 39.59	2.10 2.11	40.37 39.59	4.01 4.21	5.17 5.36	0.43 0.33	10.24 10.81	1.71 1.69
18	6.45 4.32	4.10 51.76	6.45 4.32	15.13 0.88	-5.32 -3.28	12.68 8.84	-0.09 -0.10	1.58 1.97	-0.14 -0.18	6.37 4.69
19	29.75 30.55	0.41 0.66	29.75 30.55	0.09 2.83	21.46 22.66	0.20 2.83	1.58 1.81	0.04 0.01	2.93 3.34	0.08 0.83
20	-87.79 -105.85	0.99 0.85	-87.99 -15.29	14.76 5.81	-88.68 -15.39	4.99 18.68	-4.20 -0.39	0.45 1.77	-5.11 -0.95	1.04 4.25

Calculated by the author as per the data from Stock exchanges from Americas and stock exchanges from Europe.

The findings show a high spread of the virus in Group A Region in comparison to Group B Region. 81% confirmed cases fall under Group A Region, whereas 19% confirmed cases are under Group B Region. This result depends on the measures taken by external (governments) and internal organizations. Unscientific/uncontrolled measures taken by Group A region lead to spreading of virus whereas scientific/controlled measures taken by Group B region resulted in low spread of the virus.

4.1. Group A & Group B, Industry I

Group A region (Americas and Europe) and Group B (South-east Asia, Western Pacific, and Africa) region, considering 20 selected companies from each Group under Industry type I (essential products such as food and pharma), showed a comparative result as discussed below:

Table 3, Gross profit Ratio (Group A, Industry I and Group B, Industry I) does not show many variations in Industry I in both regional groups.

The result shows that the industries producing essential products such as food and pharmaceuticals have not faced adverse effects on their business operational activities as well as their financial statements. Therefore, the company was keeping stable gross profit in comparison to Q 2020 and Q 2019.

Table 3, Operating profit margin (Group A, Industry I and Group B, Industry I) does not show many variations in Industry I in both regions A and B.

The result prooves that the industries producing essential products such as food and pharmaceuticals have not faced adverse effects on their business operational activities as well as their financial statements. Therefore, the company was keeping a stable operating margin in comparison to Q 2020 and Q 2021.

Table 3, Net profit margin (Group A, Industry I and Group B, Industry I) shows slight variations in Industry I in both regions A and B.

The result shows that the industries producing essential products such as food and pharmaceuticals have faced adverse effects on their business operational activities as well as their financial statements. Therefore, the company could not be able to keep a stable net profit margin in comparison to Q 2020 and Q 2019.

Table 3, Return on assets (Group A, Industry I and Group B, Industry I) shows a decreasing trend in Industry I in region B in comparison to region A.

The result shows that the industries producing essential products such as food and pharmaceuticals have faced negative effects on their business operational activities as well as their financial statements. Therefore, the company could not be able to keep a stable return on assets in comparison to Q 2020 and Q 2019.

Table 3, Return on capital employed (Group A, Industry I and Group B, Industry I) shows a decreasing trend in Industry I in region B in comparison to region A.

The result shows that the industries producing essential products such as food and pharmaceuticals have faced adverse effects on their business operational activities as well as their financial statements. Therefore, the company could not be able to keep a stable return on capital employed in comparison to Q 2020 and Q 2019.

Table 4, Current ratio (Group A, Industry I and Group B, Industry I) shows no much variations in Industry I in both regions A and B.

The result shows that the industries producing essential products such as food and pharmaceuticals have faced ad-

Table 4
Group A & Group B, Industry I
Таблица 4
Группы А и В, отрасль I

	Group A, Industry I		Group B, Industry I		Group A, Industry I		Group B, Industry I		Group A, Industry I		Group B, Industry I	
Company	Current Ratio		Current Ratio		Acid Test Ratio		Acid Test (Quick) Ratio		Working Capital Ratio		Working Capital Ratio	
	(Q1,'19)	(Q1,'20)	(Q1,'19)	(Q1,'20)	(Q1,'19)	(Q1,'20)	(Q1,'19)	(Q1,'20)	(Q1,'19)	(Q1,'20)	(Q1,'19)	(Q1,'20)
1	0.86	1.10	4.79	3.54	0.84	1.09	4.20	3.00	-0.04	0.03	8.00	5.56
2	1.03	1.48	1.43	1.46	0.97	1.45	0.78	1.27	0.00	0.04	0.00	0.00
3	0.50	0.53	1.28	1.32	0.33	0.39	1.01	1.02	-0.12	-0.12	0.28	0.25
4	1.05	0.99	2.14	2.19	0.65	0.70	0.96	1.06	0.01	0.00	1.14	1.26
5	1.50	1.58	0.76	0.93	0.83	0.98	0.48	0.61	0.08	0.10	0.00	0.00
6	1.38	1.94	4.79	4.47	0.77	1.23	4.20	3.84	0.28	0.48	8.00	7.75
7	1.73	1.67	1.43	0.52	1.33	1.36	0.78	0.39	0.10	0.10	0.01	0.16
8	0.62	0.66	1.28	2.18	0.32	0.35	1.01	1.81	-0.10	-0.06	0.31	0.92
9	0.98	1.59	2.14	1.63	0.83	1.42	0.96	0.85	0.00	0.09	1.12	0.96
10	1.20	1.31	0.76	0.22	0.65	0.80	0.48	0.18	0.04	0.07	0.00	0.00
11	0.88	1.03	4.79	4.00	0.66	0.78	4.20	3.37	-0.03	0.01	0.77	0.64
12	1.26	1.31	1.43	33.46	1.01	1.05	0.78	29.87	0.06	0.07	0.49	0.32
13	3.10	3.04	1.28	1.88	3.01	2.92	1.01	1.76	0.33	0.30	0.19	0.45
14	1.44	1.59	2.14	3.01	1.16	1.28	0.96	1.00	0.09	0.11	0.76	2.20
15	4.47	3.83	0.76	1.98	4.26	3.62	0.48	1.44	0.23	0.22	0.00	0.00
16	3.18	3.14	4.79	3.78	3.06	3.03	4.20	3.18	0.38	0.39	0.80	0.62
17	1.72	1.73	1.43	1.19	1.56	1.54	0.78	0.90	0.13	0.13	0.89	0.86
18	8.24	4.54	1.28	3.41	8.13	4.49	1.01	2.95	0.66	0.57	0.22	0.78
19	2.94	3.31	2.14	3.59	2.78	3.16	0.96	3.17	0.27	0.33	0.25	0.32
20	5.55	8.31	0.76	4.77	4.90	7.75	0.48	4.50	0.66	0.76	0.33	0.09

Calculated by the author as per the data from Stock exchanges from Americas and stock exchanges from Europe.

verse effects on their business operational activities as well as their financial statements. Therefore, the company could not be able to keep stable current assets in comparison to Q 2020 and Q 2019.

Table 4, Acid test (Quick) ratio (Group A, Industry I and Group B, Industry I) shows a decreasing trend in Industry I in region B in comparison to region A.

The result shows that the industries producing essential products such as food and pharmaceuticals have faced adverse effects on their business operational activities as well as their financial statements. Therefore, the company could not be able to keep stable quick assets in comparison to Q 2020 and Q 2019.

Table 4, Working capital ratio (Group A, Industry I and Group B, Industry I) does not show many variations in Industry I in both regions A and B.

The result proves that the industries producing essential products such as food and pharmaceuticals have faced adverse effects on their business operational activities as well as their financial statements. Therefore, the company could not be able to keep stable working capital in comparison to Q 2020 and Q 2019.

Table 5, Impairment of assets (Group A, Industry I and Group B, Industry I) shows an increasing trend in Industry I in region B compared to region A.

The result shows that the industries producing essential pro-ducts such as food and pharmaceuticals have faced adverse effects on their business operational activities as well as their financial statements. Therefore, the companies are having impairment of assets at a higher rate compared to Q 2020 and Q 2019.

Table 5
Group A & Group B, Industry I

	Group A, Industry I	Group B, Industry I
Company	Imapairement of Assets (Change (Q1,'20)	Imapairement of Assets (Change (Q1,'20)
1	46.15	0.0
2	3.98	-12.5
3	-20.00	9.6
4	4.81	-10.0
5	-0.45	0.0
6	-1.96	20.0
7	11.11	0.0
8	16.67	8.4
9	100.00	-30.0
10	20.00	20.0
11	73.33	-41.0
12	-0.64	3.4
13	11.11	-3.6
14	0.00	20.0
15	100.00	-28.6
16	0.00	-20.0
17	-9.80	0.0
18	13.33	7.2
19	0.00	-1.0
20	9.52	-8.3

Calculated by the author as per the data from Stock exchanges from Americas and stock exchanges from Europe.

Results of the tested hypothesis

Scientific and controlled measures taken by external bodies (governments and WHO), adversely affected business operational activities and financial statements. Scientific and controlled measures taken by internal institutions (organizations), negatively affected business operational activities and financial statements. Therefore, H1 and H3 are supported.

4.2. Group A and Group B, Industry II

Group A region (Americas and Europe) and Group B (South-east Asia, Western Pacific, and Africa) region, results of 20 selected companies from each Group A and B in Industry type II (non-essential products such as automobiles and textile products), showed a comparative result as discussed below:

Table 6, Gross profit ratio (Group A, Industry II and Group B, Industry II) shows that there is a slight adverse variation in Industry II in region A compared to region B.

The result shows that the industries producing non-essential items such as automobiles and textile products have faced adverse effects on their business operational activities as well as their financial statements in region A (badly affected by virus, COVID-19). Therefore, the company could not keep a stable gross profit in comparison to Q 2020 and Q 2019.

Table 6, Net profit margin (Group A, Industry II and Group B, Industry II) shows that there is highly adverse variation in Industry II in region A compared to region B.

The result shows that the industries producing non-essential products such as automobiles and textile have faced negative effects on their business operational activities as well as their financial statements in region A. Therefore, the company could not keep a stable net profit margin in comparison to Q 2020 and Q 2019.

Table 6, Net profit ratio (Group A, Industry II and Group B, Industry II) shows that there is highly adverse variation in Industry II in region A compared to region B.

The result shows that the industries producing non-essential products such as automobiles and textile have faced adverse effects on their business operational activities as well as their financial statements in region A. Therefore, the

Table 6
Group A & Group B, Industry II

	Group A, Industry II		Group B, Industry II		Group A, Industry II		Group B, Industry II		Group A, Industry II		Group B, Industry II		Group A, Industry II		Group B, Industry II		Group A, Industry II		Group B, Industry II	
Company	Gross Profit Ratio		Gross Profit Ratio		Net Profit Margin		Net Profit Margin		Net Profit Ratio		Net Profit Ratio		Return on Assets		Return on Assets		Return on Capital Employed		Return on Capital Employed	
	(Q1,'19)	(Q1,'20)	(Q1,'19)	(Q1,'20)	(Q1,'19)	(Q1,'20)	(Q1,'19)	(Q1,'20)	(Q1,'19)	(Q1,'20)	(Q1,'19)	(Q1,'20)	(Q1,'19)	(Q1,'20)	(Q1,'19)	(Q1,'20)	(Q1,'19)	(Q1,'20)	(Q1,'19)	(Q1,'20)
1	46.53	44.49	44.19	43.47	65.68	45.05	7.04	2.91	15.37	-13.57	4.83	1.62	0.21	(0.17)	1.27	0.36	0.77	-0.72	4.02	1.29
2	5.56	2.43	22.22	21.77	4.77	1.88	2.31	1.27	4.44	1.71	1.86	0.41	1.81	0.59	2.31	0.51	2.96	1.03	60.65	1.27
3	0.49	0.44	107.53	108.34	-2.34	-23.98	-45.70	-74.42	-2.61	-21.87	-45.10	-2.77	-0.88	-6.86	-2.11	-0.09	-1.67	-12.94	-2.78	-0.12
4	20.23	19.61	50.04	51.02	10.29	8.29	1.77	4.90	6.24	5.66	1.57	9.51	1.65	1.36	0.66	1.03	2.51	2.02	1.34	9.25
5	8.96	8.24	4.25	5.45	0.68	-0.78	5.67	4.57	2.44	-11.20	2.78	2.53	0.79	-2.89	0.00	0.00	1.91	-5.76	0.00	0.00
6	60.51	54.42	6.59	37.09	-3.71	-43.09	5.66	22.50	-2.61	-50.30	8.21	1.24	-0.54	-7.42	2.16	0.28	-1.79	-30.59	6.83	0.95
7	35.53	17.41	19.67	19.43	5.82	-19.23	1.75	3.99	1.52	-17.96	2.15	0.03	0.36	-3.15	2.66	0.04	0.04	-0.25	69.78	0.10
8	25.59	26.97	88.06	86.08	6.77	6.63	-4.59	-0.01	4.98	4.83	-0.21	-7.90	0.91	0.83	-0.01	-0.27	1.26	1.18	-0.01	-0.33
9	36.51	37.95	89.24	14.62	15.95	16.79	1.97	1.82	11.70	3.22	1.38	1.69	1.99	0.51	0.58	0.50	2.62	0.66	1.17	1.57
10	60.51	54.42	2.10	3.85	-3.71	-43.09	5.20	4.95	-2.49	-50.28	0.68	1.10	-0.52	-7.41	0.00	0.00	-0.67	-10.53	0.00	0.00
11	60.51	50.30	37.42	6.40	-3.71	-45.15	6.03	2.22	-2.49	-52.75	3.47	0.36	-0.52	-7.78	0.91	0.08	-0.67	-11.05	2.89	0.27
12	35.53	35.55	19.42	2.16	5.82	-31.32	0.06	0.58	1.52	-24.00	1.86	0.29	0.36	-4.21	2.31	0.36	0.04	-0.33	60.65	0.90
13	35.53	38.92	88.20	102.76	5.82	-41.31	36.92	0.86	1.52	-47.61	0.00	-7.05	0.36	-6.32	0.00	-0.24	0.04	-0.50	0.00	-0.29
14	60.51	75.03	46.12	32.82	-3.71	-45.15	17.65	3.64	-2.49	-52.34	0.40	1.87	-0.52	-7.72	0.17	0.55	-0.67	-10.96	0.34	1.74
15	8.96	6.67	3.67	4.95	0.68	-1.00	3.67	54.49	2.44	-16.50	0.68	0.66	0.79	-3.98	0.00	0.00	1.91	-7.93	0.00	0.00
16	60.51	50.30	34.03	37.17	-3.71	-45.15	4.67	3.71	-2.49	-52.75	2.46	1.49	-0.52	-7.78	0.64	0.33	-0.67	-11.05	2.04	1.13
17	60.51	53.13	19.42	13.02	-3.71	-59.70	1.75	2.92	-2.61	-50.21	1.02	0.29	-0.54	-10.45	1.27	0.36	-1.79	-43.12	33.27	0.90
18	35.53	17.41	87.85	95.50	5.82	-19.23	-4.41	-0.01	1.52	-17.96	19.72	8.57	0.36	-3.15	0.92	0.29	0.04	-0.25	1.22	0.36
19	8.96	8.40	30.43	36.46	0.68	-2.33	3.93	1.41	2.44	-15.55	1.18	9.50	0.79	-4.02	0.50	1.03	1.91	-8.01	1.00	9.24
20	8.96	3.42	3.15	4.40	0.68	-3.89	35.66	4.40	2.44	-11.98	1.26	1.99	0.79	-3.09	0.00	0.00	1.91	-6.16	0.00	0.00

Calculated by the author as per the data from Stock exchanges from Americas and stock exchanges from Europe.

company could not keep a stable net profit in comparison to Q 2020 and Q 2019.

Table 6, Return on assets (Group A, Industry II and Group B, Industry II) shows that there is highly adverse variation in Industry II in region A compared to region B.

The result shows that the industries producing non-essential items such as automobiles and textile goods have faced adverse effects on their business operational activities as well as their financial statements in region A. Therefore, the company could not get a stable return on assets in comparison to Q 2020 and Q 2019.

Table 6, Return on capital employed (Group A, Industry II, and Group B, Industry II) shows that there is highly adverse variation among Industry II in region A compared to region B.

The result shows that the industries producing non-essential items such as automobiles and textile goods have faced adverse effects on their business operational activities as well as their financial statements in region A.

Therefore, the company could not get a stable return on capital in comparison to Q 2020 and Q 2019.

Table 7, Current ratio (Group A, Industry II and Group B, Industry II) shows that there is highly adverse variation in Industry II in region A compared to region B.

The result shows that the industries producing non-essential items such as automobiles and textile goods have faced adverse effects on their business operational activities as well as their financial statements in region A. Therefore, the company could not be able to maintain adequate current assets in comparison to Q 2020 and Q 2019.

Table 7, Acid-test (Quick) ratio (Group A, Industry II and Group B, Industry II) shows that there is highly adverse variation in Industry II in region A compared to region B.

The result shows that the industries producing non-essential items such as automobiles and textile goods faced adverse effects on their business operational activities as well as their financial statements in region A. Therefore, the company could not be able to maintain adequate quick assets in comparison to Q 2020 and Q 2019.

Table 7, Working capital ratio (Group A, Industry II and Group B, Industry II) shows that there is slight adverse variation in Industry II in region A compared to region B.

The result shows that the industries producing non-essential items such as automobile and textile goods face adverse effects on their business operational activities as well as their financial statements in region A.

Therefore, the company could not be able to maintain adequate working capital in comparison to Q 2020 and Q 2019.

Table 7
Group A & Group B, Industry II

	Group A, Industry II		Group B, Industry II		Group A, Industry II		Group B, Industry II		Group A, Industry II		Group B, Industry II	
Company	Current Ratio		Current Ratio		Acid Test (Quick) Ratio		Acid Test (Quick) Ratio		Working Capital Ratio		Working Capital Ratio	
	(Q1,'19)	(Q1,'20)	(Q1,'19)	(Q1,'20)	(Q1,'19)	(Q1,'20)	(Q1,'19)	(Q1,'20)	(Q1,'19)	(Q1,'20)	(Q1,'19)	(Q1,'20)
1	0.03	0.05	1.27	1.36	0.03	0.05	0.28	0.42	-0.65	-0.64	-0.58	0.07
2	1.37	1.29	1.28	1.57	1.10	1.04	0.87	1.10	0.14	0.12	-0.51	0.14
3	1.33	1.42	2.91	4.89	0.87	0.91	2.19	4.31	0.11	0.14	-0.71	0.19
4	1.65	1.76	1.42	1.55	1.53	1.64	0.53	0.63	0.16	0.17	-0.51	0.13
5	1.69	2.17	1.46	2.23	1.47	1.92	1.24	1.96	0.24	0.34	-0.58	0.22
6	1.55	1.32	1.27	0.97	1.02	0.88	0.28	-0.16	0.13	0.09	-0.67	-0.18
7	1.34	1.06	1.28	2.47	0.72	0.51	0.87	1.52	0.07	0.02	-0.86	0.11
8	1.63	1.61	2.91	5.74	0.79	0.84	2.19	4.69	0.13	0.13	-0.92	0.18
9	3.05	3.33	1.42	0.85	2.58	2.74	0.53	-0.92	0.28	0.29	-0.35	0.07
10	1.55	1.31	1.46	3.12	1.02	0.80	1.24	2.80	0.13	0.09	-1.21	0.10
11	0.03	0.04	1.27	1.53	0.03	0.04	0.28	0.61	-0.03	-0.04	-0.68	0.06
12	1.37	1.08	1.28	2.47	1.10	0.73	0.87	1.51	0.16	0.05	-0.89	0.10
13	1.33	0.93	2.91	7.13	0.87	-0.48	2.19	6.68	0.13	-0.04	-1.95	0.10
14	1.65	0.88	1.42	1.44	1.53	0.67	0.53	-0.49	0.00	0.00	-0.60	0.07
15	1.69	1.60	1.46	1.33	1.47	0.76	1.24	1.07	0.24	0.22	-0.62	0.03
16	1.55	1.19	1.27	1.43	1.02	0.69	0.28	0.41	0.13	0.06	-0.62	0.07
17	1.34	0.75	1.28	1.87	0.72	0.21	0.87	0.99	0.00	0.00	-0.65	0.11
18	1.19	1.09	2.91	4.06	0.58	1.01	2.19	1.81	0.22	0.78	-0.74	0.16
19	3.05	1.52	1.42	1.39	2.58	0.79	0.53	-0.12	0.25	0.32	-0.58	0.07
20	1.55	1.19	1.46	16.71	1.02	0.69	1.24	16.38	0.33	0.09	-6.22	0.12

Calculated by the author as per the data from Stock exchanges from Americas and stock exchanges from Europe.

Table 8
Group A & Group B, Industry II

	Group A, Industry II	Group B, Industry II
Company	Imapairement of Assets (Change %) Change % (Q1,'20)	Imapairement of Assets (Change Change % (Q1,'20)
1	10.0	-17.0
2	-15.5	-30.6
3	400.0	0.0
4	50.0	10.7
5	0.0	-2.0
6	7.3	-1.0
7	90.0	-60.8
8	-2.3	0.0
9	0.0	20.0
10	24.8	-2.0
11	76.0	30.0
12	661.7	-13.0
13	200.0	0.0
14	122.0	10.0
15	1.0	-2.0
16	8.5	70.0
17	11.1	13.1
18	-4.2	40.0
19	0.0	66.0
20	24.8	-1.0

Calculated by the author as per the data from Stock exchanges from Americas and stock exchanges from Europe.

Table 8, Impairment of assets (Group A, Industry II and Group B, Industry II) shows that there is a high increase in variation in Industry II in region A compared to region B.

The result shows that the majority of the industries producing non-essential items such as automobile and textile goods faced adverse effects on their business operational activities as well as their financial statements in region A. Therefore, the companies are facing impairment of assets at a higher rate in comparison to Q 2020 and Q 2019.

Unscientific and uncontrolled measures taken by external bodies (governments & WHO), adversely affect business operational activities and financial statements. Unscientific and uncontrolled measures taken by internal institutions (organizations), negatively affect business operational activities and financial statements. Therefore, H2 and H4 are supported. Thus, the

findings revealed that during the pandemic as a phenomenon, the measures taken by external bodies (governments, World Health Organization (WHO)) and internal institutions (organizations) play a vital role in the degree of repercussion effect in economic and business operations and they will, in turn, affect organizational financial statements.

5. Conclusion

Based on the results of the research and discussion, it can be concluded that the measures taken by external bodies (governments, World Health Organization (WHO)) and internal institutions (organizations) play a vital role in the degree of repercussion effect in economic and business operations and they will, in turn, affect organizational financial statements during the pandemic period.

Thus, this study has obtained unique findings as compared to previous studies. Furthermore, such a research in the field of pandemic effects on financial statements provides novelty in the world literature. This is thanks to the knowledge of the researchers; there was no empirical study that combined these variables and evaluated their empirical significance. The findings confirmed that there is a positive relationship between four hypothesis. Scientific and controlled measures taken by external bodies (governments and WHO), low adversely affected business operational activities (revenues, manufacturing/production, inventory, expenses) and financial statements (profitability, liquidity, impairment of assets, wealth and dissolution). Scientific and controlled measures taken by internal institutions (organizations) adversely affected business operational activities (revenues, manufacturing/production, inventory, expenses) and financial statements. Unscientific and uncontrolled measures taken by external bodies (governments and WHO) adversely affected business operational activities and financial statements (profitability, liquidity, impairment of assets, wealth and dissolution). Unscientific and uncontrolled measures taken by internal institutions (organizations) adversely affected business operational activities and financial statements towards business operational activities (revenues, manufacturing/production, inventory, expenses) and their financial statements (profitability, liquidity, impairment of assets, wealth and dissolution). The findings also suggest the role of governments and organizations for future prevention of 'Pandemic Effect on Financial Statements' that can be relied upon to fight with future pandemic situations.

In the future, even small and medium enterprises can also incorporate automated accounting software [Muneerali, 2020; Thottoli, 2020] to set aside a provision for such future pandemic contingencies. Information communication technology (ICT) enabled auditing to help professional auditors examine those statutory provisions on pandemic in any organization [Thottoli et al., 2019a; 2019b; 2019c; Thottoli, Thomas, 2020; Thottoli, 2021c; 2021d].

6. Significance of the study

This study is the first to suggest strengthening economic stability for a country during a pandemic era. Since pandemic is a universal disease which has already happened many times - smallpox, tuberculosis, plague, influenza pandemic, flu pandemic (H1N1), HIV/AIDS and current coronavirus pandemic. This pandemic impedes business operations and economic growth around the world as a universal phenomenon; governments and WHO are required to take well-organized scientific/controlled measures. This may help the government to keep statutory money reserve for coping with pandemic situations in the future. For example, the government keeps a certain budgeted amount for defense. Further, we can think of the various organizations to keep an adequate statutory reserve for facing such pandemic situation in the future, as well as this current study may assist the policymakers in various world organizations, ministry of health and governments, in particular, to implement wise and deliberate policies that can cope with a future pandemic situation.

7. Limitations and future research

The key goals established for this research were the identification of the factors that affect business operational activities during the pandemic period. However, this research has not touched upon the cultural aspects of each country that might be a barrier to implement strict governmental rules and policies. This study has considered four types of industries, moreover it can be applied for other types of industries too. Further research is necessary to extend and replicate this study to cultural and other spheres – geographical and economic environments to provide this wider support.

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The article was submitted on 21.10.2021; revised on 2.11.2021 and accepted for publication on 10.11.2021. The authors read and approved the final version of the manuscript.

DOI: 10.17747/2618-947X-2021-2-150-156

Efficiency evaluation of activity of the Russian public companies in the conditions of active regulation of operating costs and external effects (shocks)

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Abstract

The author considers influences of active regulation of operating costs and negative effects (shocks) on financial policy of the Russian public companies. The Russian firms make the choice for benefit of internal financing for the purpose of increase in the corporate benefit in the conditions of external financial restrictions (sectoral sanctions). Growth of the corporate benefit leads to increment of company assets and respectively to welfare of the shareholder. The Russian public companies will review the capital structure in the conditions of growth of adjustment costs. The active policy of the Russian companies is connected with availability of sufficient size of assets which are source of mortgage providing for regulation of capital structure. Thereby, the organization solves problem of adverse selection – financing source selection taking into account its price. The companies are forced to regulate actively the capital structure in the conditions of growth of operating costs and negative shocks. Regulation of capital structure is connected with the aspiration of the company to keep part of debt for its use as financing source. Operating costs are the indicator estimating efficiency of management decisions. The Russian companies will finance the investments, first of all, by internal financing sources. Cash flows are the resource servicing the investment capital. The firms will be attracted the loan capital in the period of deficit of cash flow. The Russian companies will work in logic of precautionary motive, creating monetary stock in the conditions of shocks. The precautionary motive is the protective buffer from negative impacts from the capital markets. Low values of cash flows allow to limit the management concerning his illegal behavior – decision making in private interests.

Keywords: financial policy, adjustment costs, shock, pecking order, capital structure, debt policy, investment potential.

For citation:

Lutsenko S.I. (2021). Efficiency evaluation of activity of the Russian public companies in the conditions of active regulation of operating costs and external effects (shocks). *Strategic Decisions and Risk Management*, 12(2): 150-156. DOI: 10.17747/2618-947X-2021-2-150-156. (In Russ.)

Acknowledgements

The research is awarded appreciation from Federal State Statistics Service (Rosstat) on which materials this article is written. In particular, it is noted that the conclusions provided in research will be useful to improvement of federal statistical observations of organization activity. The author expresses gratitude to A.V. Trachuk and N.V. Linder for their help in preparing for publication of the article.

1. INTRODUCTION

As noted in the Address of the President of the Russian Federation to the Federal Assembly[1], high risks remain for business, especially when it comes to long-term projects. Therefore, the priority direction for companies is the transformation of profit into investment. In the face of external financial constraints, Russians must use domestic funding as a source of capital efforts in order to enhance corporate good. Derivatives of corporate benefits increase the value of shares and the investment attractiveness of the company[2]. In turn, the growth of corporate good leads to an increase in sales through the accumulation of the company's assets[3].

The corporate good is based on the economic interest of the shareholder. Management function is down to

[1] Message from the President of the Russian Federation to the Federal Assembly of 04/21/2021. Consultant Plus. URL: https://clck.ru/UeGCk.

[2] Resolution of the Constitutional Court of the Russian Federation of February 24, 2004 No. 3-P. Consultant Plus. URL: https://clck.ru/DEJ6b.

[3] Resolution of the Fifteenth Arbitration Court of Appeal dated March 26, 2020 in case No. A53-33668 / 2019. Consultant Plus. URL: https://clck.ru/UeGPD.

taking economically sound decisions that serve the interests of shareholders. A decline in stock value can be seen as a negative consequence of the policy affecting the legal rights associated with the shares, in particular the shareholder's right to influence the company[4].

Existing studies see into a certain set of organization's characteristics that influence its financial policy without taking into account the costs of regulation and externalities (shocks).

As noted by D. Mauer and A. Triantis [Mauer, Triantis, 1994], companies that poorly manage operational risks (associated with high levels of costs) are characterized by a high level of debt burden. J. Graham [Graham, 2000] singles out the company's profitability as an important factor influencing corporate financial decisions. In other words, this indicator allows you to determine the logic of management decisions related to the financing of the company's activity. In addition, using the profitability indicator, management can regulate capital framework (accumulating profits for the subsequent repayment of debt).

K. Chang and co-authors [Chang et al., 2006] consider information asymmetry as a significant component that influences managerial decision-making associated with the source of funding. The presented indicator (information asymmetry) is the one that defines the proprietary security of the debt. A company with a high level of fixed assets has a higher debt potential (that is, the ability to repay a loan of a certain size).

A. Korteweg and O. Oztekin [Korteweg, 2010; Oztekin, 2015] investigate the impact of company size on capital framework. A large company has easier access to the debt financing market.

O. Gu and co-authors [Gu et al., 2020] assess the relationship between inflexibility (inaction on the part of management regarding the capital structure) and financial policy.

In this work, the author expands the research horizon.

The correlation between operating costs (costs of regulating the capital structure), shocks and financial policies of Russian public companies will be studied as well as evidence that Russian organizations are forced to actively regulate their capital structure in the face of rising operating costs and negative shocks will be provided. Otherwise an increase in debt burden can lead to financial instability.

In addition, we will analyze the influence of the precautionary motive hypothesis put forward by J. Keynes [Keynes, 1936, p. 403] on financial leverage.

The policy of Russian companies in terms of the active regulation of the capital structure is aimed at the ability to use debt financing without regard to the risk associated with the repayment of debt obligations (taking into account the sufficient amount of assets as collateral guarantee). As noted by D. Hackbart and T. Johnson [Hackbart, Johnson, 2015], companies that are more flexible in regulating their debt level have greater debt potential (ability to borrow).

In addition, it will be shown that a positive relationship between operating costs and financial leverage (financial policy) is associated with their activity to reduce the costs of regulating the capital structure, as well as with the search for sources of funding in response to negative shocks (external effects). Operating costs are a key performance indicator used to measure management efficiency[5].

It should be noted that a shock is understood as market fluctuations in circumstances that cannot be influenced and reasonably foreseen (negative effects or externalities).

An example of negative effects is the sectoral sanctions of the European Union against oil companies in accordance with Regulation No. 833/2014 from July 31, 2014. The sanctions are regularly extended and are still in effect[6]. First of all, we are talking about a ban on debt financing and restrictions on the participation of bonds (with a maturity of more than 30 days) in trading concerning fuel and energy companies (Rosneft, Transneft, which are presented in the study). The purpose of the introduction of sectoral sanctions is called "increased costs of Russia for its actions to undermine the territorial integrity, sovereignty and independence of Ukraine"[7]. In other words, the EU economic sanctions are an unavoidable or force majeure circumstance, since they make it impossible for a person to fulfill his contract commitments[8].

In some cases, a pandemic of coronavirus infection COVID-19, taking into account prohibitive and restrictive

[4] Case of Albert and Others v. Hungary of 07.07.2020 (Application No. 5294/14). URL: https://clck.ru/UeGgi.
[5] Order of the Federal Property Management Agency of March 10, 2016 No. 90 "On Approval of the Methodological Guidelines for the Calculation of Cost Reduction by Joint-Stock Companies, the State's Share in the Authorized Capital of which is more than 50 percent." Consultant Plus. URL: https://clck.ru/UeJEE.
[6] Resolution of the Ninth Arbitration Court of Appeal dated 02.03.2021 in case No. A40-14071 / 2020. Consultant Plus. URL: https://clck.ru/UeJLr.
[7] Resolution of the Ninth Arbitration Court of Appeal dated 03.11.2020 in case No. A40-97367 / 2019. Consultant Plus. URL: https://clck.ru/UeJUJ.
[8] Resolution of the Arbitration Court of the Moscow District of 10.11.2020 in case No. A40-46243 / 2019. Consultant Plus. URL: https://clck.ru/UeJZV.

Table 1
Descriptive statistics

Variable	Average	Standard deviation	Minimum value	Maximum value
Financial leverage	0.579	0.228	0.16	1.00
Operational costs	0.859	0.114	0.46	1.12
Shock	10.670	16.698	–57.4	58.50
Tangible assets	0.472	0.257	0.02	0.89
Tobin's *Q*	1.969	2.707	0.16	12.50
Investements	0.073	0.038	0	0.17
Cash flow	0.101	0.097	–0.28	0.38

measures by the state, may also be a force majeure circumstance, since it affects the unstable situation in the economy, the decline in the purchasing power of the population[9].

Russian public companies will finance their investments primarily from internal funds (cash flows from operating activities – resources that are available to service investment capital, that is, the total amount of equity and borrowed capital). In the context of time gaps for cash flows for making a profit from the main type of activity they will attract borrowed sources of financing[10].

In the face of negative shocks, Russian public companies will act in the logic of a precautionary motive. According to the hypothesis of a precautionary motive, in order to avoid unforeseen circumstances that require sudden spending, it is necessary to form a cash reserve, which will be a protection against negative influences from external capital markets.

In the presence of a cash flow deficit, shareholders, as a rule, in order to cover this deficit, make a decision to attract debt financing.

2. METHODOLOGY OF THE STUDY AND DESCRIPTION OF THE SAMPLING

In order to identify the impact of operating costs (costs of regulating the capital structure), a shock on financial policy, 24 public Russian companies from 10 sectors of the economy were selected: agriculture (production, processing and sale of agricultural products), oil and gas complex (oil and gas industry), food industry (production and processing of poultry meat, pork and mixed feed), ferrous and non-ferrous metallurgy, mechanical engineering (production of parts and accessories for cars and engines), electric power industry, construction (general construction works), trade (retail trade in food and non-food products), transport (transportation by pipes, sea transport), telecommunications (communication services). The sample included public Russian companies with a total income of more than 10 billion RUB.[11] The selection criterion was the availability of reporting in accordance with international financial reporting standards. The company's shares must be traded on the stock market. Information about Russian organizations was obtained from annual financial statements, reports of issuers, as well as data on corporate websites. The sampling period is 2016-2020. The number of observations for each company varies (for some companies – 2017–2020, for others – 2016–2019), so the data is unbalanced. Econometric calculations were performed by Stata statistical package.

3. DESCRIPTION OF VARIABLES

When evaluating the regression model, the dependent variable (explained variable) was used – financial

[9] Resolution of the Sixth Arbitration Court of Appeal dated December 17, 2020 in case No. A73-12223 / 2020. Consultant Plus. URL: https://clck.ru/UeJhu.
[10] Letter of the Ministry of Finance of Russia dated 05.09.2017 No. 03-08-05 / 56927. Consultant Plus. URL: https://clck.ru/UeJpN.
[11] Order of the Federal Tax Service of Russia dated May 16, 2007 No. MM-3-06 / 308 @. Consultant Plus. URL: https://clck.ru/DELZD.

leverage (the company's financial policy indicator). In addition, this variable allows us to assess the features of the regulation of the capital structure.

As independent (explanatory) variables we selected: tangibility of assets, Tobin's Q, investments, cash flow from operating activities. These explanatory variables were borrowed from [Frank, Goyal, 2003, Gu et al., 2020].

In addition, the model includes two independent variables - indicators of operating costs and shock.

Financial leverage (Lev) is defined as the ratio of total debt to total assets. The indicator determines the company's financing policy.

Operating costs (Oper_Costs) are calculated as the ratio of operating costs (including cost of sales, selling and administrative expenses) to revenue. The indicator makes it possible to assess the activity and effectiveness of the company's management in the context of adjusting the regulatory costs associated with the capital structure.

Shock is the ratio of profit after tax to market capitalization *(Shock)* Shock (negative effects – externalities) is a guideline for choosing a source of funding, taking into account the costs of regulating the capital structure.

Asset tangibility (PPE/A) is calculated as the ratio of fixed assets to total assets. The indicator is associated with information asymmetry and allows you to choose a source of funding, taking into account its price. It characterizes the property security of the company when turning to debt financing.

Tobin's Q is an indicator that assesses the investment potential of a company and is calculated as the ratio of market capitalization to the cost of equity capital according to balance sheet valuation.

Investments (Invest) – the ratio of the acquisition of fixed assets and intangible assets to the total value of assets.

Cash flow (Cash_Flow) is defined as the ratio of cash flow from operating activities to total assets. The indicator assesses the company's resources required to finance investments.

All independent variables are lagged. The lag takes one year.

Descriptive statistics are presented in table. 1. On average, the capital structure of a Russian public company consists of 58% of debt financing and 42% of equity. For every ruble of revenue, on average, 86 kopecks are accounted for operating costs. The average value of the shock is 10.7% of the market value of assets. For every ruble of assets, on average, there are 7 kopecks of investments. On average, every ruble of total assets accounts for 10 kopecks of cash flow from operating activities.

4. EVALUATION AND MODEL ANALYSIS

We single out a regression model that estimates the impact of operating costs, shock and other characteristics of a company on financial policy:

$$Lev_t = a_0 + a_1(Oper\_Costs)_{t-1} + a_2(Shock)_{t-1} + a_3(PPE/A)_{t-1} + \\ + a_4(Tobin's\ Q)_{t-1} + a_5(Invest)_{t-1} + a_6(Cash\_Flow)_{t-1} + \varepsilon_t,$$

where is t – the time period for the company, a_0 – is the free term of the regression equation, a_1, a_2, a_3, a_3, a_4, a_5, a_6 – are the regression coefficients, ε – is the error of the regression equation.

In order to improve the forecast accuracy, the regression model was tested for the insignificance of the specification, autocorrelation of residuals, heteroscedasticity, and for the presence of multicollinearity (model robustness).

To test the hypothesis about the insignificance of the regression in general (i.e. , the hypothesis about zero values of the coefficients for the explanatory variables *Oper_Costs*, *Shock*, *PPE/A*, *Tobin's Q*, *Invest*, *Cash_Flow*) we used the Wald criterion based on the *Wald* = *qF*, statistic, where F – is the usual F-statistic for testing the hypothesis, and q – the number of linear constraints on the parameters of the model (q = 6). The Wald test statistic has an asymptotic chi-square distribution with q degrees of freedom. Based on the asymptotic distribution, the observed significance level corresponds to the observed value of 26.87, equal to *Prob* > *chi*2 = 0.000, so the hypothesis of zero values of the coefficients for the explanatory variables is rejected. The obtained results characterize the high statistical significance of the coefficient estimations.

The test for autocorrelation of residuals was carried out using the Dickey - Fuller criterion with a constant and a trend, taking into account the transition to the first differences. The diagnostics indicates stationarity of the time series (the significance level (MacKinnon approximate p-value for $z(t)$) for the explanatory variables is less than 5% significance level). Critical scores and test statistics reject the null hypothesis (test statistics exceeds the critical value by a 5% significance level). The hypothesis that the specification is correct should

Table 2
The model considering influence of operating costs, shock and other characteristics on financial policy of the Russian public companies

Independent variables	Coefficient	*t*-statistics	Significance level of *t*-statistics
Oper_Costs	0.420	2.16	0.033
Shock	– 0.002	–2.01	0.048
PPE/A	– 0.361	–4.17	0.000
Tobin's Q	0.042	5.70	0.000
Invest	1.271	2.51	0.014
Cash_Flow	– 0.560	–2.46	0.016
Invariable	0.290	1.46	0.149

Note. Number of observations – 86; R^2 = 67.12%; *F*-statistic = 26.87 [0.000].

be accepted. There is a long-term relationship between operating costs, shock and financial policies of Russian public companies.

The presented regression was also tested for heteroscedasticity (Brousch-Pagan test at 5% significance level). A check was carried out for the independence of the residuals from the number (moment) of observation (all independent variables). When this condition is not met, it is called heteroscedasticity. During testing, it turned out that the significance level is 70.76%, i.e. exceeds the 5 percent level. The null hypothesis of homoscedasticity is not rejected. The hypothesis of the presence of heteroscedasticity is rejected (the hypothesis of the presence of autocorrelation of residuals, leading to a decrease in the forecast accuracy, can be rejected). The regression residuals are similar to "white noise" (values at different points in time are independent and equally distributed).

Finally, a test was carried out to find the relationship between the independent variables (multicollinearity – *VIF* indicator - Variance Inflation Factor).

The model has multicollinearity if for one of the independent variables the value of the *VIF* coefficient is > 10. In our case, the largest value is significantly lower than 10 (*VIF* = 2.29), the average *VIF* value for all parameters is 1.94. There is no multicollinearity in the model (the hypothesis of multicollinearity is rejected).

A qualitative forecast can be made using the presented regression model.

The results of the regression testing are presented in table. 2.

Model considering the role of operating costs, shock and other characteristics on the financial policy of Russian public companies.

A model that takes into account the impact of operating costs, shock and other characteristics on the financial policy of Russian public companies.

All characteristics of the company are significant at the 5% significance level.

In the face of negative external shocks (externalities), Russian public companies opt for internal financing (negative relationship between shock, cash flow and financial leverage).

Management is active in regulating the capital structure (a positive relationship between operating costs and financial leverage), in particular due to the fixed adjustment costs associated with active regulation of the capital structure. The author's position is consistent with previous studies [Fischer et al., 1989; Lutsenko, 2017].

The purpose of regulation of the capital structure is associated with the desire of Russian public companies to preserve a certain part of the debt for its further use as a source of financing (negative relationship between cash flow and financial leverage). Thus, Russian organizations will operate within the logic of a conservative debt policy [Minton, Wruck, 2001].

In addition, the feedback link between cash flow and financial leverage suggests a certain limitation

on opportunistic (misconduct) behavior on the part of management, since low cash flows limit the company's management in terms of self-dealing.

The negative relationship between the tangibility of assets and the financing policy indicates a low information asymmetry in relation to property security, allowing one to overcome the problem of unfavorable selection - choosing a cheaper source of financing [Harris, Raviv, 1991].

Russian public companies will resort to debt financing if there is sufficient collateral (positive relationship between Tobin's Q and financial policy).

Russian organizations will follow the hierarchical theory of financing, referring to a cheaper source of financing (since cash flow is a resource available to finance investments).

The adjustment of the capital structure is influenced by investments and Tobin's Q indicator (a positive relationship of these indicators with financial leverage). Russian companies act in the logic of a precautionary motive, switching to internal sources of financing (saving part of the cash flow) in order to finance their investment projects in the future, taking into account their priority.

The warning motive, as noted by S. Myers and N. Majluf [Myers, Majluf, 1984], can be associated with financial instability, hence, companies save more money.

The author disagrees with the position of Gu and the co-authors (Gu et al. (2020)) that companies with low leverage do not increase it in response to negative shocks, thereby showing inaction with regard to capital structure regulation. On the contrary, companies with an increase in fixed costs (costs of regulating the capital structure) will be active in adjusting their financial policy (implementation of the recapitalization policy). We are talking about changes in the capital structure by increasing debt financing and using it as an investment (a positive relationship between operating costs, investments and financial leverage).

5. CONCLUSION

Operating costs and negative shocks make it possible to assess the effectiveness of management's activities, as well as to understand their logic in making decisions related to the financing of an organization. The management of Russian companies will finance investments following a hierarchical theory: referring primarily to a cheaper source of financing - cash flow from operating activities. Management decisions are associated with the active regulation of the capital structure. Russian companies operate in the plane of a conservative debt policy, within which the following factors are of great importance: investment potential, property security and negative shocks, and the shock indicator determines the choice of a financial source, taking into account its price. Finally, management decisions are consistent with the precautionary motive hypothesis. In the context of financial constraints and sanctions, Russian companies will seek to build up a cash reserve as a defense against negative effects (externalities).

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The article was submitted on 2.09.2021; revised on 27.09.2021 and accepted for publication on 10.10.2021. The authors read and approved the final version of the manuscript.

DOI: 10.17747/2618-947X-2021-2-157-169

An empirical analysis of the barriers of transition from the fourth industrial revolution technologies pilot phase to widespread adoption

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Abstract

Nowadays business processes in industrial companies are undergoing significant changes under the influence of the trends of the fourth industrial revolution, and the pace and scale of the spread of digital technologies has significantly accelerated due to the coronavirus pandemic. The technological basis for the digital transformation of industrial companies is the industrial Internet of things, cloud computing and blockchain, the collection of big data and their subsequent analytics, machine learning technologies, digital twins, human-machine interaction, including virtual and augmented reality, robotics and automation.

Even though the technologies of the fourth industrial revolution can transform the activities of enterprises and increase their efficiency, today most of the projects do not move from the pilot stage to widespread implementation in the company. The purpose of this study is to identify and assess the main barriers that impede the successful implementation of digital technology implementation projects.

At the first stage of the study based on a review of domestic and foreign literature, as well as in-depth interviews with experts, groups of barriers were identified and verified that impede the implementation of digital technologies in industrial companies: economic and financial, managerial, competence, regulatory and technological barriers. Also, questionnaires were developed for the quantitative stage of the study.

At the second stage of the study, a quantitative assessment of the strength of the influence of barriers was carried out. The barriers with the greatest influence are lack of funds, the need to attract large amounts of funding, and insufficient support from the organization's management. According to the analysis, the least significant barriers for companies include the complexity of introducing new technologies and the need to change the company's business model.

At the end of the work, a list of proposals was developed to overcome the barriers to the transition from the stage of pilot implementation of technologies of the fourth industrial revolution to widespread implementation.

Keywords: digitalization, fourth industrial revolution, industrial companies.

For citation:

Kuzmin P.S. (2021). An empirical analysis of the barriers of transition from the fourth industrial revolution technologies pilot phase to widespread adoption. *Strategic Decisions and Risk Management*, 12(2): 157-169. DOI: 10.17747/2618-947X-2021-2-157-169. (In Russ.)

Acknowledgements

The article was prepared based on the results of the research "Project support mechanisms in digital high-tech areas development", carried out in 2021 on the Financial University state order at the expenses of budgetary funds.

1. INTRODUCTION

Currently, business processes in industrial companies are suffering dramatic changes under the influence of the fourth industrial revolution trends, and the pace and scale of digital technology spread have accelerated significantly due to the coronavirus pandemic.

The paper [Trachuk, Linder, 2017c] notes that the basis of Industry 4.0 is technological innovation, some of which are already widespread and successfully implemented by enterprises, while the other part is at the stage of development or a pilot project.

Industrial companies are the leaders in digital transformation and develop new or improve current ways of doing business using the following Industry 4.0 technologies:

- 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.

As the widespread practice of deploying digital technologies shows, their implementation will be successful

only if a positive economic effect is created in relation to the production methods and business models used previously [Trachuk, Linder, 2017a]. However, most companies that have attempted enterprise-wide digital transformation cannot realize all business opportunities available with the help of new technologies.

Despite the fact that the technologies of the fourth industrial revolution can significantly transform the activities of enterprises and increase their efficiency, today most of the projects are implemented fragmentarily, without reaching the stage when the company receives a significant financial and economic effect.

According to a study by KPMG consulting company, based on an analysis of Russian firms, 63% of respondents indicate that they have a digital transformation program in their company, but more often these are short-term pilot projects. Similar data were obtained in a study conducted by McKinsey consulting company, which showed that, despite the recognition of the need for digital transformation by many companies, only 30% pass the stage of transition from implementing pilot projects to scaling the use of digital technologies at the company level.

Most researchers in the field of digital technology adoption agree that the barriers and factors affecting the success of industry 4.0 technology adoption remain largely unexplored and require further study.

Thus, the purpose of this paper is to identify and evaluate the main barriers that hinder the successful realization of digital technology projects.

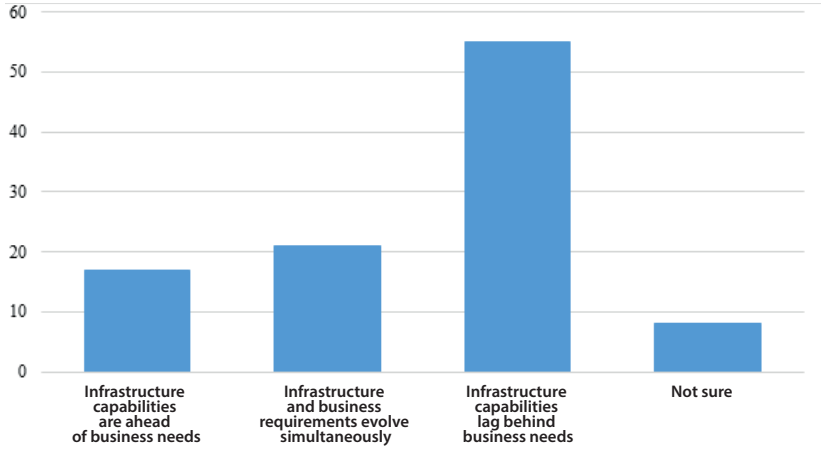
2. IDENTIFICATION OF BARRIERS: QUALITATIVE STAGE OF THE RESEARCH

In order to identify barriers to the widespread adoption of digital technologies in Russian industrial companies, a many-stage study was conducted.

The first stage included the analysis of foreign and Russian sources and the statistics on the implementation of technologies related to the fourth industrial revolution, scientific publications in this area, as well as reports and case studies on the implementation of various industry 4.0 technologies, published by consulting, manufacturing and research organizations.

For example, a study by McKinsey consulting company, based on the analysis of industrial enterprises, showed that only 3 out of 17 companies considered as digital transformation leaders in Europe were able to overcome the pilot project stage and introduce digital technologies throughout the value chain[1].

Fig. 1. Infrastructure capabilities and business needs comparison (%)



The source: KMDA survey, 2020.

According to the study, one of the main obstacles to the widespread use of digital technologies in companies is outdated infrastructure (equipment) that does not meet the requirements for integrating new technologies, but it is still used by industrial companies. Outdated infrastructure (equipment) can cause the situation when the digitalization of existing industries is considered more complex in comparison to digital plants or factories under formation. At the same time, this problem is relevant not only for European, but also for Russian companies, which risk being unable to compete with technologically more advanced industrial enterprises.

According to KMDA survey conducted among Russian companies in 2020, 55% of representatives from these firms say that the existing infrastructure lags behind business needs (Fig. 1).

The study of barriers to the introduction of digital technologies in industrial companies is the subject of many works both in Russian and foreign literature. [Nalbandyan, Khovalova, 2020] give the classification of potential barriers based on the review of Russian and foreign publications. The authors identify six main groups of barriers (Table 1).

The study [Trachuk, Linder, 2017c] proposes to classify the barriers for the introduction of digital technologies as financial, knowledge and market ones.

The group of financial barriers includes the lack of own financial capital and the difficulty in raising funds for the implementation of the technologies connected with the fourth industrial revolution, the lack of free funds, as well as the lack of experience in risk management of investment projects [Zuev, 2012]. At the same time, financial barriers have a negative impact both at the stage of investing in promising developments and large-scale implementation of digital technologies.

Knowledge barriers are presented as a lack of innovation culture among industrial enterprises, a lack

[1] URL: https://www.mckinsey.com/business-functions/operations/our-insights/preparing-for-the-next-normal-via-digital-manufacturings-scaling-potential.

Table 1
Classification of potential barriers to digital adoption in industrial companies

Group of barriers	Characteristic
Financial and economic barriers	Conditioned by the need for large volumes of investments with widespread introduction of technologies in conditions of significant uncertainty while obtaining a positive economic effect
Managerial barriers	Conditioned by inertia and resistance to change on the part of both the management and employees themselves and, as a result, the lack of support for the implementation of industry 4.0 technologies
Competency based barriers	Associated with a low level of personnel qualification involved in both the introduction of digital technologies and subsequent operation. The lack of information about the digital solution reduces the effectiveness of its application and pushes away from wider implementation.
Legal barriers	Conditioned by both the overload and lack of transparency of the regulatory legal framework in the field of digitalization, as well as relatively high requirements for ensuring cybersecurity in a number of enterprises and industries
Technical barriers	Conditioned by the complexity of introducing digital technologies, the impossibility of testing them, the unavailability of the enterprise infrastructure for their implementation. This group also includes barriers associated with consumer distrust in the reliability of technology, as well as a low level of technological maturity at the enterprise.
Implementation barriers	Driven by the need to fundamentally change the company's business model

The source: [Nalbandyan, Khovalova, 2020].

of qualified personnel (employees capable of innovating, commercializing digital technologies, as well as management personnel capable of implementing projects in order to introduce technologies of the fourth industrial revolution) [Kuznetsova, Rud, 2011], and insufficient protection of intellectual property.

The Analytical Center under the Government of the Russian Federation identifies similar barriers for the development of digital economy in Russia: according to the results of a survey conducted among regional executive authorities, the key barriers were ranked by the relative value of their mentioning (Fig. 2).

One of the important conclusions of the study conducted by the analytical center is the fact that barriers are similar for most of the Russian territories, although the level of digitalization in the Central region and large cities as a whole is higher than the average for the Russian Federation.

The Digital Leader networking platform[2] supported by PwC, IDC, and CROC, has identified a similar set of barriers and provides a scoring assessment to what extent these barriers influence both at the moment and over a 5-10 year planning horizon (Fig. 3).

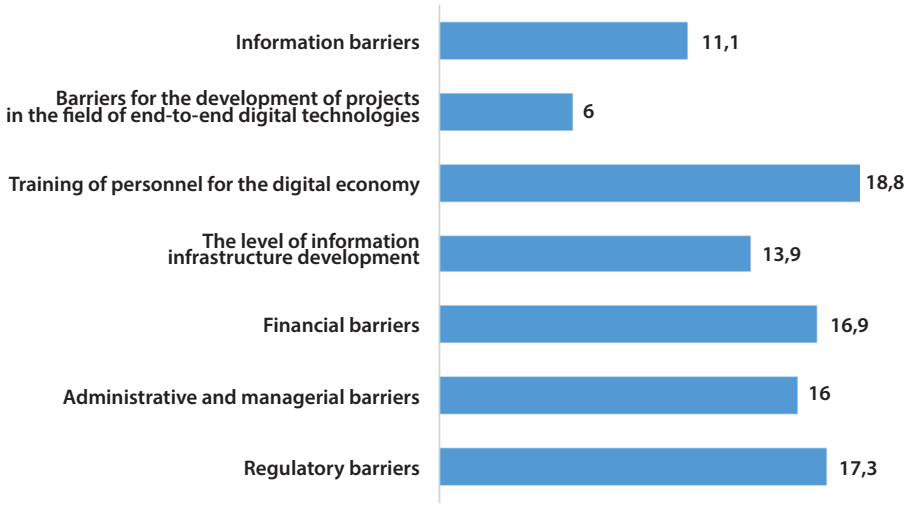
Most specialists agree that the most significant barrier is the lack of qualified personnel. Digital transformation affects both the technological and organizational structure of the company, and its competent implementation requires a team that can quickly change and acquire the skills necessary to work with innovative solutions. According to Accenture, at the moment, about 15% of the staff in leadership positions do not have the skills to implement industry 4.0 technologies.

Moreover, the management of the organization often cannot ensure the optimal pace of the introduction of new technologies. An unreasonably fast pace can use too many company resources and reduce the effectiveness of digital transition, while too slow one can suppress the interest in the transition [Digital Technologies.., 2019].

The Analytical Center under the Government of the Russian Federation notes that in addition to the lack of qualified personnel, there is a lack of educational programs and advanced training courses, there is no list of digital competencies. As in the Accenture study, the emphasis is on the lack of leadership and analytical competencies [Barriers in Development.., 2019]. The research also notes a shortage of applicants studying high-tech and digital specialties in

[2] URL: https://www.pwc.ru/ru/publications/collection/tehnologii-2030.pdf.

Fig. 2. The main barriers to the introduction of industry 4.0 technologies (% of the total number of



the regions of Russia, as well as gradual outflow of already established specialists. In addition to personnel working in the digital economy, these trends also affect specialists in the field of information security.

Due to a lack of personnel, most Russian companies cannot successfully reach digital transition, hence, the effective implementation of the fourth industrial revolution technologies is being realized by large companies such as Rosatom State Corporation, Rosseti PJSC, ALROSA JSC, RUSAL JSC and a number of other fuel companies – energy complex and metallurgy [Ismagilova et. al., 2017].

The next barrier mentioned in many studies is managerial [Golikova et al., 2012]. As noted earlier, in addition to the lack of digital competencies, many managers do not have sufficient skills to implement digital innovations [Gokhberg et al., 2010].

Often, the deployment of digital systems encounters resistance from the static organizational culture of the company [Kazantsev, Logacheva, 2014]. Employees tend to avoid fundamental changes in the established way of their work [The intelligent enterprise.., 2019]. According to the Swedish company IFS AB, which specializes in the implementation of ERP systems, there are about 42% of such employees in organizations.

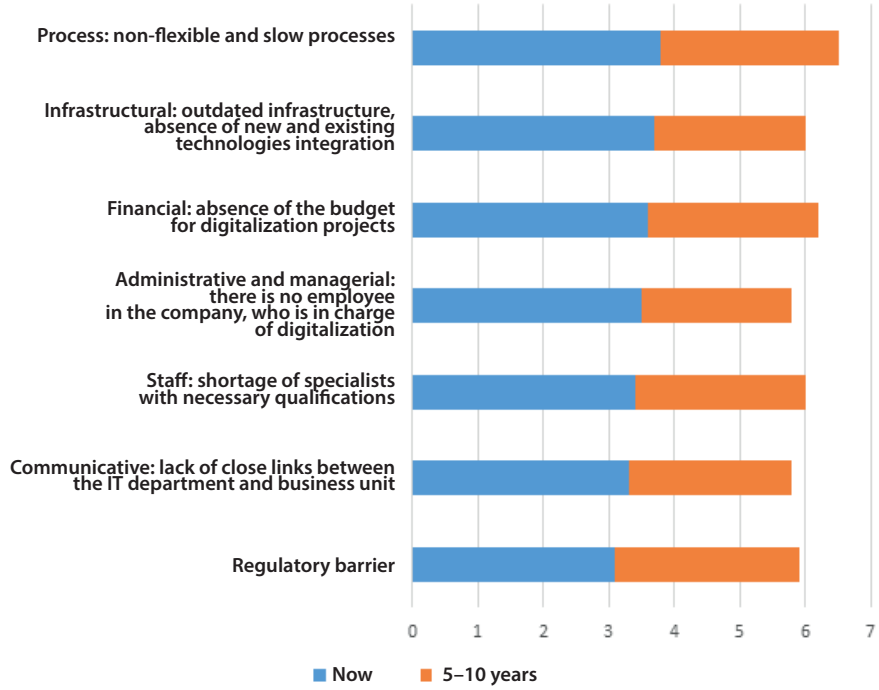
According to the study by the NAFI analytical center [Pandemic and the transition of companies.., 2020], one of the most significant restrictions is related to the budget. This issue is especially critical for regional enterprises and small and medium-sized businesses that do not have sufficient funds to purchase hardware and software [Arnold et al., 2016]. Thus, the priority in implementation is given to technologies, the use of which is associated with lower investments [Geissbauer et al., 2014].

Outdated infrastructure at enterprises also increases the cost of implementing digital solutions [Mityaeva, Zavodilo, 2019], which can be even more difficult due to the great variety and lack of mutual integration of the proposed technologies.

The next group of barriers is related to legal aspects and features of state regulation; it includes several main areas.

The absence of regulatory legal acts that determine the target representation of state and municipal services digitalization. A number of technologies that are essential for the development of the digital economy are not reflected in regulatory legal acts, such as block chain or unmanned passenger and truck cars, unmanned aerial vehicles, etc. In

Fig. 3. The main barriers to the adoption of industry 4.0 technologies and their score according to the Digital Leader version



other cases, the lack of requirements for information systems hinders the development of technical specifications for their implementation, for example, in the field of medicine.

Lack of standards for both digital technologies themselves and their development directions [Kamble et al., 2018]. For the widespread use of digital solutions, standardization plays an indisputable role, since it is precisely this that can make it possible to widely scale technologies and increase their level of interoperability [The Internet of things.., 2016].

It should be noted that the pace of adoption of standards is significantly behind the pace of digital technologies development not only in Russia, but throughout the world, which significantly slows down the penetration of industry 4.0 technologies into various sectors, as well as the fields of medicine and education [Barriers in development..., 2019].

Underdevelopment of the legal regulation of personal data and cybersecurity. The imperfection of legislation in the field of personal data protection slows down the digitalization of state and municipal services and in some cases hinders the widespread use of big data processing technologies and artificial intelligence. This risk is primarily associated with unauthorized access to user data and control systems and is one of the most significant threats associated with the introduction of cyber-physical systems [Trachuk, Linder, 2018]. Security systems should advance at the pace of digital technology development, because as digitalization penetrates into all spheres of life, personal data, the performance of production, energy supply systems, urban transport and the military-industrial complex may be under the threat of cyber attacks.

For corporations and their clients, the risk of losing money and disseminating confidential corporate data is unacceptable [Golikova et al., 2012]. Moreover, the distribution of sensitive data along the value chain increases the risks of fraud and reputational damage for companies [Haddud et al., 2017].

This threat is driving companies to adopt simpler, cleaner technologies that are associated with lower downstream risk and complexity. This trend has a negative impact on the development of technologically complex digital solutions.

In some cases, a number of large, innovative and financially stable companies are not able to implement quickly digital technologies due to the high level of potential consequences from the realization of the risk of a cyber attack [Buer et al., 2018]. In particular, companies undergoing international certification under such management system standards as ISO 27000 “Information Technology. Security methods. Information security management...” or ISO 28000 “Specification for supply chain security management systems”, are forced to ensure a high level of implemented digital solutions security or to reject a digital product with doubtful security.

The inability to conclude a concession agreement in the field of information technology at the municipal level hinders the implementation of public-private partnership programs on digital technologies in a number of Russian regions.

The need to update the law on the contract system. Currently, the two main laws regulating the field of procurement are Federal Law No. 223 of July 18, 2011 “On the Procurement of Goods, Works, Services by Certain Types of Legal Entities” and Federal Law No. 44 of April 5, 2013 “On the Contract System in the field of procurement of goods, works, services to meet state and municipal needs. These laws significantly affect the procurement activities of organizations. However, their specificity hinders the deployment of digital technologies and prevents some of the technologies of the fourth industrial revolution from realizing their full potential [Kuzmin, 2020; Pleshchenko, 2020;].

The next significant barrier is the lack of alignment of the implemented technology with the business goals of the organization. If the company's management has its own plans for the implemented digital solutions, and at the same time they are not consistent with the company's strategic goals, a digital transition can lead to a decrease in the company's economic performance.

Moreover, a bad digitalization experience due to inconsistent goals can lead to a reduction in funding for the IT department, the closure of digital transformation programs and the dismissal of some employees.

Technical barriers due to the complexity of implementing digital technologies, the impossibility of testing them, and the unpreparedness of the enterprise infrastructure for their implementation can also lead to a slowdown in the digital transition at an enterprise [Digital Technologies.., 2019].

When developing a flexible intelligent system that can quickly change according to new requirements and tasks, one may face the difficulty of mutual integration concerning various elements of the system, which has led to the lack of standardization of the elements in intelligent systems [Kamble et al., 2018].

Thus, as a result of the literature review, it is possible to identify barriers that prevent the widespread introduction of technologies of the fourth industrial revolution. They include: lack of funding, lack of initiative on the part of management, resistance to change on the part of employees, lack of qualified personnel, lack of standardization and mutual integration of technologies. Among them also are: excessively fast or excessively slow pace of technology implementation, inconsistency of the digitalization strategy with the company's strategy, underdevelopment of the regulatory legal framework, risks from insufficient cybersecurity, as well as technological barriers to the unpreparedness of the enterprise infrastructure for the introduction of digital technologies. The barriers identified during the analysis of the literature can be classified into several main groups, as presented in Table. 2.

At the next stage of the study, in order to verify and supplement previously identified barriers that impede the transition from the realization of pilot projects to the large-scale implementation of digital technologies in the company's activities, in-depth interviews were conducted

Table 2
Barriers of digital technologies adoption in industrial companies

Barrier group	Barrier	Works
Economic/financial	The need to attract more investment	[Teplykh, 2015; Arnold et al., 2016; Trachuk, Linder, 2017c; Barriers in development.., 2019; Komarova, 2019; Nalbandyan, Khovalova, 2020]
	Lack of free cash	[Zuev, 2012; Arnold et al., 2016; Trachuk, Linder, 2017c; Nalbandyan, Khovalova, 2020; Pandemic and the transition of companies.., 2020]
Managerial	Lack of support from enterprise management	[Gokhberg et al., 2010; Golikova et al., 2012; Trachuk, Linder, 2017c; 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]
Competency based	Lack of qualified personnel capable of implementing/using digital technologies	[Gokhberg et al., 2010; Golikova et al., 2012; Trachuk, Linder, 2017b; Ismagilova et al., 2017; Barriers in development.., 2019; Nalbandyan, Khovalova, 2020]
	Resistance from the company's static organizational culture	[Kazantsev, Logacheva, 2014; Trachuk, Linder, 2017b; Ismagilova et. al., 2017; The intelligent enterprise.., 2019]
	Insufficient provision of cybersecurity	[Golikova et al., 2012; Industry 4.0 after.., 2016; Haddud et al., 2017; Trachuk, Linder, 2018; Buer et al., 2018]
Regulatory	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][1]
	The need to update laws on the contract system and procurement	[Kuzmin, 2020; Pleshchenko, 2020]
Technological	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][1]

[1] Also: https://www.pwc.ru/ru/publications/collection/tehnologii-2030.pdf.
The source: compiled by the author.

Table 3
Barrier analysis: questionnaire questions, reliability factors (Cronbach's alpha)

Barrier	Symbol	Surveying	Cronbach's alpha
The need to attract more investment	FIN_{11}	Our company is having difficulty in raising the investment needed to scale pilot projects throughout the organization	0.82
	FIN_{12}	The scaling of new technologies may exceed the expected investment by several times, so we are postponing / turning away from their implementation	
Lack of free cash	FIN_{21}	Our organization's own funds are not enough to finance the large-scale implementation of new technologies	0.75
	FIN_{22}	The feasibility of investments in digital technologies is difficult to prove, so investments can be directed to other areas	
Lack of support from enterprise management	UPR_{11}	The management of our company has little motivation to introduce new technologies	0.71
	UPR_{12}	The organization's management is overburdened with operational activities	
The need to change the business model of the company	UPR_{21}	Digital technologies are changing the company's business model, which is associated with high risks	0.94
	UPR_{22}	To carry out the transformation of the business model of our company, it is necessary to attract additional material and human resources	
Inconsistency of the implemented digital technologies with the strategic goals of the company	UPR_{31}	Focus on technology itself, rather than as a means to achieve strategic goals	0.88
	UPR_{32}	The implemented new technologies are aimed at solving current problems, rather than at achieving the strategic goals of the company	
Lack of qualified personnel capable of implementing/ using digital technologies	$COMP_{11}$	There are not enough employees in our company who can use new technologies, even if they are implemented	0.75
	$COMP_{12}$	The management of the organization does not have sufficient knowledge to manage large-scale projects for the implementation of digital technologies	
Resistance from the company's static organizational culture	$COMP_{21}$	Employees fear job losses due to digitalization	0.93
	$COMP_{22}$	Employees do not want to change the usual work algorithm, so they resist change	
Insufficient provision of cybersecurity	$COMP_{31}$	Our company does not have a methodology for assessing the risks that arise as a result of the introduction of digital technologies	0.86
	$COMP_{32}$	Our company does not have sufficient financial resources to ensure cybersecurity	
Lack of standards for digital technologies and directions for their development	NPA_{11}	The company is not involved in national programs regarding the development of domestic digital technologies and standards	0.87
	NPA_{12}	Our company faces difficulties in the implementation of digital technologies due to the complexity of their mutual integration	
Underdevelopment of personal data and cybersecurity legal regulation	NPA_{21}	The cost of complying with the requirements of all regulatory legal acts may exceed the positive effect from the introduction of new technologies	0.79
	NPA_{22}	The underdevelopment of legal acts in the field of cybersecurity and constant changes in them divert a significant amount of resources to the processing of the internal information protection system	
The need to update laws on the contract system and procurement	NPA_{31}	Our company is having difficulties in finding Russian suppliers of the necessary digital technologies to comply with import substitution requirements	0.92
	NPA_{32}	The choice of technology suppliers of our company is limited by competitive procedures defined in the legislation	
Difficulty in implementing digital technologies	$TECH_{11}$	Due to the complexity of introducing new technologies and their complex nature, our company needs to attract additional material and human resources	0.81
	$TECH_{12}$	The results of the pilot project show that some technologies require an excessive amount of resources to support their operation	
Unpreparedness of the enterprise infrastructure for the introduction of digital technologies	$TECH_{21}$	Within the framework of the current infrastructure of the enterprise, there is no possibility to introduce digital technologies	0.76
	$TECH_{22}$	The introduction of new technologies will require the replacement of part of the equipment already in use, for which our company is not ready	

The source: compiled by the author.

with representatives of both industrial and consulting companies. These companies provide consulting services to enterprises in various industries, including the introduction of digital technologies. Representatives of NPK Krypten JSC, Sibur JSC, KPMG JSC, Accenture, Rosatom State Corporation took part in the survey as respondents.

When forming the sample, representatives of companies that meet one or more of the following criteria were invited as respondents:

- occupies a senior position within the department in which the implementation of the project on the introduction of digital technologies was carried out, or is the head of such a project;
- is directly related to the development of digital technologies;
- develops technologies for the fourth industrial revolution.

Based on the results of the interviews, the previously identified barriers were confirmed and updated. Also, the materials obtained during the interviews served as additional justification for the questionnaire designed to quantify the barriers that affect the adoption of digital technologies.

3. ASSESSMENT OF BARRIER INFLUENCE: QUANTITATIVE STAGE OF THE STUDY

To study further the barriers for transition from the implementation of pilot projects of digital technologies to their replication, an analysis was carried out in order to identify the strength of the influence of barriers. As part of this stage, a questionnaire was prepared in which respondents were asked to assess the degree of their agreement with the proposed statements given in Table. 3, according to a 7-point Likert scale, where 1 – "completely disagree with the statement", 7 – "fully agree with the statement."

In order to build a regression model and quantify the strength of the barrier influence, the questionnaire was sent to 405 industrial companies. Only 173 company gave the response (42.7%). The characteristics of the sample are presented in Table. 4.

At the initial stage of the quantitative analysis, reliability coefficients (Cronbach's alpha) were calculated for the studied barriers, assessed by several questions according to 7-point Likert scales. The obtained Cronbach's alphas meet the requirement for a minimum level of reliability for a field study of 0.65.

At the next stage, factor analysis was performed. It used the principal component method for 26 questions describing 13 barriers for 6 groups. The results of the factor analysis were applied in a regression model designed to assess the degree of barrier influence to the transition from the stage of pilot introduction of the fourth industrial revolution technologies to widespread implementation:

$$Y_i = \beta_0 + \sum_{j=1}^{2} \beta_j \cdot FIN_{ji} + \sum_{j=1}^{3} \beta_{j+2} \cdot UPR_{ji} + \sum_{j=1}^{3} \beta_{j+5} \cdot COMP_{ji} + \\ + \sum_{j=1}^{3} \beta_j + 8 \cdot NPA_{ji} + \sum_{j=1}^{2} \beta_{j+11} \cdot TECH_{ji} + \varepsilon_i. \quad (1)$$

The list of variables used in the regression model is presented in Table. 5.

The regression analysis revealed the degree of influence of various barriers to the transition from the stage of pilot implementation of industry 4.0 technologies to their widespread use. The results of the analysis are presented in table. 6.

Thus, the analysis showed that the barriers that most hinder the transition from the realization of pilot projects to the large-scale implementation of digital technologies at enterprises include the lack of funds (significance coefficient – 0.631), the need to attract a large amount of investment (significance coefficient – 0.552), insufficient support from the management of the enterprise (significance coefficient – 0.478). According to the results of the analysis, the least significant barriers for companies include the difficulty of introducing new technologies (significance coefficient – 0.098), as well as the need to change the company's business model (significance coefficient – 0.061).

Table 4
Sample characteristics

Characteristics of sampled companies		Number of companies	%
Company's lifespan (years old)	Less than 5 years	19	11
	5–10 years	55	32
	More than 10 years	99	57
Average number of employees (people)	500–1000	12	7
	1001–5000	71	41
	More than 5000	90	52
Revenue for the year from sales (excluding VAT) (mln RUB.)	No more than 50	21	12
	50–500	57	33
	More than 500 million	95	55

The Source: compiled by the author.

Table 5
Description of variables

Group of barriers	Variable symbol	Variable description
—	Y_i	Indicator of the transition from the stage of pilot implementation of technology to wide application (binary variable, where 0 – the transition to wide application has occurred, 1 – has not occurred)
Economic/financial	FIN_{1i}	The need to attract more investment
	FIN_{2i}	Lack of free cash
Managerial	UPR_{1i}	Lack of support from enterprise management
	UPR_{2i}	The need to change the business model of the company
	UPR_{3i}	Inconsistency of the implemented digital technologies with the strategic goals of the company
Competency based	$COMP_{1i}$	Lack of qualified personnel capable of implementing/using digital technologies
	$COMP_{2i}$	Resistance from the company's static organizational culture
	$COMP_{3i}$	Insufficient provision of cybersecurity
Regulatory	NPA_{1i}	Lack of standards for digital technologies and directions for their development
	NPA_{2i}	Underdevelopment of the legal regulation of personal data and cybersecurity
	NPA_{3i}	The need to update laws on the contract system and procurement
Technological	$TECH_{1i}$	Difficulty in implementing of digital technologies
	$TECH_{2i}$	Unpreparedness of the enterprise infrastructure for the introduction of digital technologies

The source: compiled by the author.

4. PROPOSALS TO OVERCOME BARRIERS IN THE IMPLEMENTATION OF DIGITAL TECHNOLOGIES

Based on the identified barriers, as well as on the analysis of interviews with experts and the results of surveys of industrial companies, proposals were formulated to overcome barriers for the transition from the implementation of pilot projects on digital technologies to their replication.

1. The effectiveness and success of the project realization on digital technology can be positively affected by the presence of a developed business case that reflects the goals and results of the implementation, the required amount of funds, as well as the predicted effect in terms of the economic component.
2. Large-scale implementation of industry 4.0 technologies requires significant costs. Thus, the availability of a sufficient amount of free funds of the organization or the possibility of attracting additional funding may become a factor for successful implementation.
3. For successful digital transformation, the management of the organization must provide support in order to link current processes, human resources and implemented technologies.
4. A success factor can be a detailed study of a plan or roadmap for the implementation of technologies. In order to ensure the consistency and coordination of the individual technologies being implemented, as well as to avoid the dissipation of resources, it is necessary

Table 6
The power of the barriers of transition from the pilot phase of Industry 4.0 technologies to widespread use

Independent indicators	Non-standard coefficients	Standardized coefficients
Constant (β_0)	0.201 (0.019)	
Economic/financial barriers		
The need to attract more investment FIN_{1i}	0.552*** (0.125)	0.561***
Lack of free cash FIN_{2i}	0.631*** (0.101)	0.640*
Managerial barriers		
Insufficient support from the management of the enterprise UPR_{1i}	0.478** (0.073)	0.491***
The need to change the business model of the company UPR_{2i}	0.061** (0.014)	0.065***
Inconsistency of the implemented digital technologies with the strategic goals of the company UPR_{3i}	0.148** (0.031)	0.159***
Competency based barriers		
Lack of qualified personnel able to implement/use digital technologies $COMP_{1i}$	0.317** (0.091)	0.323**
Resistance from the company's static organizational culture $COMP_{2i}$	0.231*** (0.037)	0.242***
Insufficient cybersecurity provision $COMP_{3i}$	0.198** (0.025)	0.205***
Regulatory barriers		
Lack of standards for digital technologies and directions for their development NPA_{1i}	0.167** (0.064)	0.176**
Lack of legal regulation of personal data and cybersecurity NPA_{2i}	0.078** (0.016)	0.095*
Need to update laws on contract system and procurement NPA_{3i}	0.108*** (0.033)	0.123***
Technological barriers		
Difficulty in implementing digital technologies $TECH_{1i}$	0.098** (0.013)	0.101***
Unpreparedness of the enterprise infrastructure for the introduction of digital technologies $TECH_{2i}$	0.246** (0.068)	0.255***
Corrected R^2	0.721	
Number of observations	173	

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

to develop an integrated implementation plan that is linked to the strategic goals of the company.

5. Resistance to change on the part of the employees of the organization has a significant impact on the success of the implementation of industry 4.0 technologies, and therefore, in order to overcome this barrier, it is recommended to implement a culture of support for the use of modern digital technologies in the organization at all levels.
6. In order to successfully implement technologies and their further effective use, it is necessary to form a high level of digital competencies among the employees of the organization, since the efficiency is influenced by the speed and quality of big data management and analysis, as well as the quality of information security tools application in the organization.
7. An important success factor is the infrastructural maturity of the organization. Implementation of Industry 4.0 technologies may require changes in the organization's infrastructure to increase the level of technical readiness for large-scale application of technologies.
8. Feedback and active participation of industrial companies in the formation of the regulatory framework and standards in the field of digital technologies can minimize legal and regulatory barriers.

For industrial companies it is necessary to conduct a comprehensive study of barriers for the transition from the pilot implementation stage of the fourth industrial revolution technologies to their widespread implementation . It can accelerate the spread of industry 4.0 technologies, as well as increase the success of their implementation and effectiveness.

5. SUMMARY AND CONCLUSIONS

The paper presents the results of a qualitative and quantitative assessment of the barriers to transition from the stage of pilot implementation of the fourth industrial revolution technologies to their widespread implementation.

A review of domestic and foreign literature made it possible to identify groups of barriers that impede the introduction of digital technologies in industrial companies, namely: economic and financial, managerial, competency-based, legal and technological. In-depth interviews with representatives of both industrial and consulting companies providing services, such as the implementation of digital technologies to enterprises in various industries, made it possible to verify and supplement the list of previously identified barriers.

At the next stage of the study, a quantitative assessment of barriers to the transition from the stage of pilot introduction of the fourth industrial revolution technologies to their wide implementation was made. The barriers with the greatest power of influence are the lack of funds, the need to attract a large amount of funding, as well as insufficient support from the management of the organization. According to the results of the analysis, the least significant barriers for companies include the difficulty of introducing new technologies and the need to change the company's business model.

In order to achieve a high success rate for the implementation of Industry 4.0 technologies, as well as their further effective use, a list of proposals has been prepared to overcome the barriers for transition from the stage of pilot implementation of the fourth industrial revolution technologies to their wide implementation.

The paper presents the results of a qualitative and quantitative assessment of the barriers to transition from the stage of pilot implementation of the fourth industrial revolution technologies to their widespread implementation.

A review of domestic and foreign literature made it possible to identify groups of barriers that impede the introduction of digital technologies in industrial companies, namely: economic and financial, managerial, competency-based, legal and technological. In-depth interviews with the representatives of both industrial and consulting companies providing services such as the implementation of digital technologies to enterprises in various industries, made it possible to verify and supplement the list of previously identified barriers.

At the next stage of the study, a quantitative assessment of the barrier influence to the transition from the pilot introduction stage of the fourth industrial revolution technologies to their wide implementation was made. The barriers with the greatest power of influence are the lack of funds, the need to attract a large amount of funding, as well as insufficient support from the management of the organization. According to the results of the analysis, the least significant barriers for companies include the difficulty of introducing new technologies and the need to change the company's business model.

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The article was submitted on 5.09.2021; revised on 21.09.2021 and accepted for publication on 10.10.2021. The authors read and approved the final version of the manuscript.

DOI: 10.17747/2618-947X-2021-2-170-177

Strategic decisions in the tourism industry based on Internet data collection technologies and their spatial analysis

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Abstract

The paper offers a look the new opportunities that open up in management in the context of the development of information technology. The aim of the study is to highlight the benefits of using technologies for collecting big data and spatial statistics for making strategic decisions in the tourism industry. In the work, using the example of the ski resort "Abzakovo", the technologies for collecting data on the Internet are shown, the spatial dependence of the data is assessed and conclusions are drawn that allow subsequent strategic decisions as to enterprises located in this territory. So are the government bodies interested in the development of this tourist zone. Thus, the analysis of the geography of the members of the "Abzakovo" group made it possible to single out a statistically significant spatial dependence of their age, which manifests itself in the neighborhood of the older members of the group near the resort. The results of the analysis of the rating of tourist infrastructure facilities in the area of the ski resort "Abzakovo" identified spatially related zones of low and high ratings.

Keywords: big data collection technologies, spatial statistics, tourism industry.

For citation:

Lakman I.A., Timiryanova V.M. (2021). Strategic decisions in the tourism industry based on Internet data collection technologies and their spatial analysis. *Strategic Decisions and Risk Management*, 12(2), 170-177. DOI: 10.17747/2618-947X-2021-2-170-177. (In Russ.)

Acknowledgements

This research was funded by the Ministry of Science and Higher Education of the Russian Federation (scientific code FZWU-2020-0027).

1. INTRODUCTION

"The flow of huge amounts of information from various structures containing knowledge of enormous value is growing at a high speed" [Shvedov, 2017]. In a competitive environment, the one that has the most complete information wins, hence, there is an ongoing process of searching for tools to collect and process emerging data. This applies to all industries and areas of activity, including the tourism industry.

The tourism industry is one of the most actively developing sectors of the world economy [Butenko, 2015]. Its development has an impact not only on the objects of tourist infrastructure, but also indirectly affects the transport sector, construction, light and food industries. Accordingly, both the owners of tourist infrastructure facilities and the authorities are interested in the development of tourism, since it has a positive effect on the inflow of funds, the development of the territory and its investment attractiveness.

The importance of this industry determines the interest for the research into the factors of its development. In the context of the evolution of big data, open data is attracting more and more research interest. Basically, these are reviews and ratings left by tourists on the Internet. The range of data sources, as well as the scope of research that use this information, is quite wide [Alaei et al., 2017; Bulgakov, 2018; Pigareva, Shevelev, 2018; Li et al., 2018; Ćurlin et al., 2019; Dombrovskaya, 2020; Chang et al., 2020]. The collected data is most often used for semantic analysis of texts, including identification of key points that are most important for clients [Alaei et al., 2017; Ćurlin et al., 2019], or "tonality of posts" [Bulgakov, 2018]. In some cases, the results are visualized

on maps [Adhinugroho et al., 2020; Chang et al., 2020]. However, there are very few studies providing a spatial analysis of these data, despite the fact that the modern development of technologies implies their geographical structuring. Moreover, Russia as a whole is characterized by their absence in relation to any research in the tourism industry. So, S.A. Tarkhov notes that research in Russia is reduced "not even to an analysis of the location of tourism, but to the study of the influence of various factors on the characteristics of tourism in a particular region or country" [Tarkhov, 2019], that is, they do not involve the use of spatial statistics tools.

At the same time, foreign literature deals with a rather wide range of issues which use these tools and models. For example, W. Lee, L. Pennington-Gray and J. Kim studied the impact of proximity to the beach, city center and airport on food safety in 308 hotel restaurants using geographically weighted regression [Lee et al., 2019]. M. Salas-Olmedo and the co-authors studied the spatial autocorrelation of tourism activity based on 234,159 tweets, compared them with the information obtained from the open data sources Panoramio and Foursquare [Salas-Olmedo et al., 2018]. S. Zhang, G. Zhang and H. Yu assessed the spatial patterns of tourism development in the Yellow River Basin in terms of the number of tourists (domestic and inbound) and tourism revenues (domestic and inbound) at the provincial and prefectural levels [Zhang et al., 2020]. In general, the list of such works can be quite wide, as well as the range of directions for using the obtained results.

In the case of businesses, this information allows them to make decisions on their business development, from simple marketing plans that take into account the geographical organization of customers, to the formation of expansion directions that involve the competitive environment and the hierarchy of tourist destinations.

If we talk about the state, then here the range of focus areas is also wide: ensuring security and developing recommendations for organizing activities near objects of attraction for the population (natural, cultural, etc.), creating infrastructure, attracting investments for the development of territories, etc. The connection of the results with the spatial location of the objects that form them is obvious, and its precise quantitative assessment in a specific situation allows you to make informed decisions.

The purpose of the study is to highlight the benefits of using big data collection technologies and spatial statistics to make strategic decisions in the tourism industry. To achieve this goal, the following tasks were solved: the review of data collection and spatial analysis tools, collection and evaluation of data from VK.ru and Google.com sites on the example of the Abzakovo ski resort, as well as generalization of the obtained results.

2. RESEARCH METHODOLOGY AND DATA

The tools used in this study can be divided into two groups: the first includes tools for collecting and structuring data, the second - analysis tools.

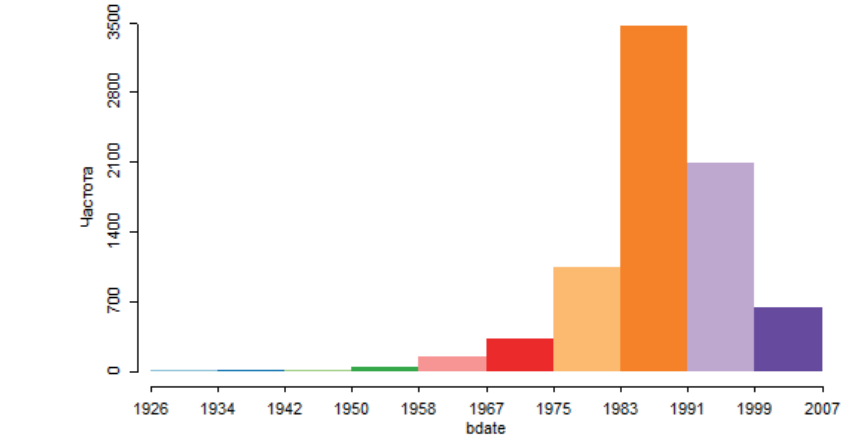
The collection of initial information often takes up the lion's share of the total time spent on research. When it comes to micro-level analysis (for example, about the operation of individual enterprises, about customer relationships), collecting information from external sources involves field research. Especially time-consuming is the survey required to understand the various behavioral patterns. At the same time, in the context of information technology development, when the population leaves data about themselves on the Internet and somehow evaluates the activities of enterprises, a number of questions can be answered even without this time-consuming method of data collection. The range of open data is quite wide, therefore, "with the development of information technology, more massive databases appear on Internet portals and sites, as well as tools (so-called parsers) to form samples with specified characteristics based on Internet data" [Trifonov et al. , 2020]. It is this tool, that was used in this work to collect data.

Parsing is defined as "automated collection of unstructured information, its transformation and presentation in a structured form" [Seliverstov et al., 2019]. "Parsing technologies allow to extract a large amount of actual data which is processed by data mining tools" [Dneprovskaya, 2020]. This tool has been actively used in Russia for the last five years, while in a number of foreign countries the results of its use were reflected in scientific works twenty years ago [Piccoli, 2001]. In general, it has a rather wide range of applications. In particular, it made possible to collect data for modeling the market value of a car based on car sales announcements [Trifonov et al., 2020], assessing the state of transport routes in the Northwestern Federal District of Russia [Seliverstov et al. applicants [Plotnikov, 2016] and electronic public procurement data [Tsyganova et al., 2020]. In the tourist sector, this collection method has been used to analyze hotel visitor reviews on Tripadvisor [Chang et al., 2020], traveler tweets [Alaei et al., 2017; Ćurlin et al., 2019], VKontakte [Dombrovskaya, 2020], Facebook [Bulgakov, 2018], Instagram [Pigareva, Shevelev, 2018], Yahoo [Li et al., 2018], etc.

For parsing, as a rule, specialized programs are used, as well as various libraries for Phyton and R packages. It should be borne in mind that large sites owing big data in demand provide access to it through the API[1]. In these cases, as a rule, their own specialized libraries are formed for each of them. In particular, within the framework of this study, the vkR, googleway libraries were used, and it was also required to connect the corresponding APIs,

[1] A set of software tools for working with data through HTTP requests.

Fig. 1. Histogram of the age of the Abzakovo group participants included in the analysis



из	1926	1934.1	1942.2	1950.3	1958.4	1966.5	1974.6	1982.7	1990.8	1998.9
к	1934.1	1942.2	1950.3	1958.4	1966.5	1974.6	1982.7	1990.8	1998.9	2007
#obs	9	6	13	41	136	326	1050	3484	2093	644
% от общего	0.1	0.1	0.2	0.5	1.7	4.2	13.5	44.7	26.8	8.3
sd from mean	-6.1	-5.2	-4.3	-3.3	-2.4	-1.5	-0.6	0	0.4	1.3

мин: 1926, макс.: 2007, медиана: 1988, среднее: 1987,52, с.о.: 8,699, #набл.: 7802

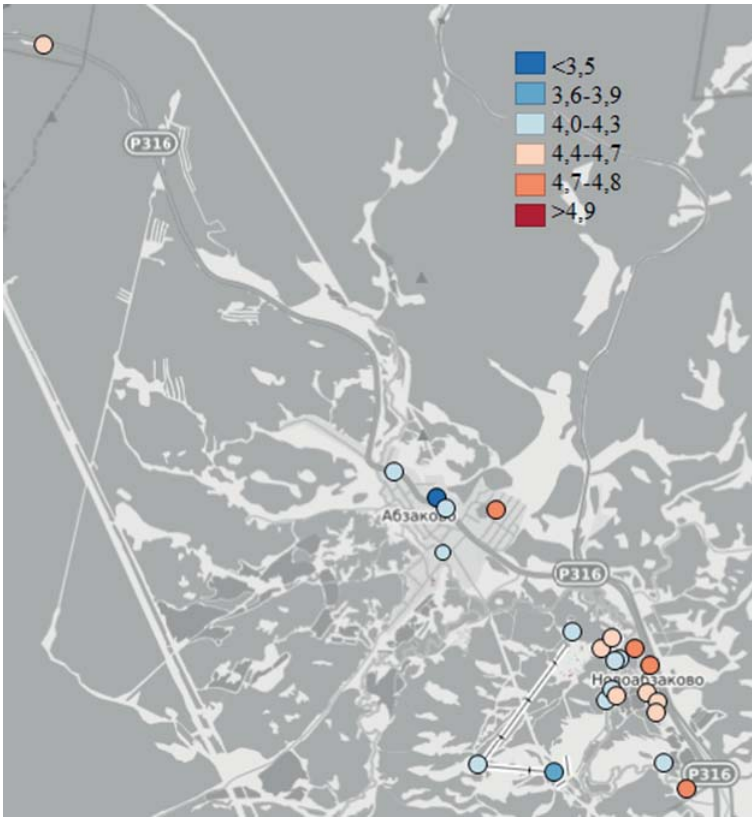
since both the VKontakte social network and the Google search engine have a clearly regulated set of ready-made classes, functions or structures for working with the available data. It should be noted, that the collection of data from sites as a whole does not break the law, if the owner of the site does not prohibit it in the robots.txt license, as, for example, in the social networks Facebook and Instagram, as well as in the Yandex search network. And if in Yandex the possibility of parsing is allowed in case of obtaining a license, including a commercial one, then Facebook currently strictly adheres to the policy of protecting users' personal data from any processing. The social network VKontakte also has restrictions on the collection, which are prescribed in the rules of the platform (clause 2), in some cases requiring consent from the site administration.

As part of this study, an analysis of the Abzakovo ski resort was made. It is located in the Ural tourist zone under construction on the territory of the Republic of Bashkortostan. In order to identify the spatial features associated with this resort, the Abzakovo group on the social network VKontakte[2], was analyzed, as well as the ratings of catering facilities and the location of the ski center in Google maps. Data collection was carried out in April, 2021.

The Abzakovo group in the social network VKontakte at the time of data collection consisted of 36,755 people, among which 54.6% indicated their affiliation to the female gender, and 19 people did not indicate or concealed their gender. 54.3% of all participants noted the city of their residence, 21.4% – the year of their birth. The absence of data on a number of participants is determined by the privacy settings they use, ranging from "all users see" to "only me". The geography of the group members is very wide, going beyond the borders of Russia. There are participants who marked their location in Abu Dhabi, Leon, London, etc. The analysis of the age of the group members was carried out only on 7802 observations in Russia (Fig. 1). It should be agreed that the reliability of these data is difficult to verify, and this should be taken into account in the analysis [Salas-Olmedo et al., 2018; Dombrovskaya, 2020]. Returning to the age of the group members, we cannot exclude the possibility that some of them overestimated their age due to age restrictions when registering on the VKontakte social network, some of the participants could underestimate their age or indicate the wrong date for some reason.

The data on 23 tourist infrastructure objects were taken from Google maps, including seven cafes, one restaurant,

Fig. 2. Ratings of accommodation and food facilities from Google maps



[2] Data collection was carried out with the consent of the group.

one canteen, fourteen hotels and holiday homes located in close proximity to the ski center in the villages of Abzakovo and Novoabzakovo, as well as on the P316 highway leading to Beloretsk (Fig. 2).

Data analysis was carried out by the most well-known method of spatial statistics and included the estimation of local Moran indices (LISA – Local Index Spatial Autocorrelation) [Moran, 1948; Anselin et al., 2002]:

$$L_{Imi} = N\frac{(x_i - \bar{x})\sum_i \sum_j w_{ij}(x_i - \bar{x})}{\sum_i (x_i - \bar{x})^2}, \quad (1)$$

where x^{-} is the average value of the indicator, w_{ij} is the spatial matrix, N is the number of units under study.

To analyze the spatial distribution of members of the VKontakte social network group and to analyze the ratings of infrastructure facilities, different matrices (w_{ij}), were used, taking into account the proximity of the i-th and j-observation objects. In the case of infrastructure ratings analysis, a simple first-order neighborhood matrix was used, built according to the queen criterion. In the case of the analysis of members of the social group VKontakte, a distance matrix with a radius of 0.4°. was used. The use of other types of matrices in the second case was impossible due to the nature of the data. Thus, the presence of cities with individual participants made it inappropriate to use a matrix of the type k – nearest neighbors, since in this case observations from other cities located at a sufficiently large distance could be taken into account as neighbors. In the cities with a significant number of participants, the neighborhood matrix, as well as the matrix of type k – nearest neighbors, did not allow us to cover the entire set of relationships that possibly exist between observations within the city.

When interpreting the results of calculating the local Moran's index, both the sign and the obtained value are important. At $L_{Imi} < 0$ there is a negative spatial autocorrelation, that is, the object of observation differs significantly from its neighbors (outlier) by this value. For $L_{Imi} > 0$ the spatial autocorrelation is positive, that is, this observation is similar to the neighboring ones (cluster) in this value. Based on the values of the local Moran's index and their statistical significance, cluster cores can be identified.

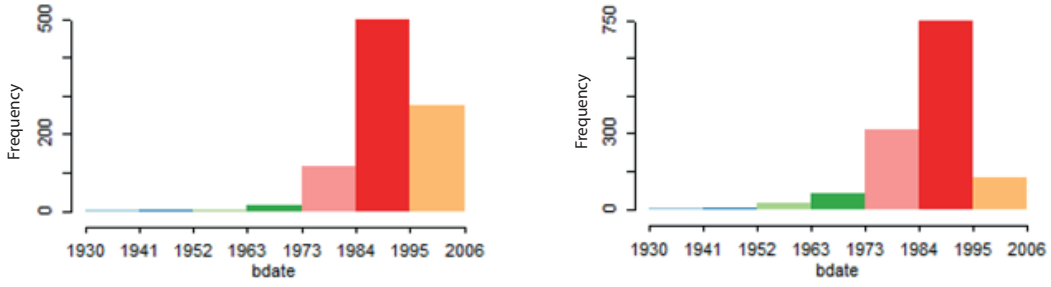
1. High – high – observations have relatively high eigenvalues of the analyzed indicator; they are surrounded by the observations with relatively high values of the analyzed indicator. The spatial autocorrelation is positive.
2. Low – low – observations have relatively low eigenvalues of the analyzed indicator; they are surrounded by the observations with relatively low values of the analyzed indicator. The spatial autocorrelation is positive.
3. High – low – observations have relatively high eigenvalues of the analyzed indicator; they are surrounded by the observations with relatively low values of the analyzed indicator. Spatial autocorrelation is negative.
4. Low – high – observations have relatively low eigenvalues of the analyzed indicator; they are surrounded by the observations with relatively high values of the analyzed indicator. Spatial autocorrelation is negative.

3. THE RESULTS OF THE SPATIAL ANALYSIS OF THE PARTICIPANTS OF THE SOCIAL GROUP "ABZAKOVO" BY AGE

The geography of the group members is shown in fig. 3. It should be noted that more than 70% of observations - group members live in the South Urals, that is, in the immediate vicinity of the ski resort. Most of the group members live in the city of Magnitogorsk (1271

Fig. 3. Local Moran's I for Abzakovo group members located in Russia

Fig. 4. Histograms of the Abzakovo group members located in Moscow and Magnitogorsk



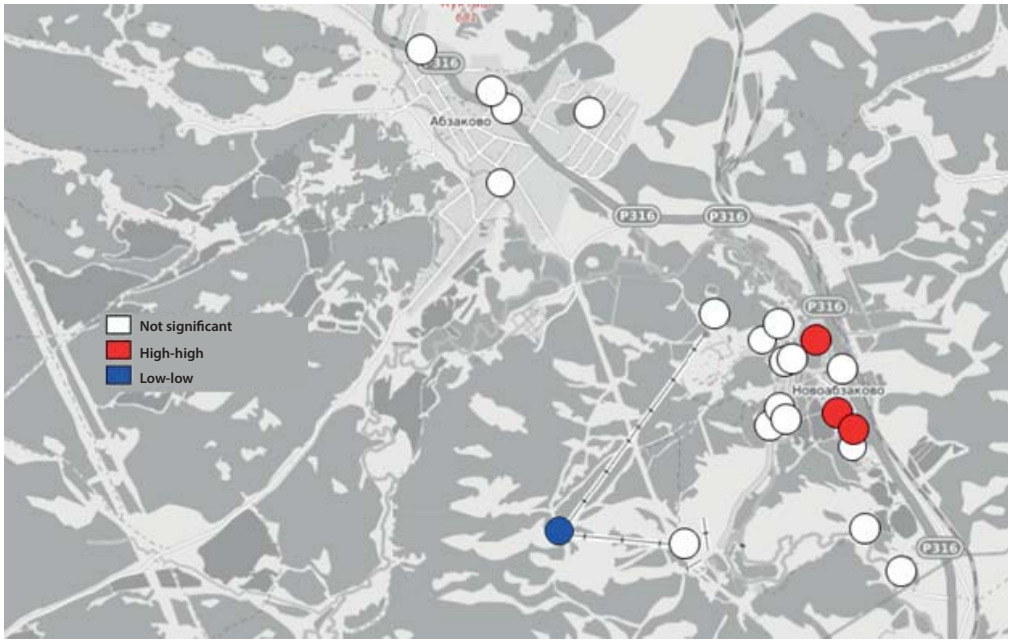
observations, or 16.3%), the next city is Ufa (952 people, or 12.2% of the surveyed participants).

The assessment of the local Moran's index showed that there is a certain (significant at $p < 0.05$) spatial relationship of observations, which makes it possible to identify individual cities (Fig. 3). Areas are in red, where observations with higher values of the indicator are adjacent to observations that also have relatively higher values of the indicator. With regard to the analyzed indicator "year of birth", we can say that in the zones in red, young members of the group predominate, and in the zones in blue, older people coexist with relatively aged people.

In general, these calculations can be confirmed by analyzing the age structure of participants in the context of each city. For example, with an equal range of birth years among group members (1930-2006 years of birth) in Moscow for 914 observations, the average value is 1991, the median is 1992, and in Magnitogorsk for 1271 observations, the average value is 1986, the median is 1987 (Fig. 4).

If you pay attention to the localization of blue dots, you can notice their concentration in the region of the southern Urals, in the immediate vicinity of the Abzakovo ski resort. This, in turn, indicates that proximity favors reaching older tourists. In the south and south-west of the country, red dots predominate, indicating that in these observation areas - group members have higher values of the birth year (that is, younger people against the entire set of observations), coexist with similarly relatively younger group members. Indirectly, this suggests that in these cities there may be groups with common values, including an interest in skiing. Objectively, when communicating, people pass the information about the resort "by word

Fig. 5. Local Moran's I for infrastructure facilities of the Abzakovo ski area



of mouth", contributing to the expansion of the circle of tourists in this age group. Such an understanding of the distribution features of potential customers in the ski resort determines the strategies for its promotion in various territories.

4. THE RESULTS OF THE SPATIAL ANALYSIS OF THE RATING OF TOURIST INFRASTRUCTURE FACILITIES IN THE AREA OF THE ABZAKOVO SKI RESORT

The geography of infrastructure facilities and the ratings they received on Google maps are shown in Fig. 2. It can be seen that the objects located directly on the skiing run and in Abzakovo are not very popular with tourists. However, spatial analysis allows you to evaluate the infrastructure from the perspective of the environment. Calculation of local Moran's indices made it possible to single out four statistically significant points. At the bottom of Fig. 5, a blue dot is clearly visible. It indicates that this object has low rating values and is surrounded by objects that also have relatively low rating values.

In Novoabzakovo, three red dots stand out, which are characterized by relatively high ratings. They are surrounded by objects that also have relatively higher ratings. Here, the emphasis is not on the rating of the object, but on the ratio of its rating and the rating of the environment, as well as the concentration of such objects in space.

5. CONCLUSION

At present, with the development of information technology, the range of data taken into account when making strategic decisions, can be significantly expanded. The emergence of open sources with unlimited information, which in addition is geographically structured, suggests a wide range of opportunities. In the framework of this study, a small example of such opportunities was presented, including the use of new technologies for data collecting, as well as their subsequent analysis by methods of spatial statistics.

The results of the geography analysis of the Abzakovo group members showed not only their predominant residence in the South Ural region, but also made it possible to identify a statistically significant spatial dependence of their age, which manifests itself in the neighborhood of older members of the group near the resort. The analysis results of tourist infrastructure objects ratings in the area of the Abzakovo ski resort showed that more rated objects are grouped in the eastern districts of the Novoabzakovo village, and spatially related low values are noted in the ski area. When analyzing infrastructure facilities, no statistically significant inverse relationships were identified. At the same time, during the analysis, they are of the greatest interest, focusing on objects with low values of indicators in comparison to the environment with high values, and vice versa.

Of course, further analysis of the reasons for this situation is required here. However, in the present work, such a problem was not stated. The key goal was to identify the opportunities that open up new tools that develop with the advent of big data. It should be realized, that in this case a small number of observation objects were analyzed. When moving to a larger number of observations, the speed of determining key points in space that require different approaches to study becomes extremely important, which can be obtained with new tools for data collecting and analyzing. In addition, an increase in the number of observations expands the possibilities of including more features in the models and contributes to an increase in the degrees of freedom in econometric models that determine the reliability of statistical estimations. It is necessary to note a number of shortcomings, in particular, inherent in parsing as a method of collecting data for analysis. First of all, this is the impossibility of verifying the accuracy of the information indicated by the participants in the personal profiles of social networks, as well as the subjectivity and artificial wrapping of ratings on interactive maps. The second disadvantage is the partial absence of information on a number of fields that are optional, as well as their hiding by privacy settings. It is also necessary to take into account that activity on the Internet is not characteristic of all people. Therefore, when analyzing the content of social networks and ratings, you need to understand that these are the opinions of people with a certain temperament, social type, etc.

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The article was submitted on 1.06.2021; revised on 9.09.2021 and accepted for publication on 27.09.2021. The authors read and approved the final version of the manuscript.

DOI: 10.17747/2618-947X-2021-2-178-183

Environmental risk management on the enterprise to realize green development

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Abstract

The environmental risk of an enterprise refers to the impact on the environment and possibility of accidents. In recent decades, the emerging industrial economies represented by BRICS countries have developed rapidly, which has inevitably led to increased pollution and deterioration of environmental quality in these countries. This chapter describes China, which has the fastest economic development among BRICS countries, as an example, and summarizes some evaluation and performance indicators of corporate environmental risk management, so as to facilitate the construction of a scientific and reasonable evaluation indicator system in our further research. The concluding paragraph briefly introduces several measures to reduce the environmental risks of industrial enterprises.

Keywords: environmental risk, environmental risk management, environmental risk assessment, sustainable development of enterprises

For citation:

Shanyi Ch., Murzin A. (2021). Environmental risk management on the enterprise to realize green development. *Strategic Decisions and Risk Management* , 12(2), 178-183. DOI: 10.17747/2618-947X-2021-2-178-183.

1. Introduction

The green development of an enterprise is of great significance for sustainable development, and the environmental risk of an enterprise is the key problem of green development. The environmental risk of an enterprise refers to the impact on the environment and possibility of accidents. Among the potential threats for the environment are emissions, wastes, and resource depletion generated during the production process. In recent decades, the rapid development of newly industrialized countries represented by BRICS countries has inevitably led to increased pollution and deterioration of environmental quality in related countries. There are more and more studies of the environmental risks on enterprises, especially industrial enterprises. In 2014, the GDP of BRICS countries accounted for 21.85% of the total global GDP, while carbon dioxide emissions accounted for 42.21% of the total global emissions. Global carbon project statistics shows that in 2016, Russia ranked fourth, Brazil and South Africa took twelfth and thirteenth place respectively [Xinjing, Baohua, 2018; National environmental protection.., 2019].

China's carbon emissions rank first in the world while India ranks third, indicating that there is still a lot of room for industrial environmental improvement. China's total environmental protection investment is continuously increasing, and its share of GDP has gradually stabilized by about 1.4%. During the tenth five-year plan period, the proportion was 1.16%, and during the twelfth five-year plan period, the proportion rose by 1.43%. Judging from the current international experience, environmental protection investment accounted for 1-1.5% of the country (region)'s total economy that year, indicating that the country (region) was only at the stage of basic control of environmental pollution. China's environmental governance goal is to improve environmental quality, that is, the proportion should reach 2-3%. It can be seen that the scale of China's environmental protection investments still needs further expansion. This article describes China, which has the fastest economic growth and the highest pollution rate

Table 1
Carbon emission efficiency of BRICS countries from 2010 to 2016

Country	Year							7-year average growth %
	2010	2011	2012	2013	2014	2015	2016	
Brazil	6.67	6.67	6.25	6.25	5.88	5.56	5.88	-11.77
Russia	1.75	1.79	1.82	1.92	1.92	1.89	1.92	9.62
India	3.13	3.13	2.94	3.13	3.13	3.23	3.23	3.23
China	1.41	1.39	1.45	1.54	1.64	1.79	1.89	33.96
South Africa	1.27	1.52	1.35	1.39	1.35	1.45	1.43	12.86

Source: [Xinjing, Baohua, 2018].

among BRICS countries. As an example, it has to introduce the concepts of industrial enterprise environmental risk, enterprise environmental management, and enterprise environmental regulation [Jingshuai, 2020; Yanxia, 2020].

2. Background

The concept of environmental risks has been mentioned earlier. Among them are different types of pollution risks: air pollution risk, water pollution risk, solid waste pollution risk, noise pollution risk, radiation pollution risk, and others. Air pollution is the most serious in various energy companies, especially thermal power and steel. Water pollution is the most serious in such industries as paper manufacturing, metal smelting, and chemicals. Several other major aspects of pollution are related to various industrial enterprises. Among them, thermal power, iron and steel, paper manufacturing, metal smelting, and chemical industries have several pollution characteristics at the same time and cause greater serious damage to the environment and the highest environmental risk.

Scholars have also conducted a research taking into account the idea of "environmental risk management → changes in enterprise production factors → enterprise competitiveness". They believe that environmental risk management has an impact on industrial economy and enterprise production not only at the macro, but also at the micro level.

1. Total factor productivity. Wang Bing and co-authors [Bing et al., 2008] used the "direction distance function" to analyze the relationship between environmental risk management and total factor productivity in many APEC countries and regions. He found out that the total factor productivity of industrial enterprises is higher in APEC countries and regions that implement environmental risk management, and environmental risk management has a positive and significant impact on actual output. Chen Kunming and co-authors [Kunming et al., 2013] analyzed the impact of different environmental risk management policies on the production efficiency of industrial enterprises through stochastic frontier analysis, and found that environmental risk management policies have a positive and significant impact on the productivity of industrial enterprises and there are obvious differences between these industries. Zhang Huiling and Sheng Dan [Huiling, Dan, 2019] conducted a research on production efficiency of industrial enterprises through front-end environmental pollution control and found out that front-end pollution control can effectively improve the production efficiency of Chinese industrial enterprises and is more suitable for small and private enterprises.

2. Production costs. Bing and co-authors [Bing et al., 2010] and Ye Xiangsong and Peng Liangyan [Xiangsong, Liangyan, 2011] used the environmental loss index method to measure the environmental risk management costs of various regions in China, and found out that most provinces in China have environmental risk management costs. They have greatly increased the production pressure of industrial enterprises. Wang Qunwei and Zhou Dequn [Qunwei, Dequn, 2011] used environmental risk management to calculate the costs in 28 regions of China. The study showed that many industries have greater pressure on environmental risk management costs. There are also drawbacks in the corporate economy.

3. Technological progress. Jie Wu [Solution chalk.., 2008] used DEA method to calculate the Malmqusit productivity index, technical efficiency and technological progress index of 31 provinces and municipalities in China from 1998 to 2004, and conducted an empirical research. The results show that an appropriate increase in pollution control investment and an appropriate reduction in industrial CO2 emissions have a significant effect on the progress of industrial productivity and production technology. Zhao Hong [Hong, 2008] examined the relationships between environmental risk management in various provinces in China and the R&D investment of industrial enterprises and the number of patents, and found out that environmental risk management has a significant delayed effect. The technological progress of Chinese industrial enterprises has a certain stimulating

effect vice versa. Li Qiang and Nie Rui [Qiang, Rui, 2009] also conducted an empirical study of the relationships between environmental risk management and technological progress, and found out that environmental risk management has a significant positive effect on the number of utility model patents developed by industrial enterprises. Zhang Cheng and co-authors [Cheng et al., 2011] conducted this analysis based on the industrial data of 30 provinces in China and found out that there is a U-shaped relationship between the intensity of environmental risk management and the technological progress of enterprises in the eastern and central regions, but this relationship has not been formed yet in the Western region.

4. Technological innovation. Huang Dechun and Liu Zhibiao [Dechun, Zhibiao, 2006] introduced technical coefficients into the Robert model, and found out that while environmental risk management increases direct costs for some companies, it also stimulates some innovations, which can partially or completely offset the cost of environmental risk management. Bai Xuejie and Song Ying [Xuejie, Ying, 2009] used a three-stage DEA model to analyze the impact of national environmental risk management on technological innovation in the thermal power industry in 2004. It is considered that the strengthening of environmental risk management can improve the overall efficiency of China's thermal power industry. At the same time, environmental risk management generally promotes technological innovation, but it is not applicable to all regions.

5. Production efficiency. Hu Angang [Angang, 2008] ranked the production efficiency of 28 provinces, municipalities and regions in China from 1999 to 2005 after the in-depth analysis of environmental factors, and found that there is a significant gap between the production Ranking efficiency that considers pollution emission factors and those that do not take it into account. Jing Weimin and Zhang Lu [Weimin, Lu, 2014] using the framework of biased technological progress and the development of China's green economy under environmental risk management, found that the continuous strengthening of environmental risk management will improve the efficiency of enterprise production to a certain extent.

6. Employment. Chen Yuanyuan [Yuanyuan, 2011] using mathematical models and panel data from various industries across the country from 2001 to 2007 proved that with the continuous strengthening of environmental risk management, employment in various industries will be better provided. Li Mengjie and Du Weijian [Mengjie, Weijian, 2014] compared the scale and substitution effect of environmental risk management on employment, and first proposed that there are a U-shaped relationships between environmental risk management and employment.

The research on corporate environmental risk can be divided into several aspects. The research lines of Chinese scholars mostly follow those of European and American scholars. Some start with environmental risk management, others - with environmental risk assessment. Strategy management is also taken into account. In terms of environmental risk management, Chinese scholars mostly use various industries for their research. China's industrial system is complete, and all major industries can find actual objects for research in China. According to the current pollution data in China, scholars mainly focus on thermal power, energy, chemical and heavy manufacturing. It is necessary to study the management of the enterprise itself, the environmental responsibility of the management of industrial parks, and the environmental management functions of the government. Most studies are based on China's actual national conditions and can propose targeted solutions to practical problems.

This chapter considers several aspects that can partially solve or reduce the environmental risks of industrial enterprises, but the academic circles have not yet come to a conclusion how to eliminate environmental risks. Taking BRICS countries as an example, their attitudes towards environmental risks of industrial enterprises are not the same as well. In case of China there are currently two major schools in the academic community studying corporate environmental management and environmental risk assessment: one studies natural sciences and conducts general research on environmental risk assessment. The questions of technological development and utilization, environmental pollution and prevention technology, clean production technology, etc. are discussed at the engineering and technical level. The second school is interested in social sciences, management (including accounting and auditing), economics, and law. Corporate environmental pollution and protection issues, such as corporate environmental management, economic evaluation of external environmental damage, accounting confirmation and measurement of related environmental matters, environmental auditing, environmental legislation, etc. [Pigou, 1932; Coase, 1960; Man, 2005; Xu, Zhifang, 2012] are the scope of its research.

This article attempts to demonstrate the problem from the aspects of management innovation as well as the perspective of technological innovation in environmental risk management.

3. Main focus of the environmental risk management

1. The task is to clarify the evaluation index system of corporate environmental management. On the example of China in many cases, the environmental management of enterprises lacks quantification and visualization. Therefore, companies need to use quantitative evaluation indicators, process scattered and fragmented information from the scientific point of view, and improve environmental risk management. And this quantitative standard should follow the five principles of systematics, importance, comparability, maneuverability, qualitative and quantitative combination in order to select evaluation indicators. At the same time companies should rely on the relevant research results of the corporate green or environmental performance evaluation indicator system. Compliance evaluation index system is recommended to use while taking into account the aspects of corporate system - environmental friendliness, energy

consumption, negative evaluation, and environmental cultural construction as the main measurement indicators.

2. Environmental risk management. The traditional cost-following theory believes that the improvement of environmental risk management will lead to an increase in the production costs of industrial enterprises, thereby giving the trigger to the growth of the industrial economy. Thomas Dean and Robert Brown [Dean, Brown, 1995] found out that environmental risk management will increase the production costs of industrial enterprises, while the rise in pollution control costs will lead to a decreasing costs in production. Consequently, the benefits for undustrial enterprises will grow. Pandej Chintrakarn [Chintrakarn, 2008] adopted the SFA empirical model, and found that environmental risk management did not improve the production efficiency of American industrial enterprises, but increased the pollution control costs and led to economic growth. Li Yunan and Li Ting [Yunan, Ting, 2012] agree that the effects of environmental risk management on industrial economic growth in various regions are different, and the gap is obvious. This is mainly limited by the industrial economic environment, industrial economic development status, geographical environmental conditions, and policy implementation in various regions. Therefore, in the context of continuous improvement of environmental risk management, in order to achieve sustained and stable growth of the industrial economy between regions, it is necessary to develop the environmental risk management and industrial economic development models suitable for each region's development.

Enterprise's response function to environmental risk management. Whether an enterprise conducts environmental management policy, the improvement of environmental management is the result of correlated internal and external factors. The environmental management decision of the enterprise can be described by the enterprise's environmental management reaction function. According to the analysis it can be seen that the external factors affecting corporate environmental management can be divided into two categories: government risk management factors and market factors. Management decisions have a key impact. Therefore, the environmental management decision of an enterprise can be described as the following environmental reaction function (ERF):

ERF = f(External factors, internal factors).

The specific content of external and internal factors in the environmental response function is presented in table 2:

Different influencing factors in independent variables will have different effects on the company's environmental management decisions: For some companies, environmental risk management is the main factor that affects the company's environmental management decisions, while for other companies, it comes from the pressure of competitors, the environmental management of upstream and downstream enterprises. The environmental pressure of residents in the district are the main factors that affect the environmental management decisions of enterprises. Among the various influencing factors presented in Table 2, the government environmental risk management is the most basic one. Since the environment has the characteristics of public good, it is difficult to imagine that enterprises will consciously carry out environmental management policy without environmental risk management as the basic point. Therefore, the reaction function of enterprise environmental management can also be called the reaction function of enterprise to environmental risk management, and other influencing factors are derived on the basis of environmental risk management.

3. Corporate environmental management strategy. This paper divides the enterprise's environmental management strategy into green supply chain strategy, green production strategy and green marketing strategy.

Table 2
Analysis of influencing factors of environmental risk management response function

Dependent variable	Industrial environmental management decision (necessity to conduct environmental management and the depth of environmental management)		
Independent variable	Type	Specific influencing factors	Factor analysis
	External factors	Specific impact on environmental risk management	Different types of environmental risk management, implementation status (indirectly dependent on economic development status), and degree of strictness of environmental risk management
		Market environment	The market structure, the degree of monopoly and competition, the position of the company in the production chain
		Social factors	Social environmental awareness, environmental pressure from customers and residents
		Competitor behavior	Relationship with competitors (whether competition or conspiracy exist)
	Internal factors	Enterprise technology status	Enterprise's production function, factor constraints, pollution control technology
		Corporate strategic positioning	Long-term vision is still necessary for quick success, based on domestic or international markets
		Management factor	Manager's ability, environmental awareness, etc.

Source: [Man, 2005].

- Implementation of the green supply chain strategy in order to achieve environmentally friendly stance at all the stages of enterprise activities. In the green management of the supply chain, environmental benefits, resource benefits, and environmental protection effects need to be considered comprehensively. When selecting cooperative enterprises, one can focus on companies with successful environmental management, intention to cooperate, build a strategic alliance for environmental management and control. Establishing a green supply chain strategy cannot only strengthen employees' awareness of environmental protection, but also promote the development of environmental management of other companies in the supply chain, and form a consensus on the green development of the entire supply chain. With the help of green production technology and taking into account the green development of the entire society, the output of three wastes in the production process can be reduced as well as resource consumption.
- Implementation of green production strategy. In the process of green production, enterprises can use new sources of energy to replace conventional energy, or reduce the use of conventional energy as much as possible, and carry out technological upgrading and transformation, introduce high-tech and advanced equipment, and promote the industrial upgrading and transformation of enterprises. When selecting raw materials for production, non-toxic materials should be chosen, and the amount of raw materials should be precisely controlled to reduce resource consumption. In the production process, of key importance is to simplify it, control the discharge of pollutants during the production process and use new technologies and processes to extend the life cycle of the product, so as to maximize the value of the company's environmental management and control measures.
- Implementation of green marketing strategy. Product marketing is the complete display of products to users in order to realize the benefits of enterprise products. The use of green marketing methods can shape a company's green and environmentally friendly image and reflect the green attributes of the product itself.

4. Limitations and discussion

Environmental risk management is a necessary prerequisite for modern enterprises to achieve sustainable development. The goal of scientific environmental risk management is to achieve ecological and green sustainable development of the manufacturing industry, which is in line with the basic trend of current global development. In the actual management link, the staff needs to take into account the local common natural disasters and the data about environmental quality status, sort out environmental problems, estimate possible hazards, and formulate corresponding prevention plans [Dongning, Changhui, 2005].

Since environmental risk management is beneficial to the development of the industrial economy or it restricting the development of the industrial economy, the solution to this problem is the key to the government and various industrial departments formulating and implementing specific environmental risk management measures. To explain the practical effect of environmental risk management on China's industrial economic growth, and to propose what environmental risk management policies must be adhered to in order to achieve a win-win situation for environmental protection and industrial economic growth are of key importance. The implementation of environmental risk management needs to be based on the status quo of regional development to ensure that environmental risk management is as small as possible to inhibit industrial economic growth. The research in this article still lacks empirical approach, which will be further proved by combining relevant models.

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The article was submitted on 5.04.2021; revised on 19.04.2021 and accepted for publication on 27.06.2021. The authors read and approved the final version of the manuscript.

DOI: 10.17747/2618-947X-2021-2-184-189
JEL O32, L67, Z2
UDC 796.022

Application of innovative digital products in sports industry

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Abstract

This article considers innovative solutions used in sports industry. Taking into account the importance for the consumer in the context of pandemic restrictions, as well as the presence of a large number of modern technological cases, the author focuses on fitness sector. The innovative solutions discussed in the study can be classified as follows: mobile apps; sensors; virtual reality. The analysis allowed the author to highlight the pros and cons of digitalization, determine the development trends of fitness industry, the specifics of its financial model and competitiveness. Despite the importance of automation, the author emphasizes the high role of "living" labor, the importance of which can be studied in further developments.

Keywords: sport management, fitness management, sport innovation, fitness innovation, digital sport, digital fitness.

For citation:

Solntsev I.V. (2021). Application of innovative digital products in sports industry. *Strategic Decisions and Risk Management,* 12(2), 184-189. DOI: 10.17747/2618-947X-2021-2-184-189. (In Russ.)

Acknowledgements

The article was prepared on the basis of the research project "Mechanisms for supporting projects in the development of digital high-tech areas", carried out at the expense of budgetary funding within the framework of the state assignment of the Financial University in 2021.

1. INTRODUCTION

The sports industry is unique with regard to the diversification of the organization activities that form it: professional and amateur clubs, media, bookmakers, equipment manufacturers, fitness and ski resorts – they all make money from sports by offering their unique products and services. These areas have been markedly transformed by digital technologies. In today's world, the use of wearables, big data analytics, social media, sensor technology and virtual reality has revolutionized the way sports are conducted, analyzed and improved. With the help of modern technology professional and amateur athletes, as well as coaches, can collect and analyze any data, improve training methods, avoid injuries and improve skills. Fans receive all the necessary information, purchase club products and consume content through applications. The authors [Rathonyi et al., 2018] identify four macro-domains that demonstrate the connection between sports and informatics: sports performance, sports club, event management, and fan experience. The most popular technologies used in the sports industry include mobile applications, augmented and virtual reality, big data, and social networks.

The sports industry has suffered the start of pandemic restrictions very painfully. The product of most of its participants implies (or rather, implied) personal contact with the consumer, and the lack of such an opportunity led to the inability to generate cash flow. However, as often the case in any crisis, business difficulties have spurred a change in business model and the introduction of innovative solutions.

Among many players in the sports industry, fitness equipment manufacturers have been the most successful in terms of revenue growth. At the same time, the fitness industry itself in a very short time has ensured the

introduction of a number of innovative solutions that combine the creation of applications, the use of virtual reality technologies, detectors and sensors. Given the wide range of new digital products, this study will focus on the fitness industry, which is an important element of the sports industry.

2. DIGITAL FITNESS PRODUCTS

The first and most obvious response to the pandemic was the active development of online training, which required an appropriate technological platform [Johnson, 2021]. By itself, remote training is not a new product. However, under conditions of restrictions, on the one hand, they have become the only source of income for coaches, equipment manufacturers and clubs, and on the other hand, they have entered a new round of development, taking into account the possibilities of modern digital technologies.

One of the main areas of work is mobile fitness applications [Gowin et al., 2015; Depper, Howe, 2017], which several representatives of the sports industry began to develop at once[1,2]. Firstly, these are the largest manufacturers of sports equipment: Nike, Adidas, Under Armor. Moreover, each company simultaneously develops several applications at once. For example, Nike offers the Nike Training Club app which contains personalized training programs, nutritional advice, and expert advice. A narrower running direction - Nike Run Club - can be integrated into this application when users are offered a number of programs with audio accompaniment. They are given the opportunity to receive information about the pace, location, distance, climb, heart rate and jogging segments; there is an option to set goals and ways to achieve it, a social network containing photos, statuses, stickers and the ability to compete with other users, sneaker data regardless of the brand.

Similar functionality is offered by the Under Armor app line: all training statistics are packed into infographics, routes for jogging; walking and cycling are offered, communities are created that unite not only individual regions, but also countries. There is synchronization with Under Armor running shoes, as well as with smart Apple, Samsung, Garmin watches, etc.

Under Armor is currently the most active in developing the idea of smart shoes. In 2018, the company released an innovative line of HOVR, and in 2019 introduced the HOVR Infinite model with a sensor that transmits data via Bluetooth to a phone or watch. The sensor is installed in the right shoe, is not afraid of water, does not require recharging and is integrated with the official Under Armor applications, transmitting the following information: distance, pace, foot angle, step frequency. Guided by this data, the application gives recommendations during the training, suggests and corrects lesson plans. If you don't take your phone or watch out for a run, the data will be synchronized after the shoes are close by.

Nike only makes their smart shoes for basketball. Adapt BB sneakers are self-tightening and fixed on the foot (automatic lacing). Management is carried out through a smartphone or a button on the sole. The app remembers your training and resting positions and adjusts your running shoes automatically. In this case, the mechanism requires regular recharging on a special rug.

Gadget manufacturers form the second competitive segment in this market. On the app side, Apple has been the most successful with its Fitness+ app for iPhone, iPad, Apple TV, and Apple Watch. Device integration lets you merge metrics collected with your Apple Watch and all your media. Group training allows you to bring together up to 32 people and arrange a competition in individual disciplines.

Finally, fitness clubs offer their applications. At the same time, they allow not only to register for training and pay for services. Among the functionality is health monitoring, which allows you to control the main indicators in real time, the development of individual recommendations for a balanced diet, social network functions and the possibility of competing with other club clients or between clubs of the same network. This direction is described the works of [Benetoli et al., 2017; Goodyear et al., 2017; Lupton, 2017; 2020].

A separate segment is manufacturers of trackers that monitor various indicators in everyday life and when playing sports [Schmidt et al., 2015]. For example, the American company Fitbit, Inc. specializes in bracelets, smart watches and Wi-Fi scales. All products are synchronized via a laptop or smartphone with the cloud, which allows you to share data with friends, arrange competitions and receive analytics of various levels. Google believed in the success of the project, which bought the project for 2.1 billion USD.

A significant problem with online training has always been the lack of feedback on the correctness of the exercises. The developers of the Onyx Home Workout App tried to solve it, which monitors the accuracy and number of repetitions using motion sensors and a smartphone camera. In real time, you can adjust the training program depending on the capabilities of the person and get feedback. At the beginning of 2021, the application (technology) was bought out by the Indian company Cure.fit, which offers customers a similar set of services.

Parallel technologies are used in yoga applications. Pivot Yoga offers training clothes equipped with special sensors when artificial intelligence compares the position of the student's and teacher's body in space. Zenia uses computer vision: the position of the body in space is

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recognized by the smartphone camera. You can train with a virtual instructor or join live classes.

Among the Russian fitness apps are Spotify, Fitstars and Welps, in which trainers post their workouts, and users can choose the ones they like for individual classes online, including via Zoom, WhatsApp, Telegram. Another WorkoutMe application allows you to plan and conduct workouts, as well as search for fitness partners around the world. The emphasis is on short sessions of one minute. In the corporate mode, the service makes it possible to create communities for employee training and reward the most active ones for sports achievements.

In fitness, their own marketplaces are also being created. Thus, the Fitmost application offers a single subscription for an affiliate program with several clubs, studios and centers. The user can choose a convenient time, location and type of training and pay for them with purchased points.

Domestic service Welltory helps to control health by analyzing heart rate received through wearable devices and processed by artificial intelligence. The application analyzes the level of stress and fatigue, helps to determine the optimal duration of sleep and choose the time for sports. The system works through a special heart monitor that clings to the ear and connects to a smartphone. Additionally, you need to put your finger on the camera of your smartphone.

However, training at home was primarily a necessary measure during the quarantine period. For most people, it is important not only to play sports, but also to communicate, and the functions of social networks cannot always replace live contact. At the same time, even the offline format is characterized by the monotony of the exercises performed, and new technologies make it possible to significantly diversify the exercises.

Many people come to fitness clubs with high motivation. However, initial enthusiasm is often limited to the first months. This is due to high membership fees, lack of time and the monotony of training [Rampf, 1999]. Information technology, computer games and virtual reality help to make training more fun and, therefore, attractive in the long term [Moritz, 2003].

One of the first companies to modify fitness equipment was the American Peloton. The main business idea that changed the company's business model was equipping simulators with interactive screens that allow online training and broadcasting of entertainment content. The company pioneered tech-based fitness and created streaming, which makes fitness fun, accessible, efficient and convenient, as well as built and strengthened social bonds that encourage consumers to be "the best version of themselves"[3]. The company positions itself at the intersection of fitness, technology and the media. The company's training library already contains several thousand original fitness and wellness programs. You can choose a program depending on the type of training, instructor, music genre, duration, equipment available, area of physical activity and level of difficulty. The income of the business is generated by the sale of simulators, as well as the recurring subscription income associated with them. In 2020, the revenue was 1,825.9 million USD, by 100% and 110% from 2019 and 2018. The company identifies the following factors that enhance its competitiveness and make the developed business model difficult to reproduce:

- production efficiency;
- original content;
- quality and safety of products;
- competitive price policy;
- market vision and innovative products;
- strength of sales and marketing strategies;
- brand awareness and reputation.

Another example of innovative fitness equipment is an interactive mirror for Mirror company trainings[4]. Its main advantage compared to Peloton equipment is its compactness. The width of the mirror is 56 cm, the height is 132 cm, and the thickness is only 3.5 cm. The technology itself works as follows: on the screen you can see a fitness instructor who is training and your own reflection, which allows you to work on improving your technique. Users receive personalized recommendations, can set specific goals and monitor their achievements. The mirror itself costs 1,495 USD, while the online training subscription costs 39 USD per month. The program includes strength and cardio training, yoga and barre training: a combination of ballet exercises, yoga and Pilates.

Today, more sophisticated technologies that use virtual reality are already applied. Interestingly, back in 2006, a concept with the simulator imitating flight was presented [Henneke et al., 2006]. Hand movements resembling a butterfly were chosen as training exercises. In this case, the user observes a flight simulation on a monitor or display mounted on the head. The adaptable resistance is provided by a mechanical and hydraulic system. Thus, the flight is perceived not only optically, but also tactilely.

The Munich-based startup Icaros GmbH proposed a similar project in 2015 – a simulator equipped with a VR helmet that allows you to simulate flying or swimming in a virtual race format. As seen in Fig. 1, the idea has changed somewhat, but the essence remains the same.

Martial arts uses HTC Vive technology - a virtual reality helmet that allows you to simulate a fighting ring. Thanks to the sensors on the helmet, you can fix the accuracy of the impact. The main limitation remains the measurement and transmission of the force of blows, which makes a live sparring partner indispensable. FitXR is developing boxing (no sparring, only punching) and dance training in virtual reality.

[3] Peloton Annual Report 2020. URL: https://investor.onepeloton.com/static-files/9595d9d3-9e56-40fe-bbce-07176ae274d6.
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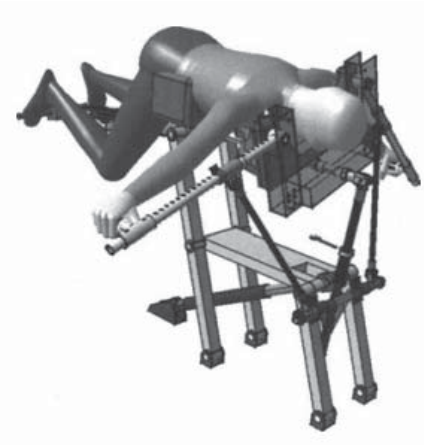
Рис. 1. Эволюция тренажеров, имитирующих полет
Fig. 1. Evolution of flight simulators



Тренажер FlyGuy (2006)
Источник:
[Henneke et al., 2006].

Тренажер ICAROS Health (2021)
Источник: URL: https://www.icaros.com/products/.

The Russian company SkyTechSport releases a smart punching bag that analyzes the movements of a boxer, the position of the legs and body, predicts his actions and evades punches. This functionality is realized by infrared sensors, as well as motion sensors installed in columns next to the punch bag.

The same company has developed a ski and snowboard simulator that imitates sliding movements and recreates the mechanics of movement. The simulator is capable of providing several levels of overload, and to enhance the effect; it is equipped with a screen that provides the effect of being on a mountain slope.

Another innovative skiing technology is the Carv Digital Trainer. Through insoles equipped with touch sensors, the system analyzes every movement and corrects the actions of the skier with feedback. The kit also includes an accelerometer, a gyroscope and a magnetometer that provides information about the movement and position of the skis. The tracker serves as a power source for the sensors. It also analyzes data and provides wireless communication with a smartphone. Finally, you will need earphones and a special application for your smartphone to work. The system allows you to analyze not only descents, but also tricks. The user can select a particular lesson according to his level of skiing, Carv will analyze the descent and give recommendations to improve the technique. In this case, the system itself can determine the level of skating and offer the desired program. The system tracks the movements and position of the skis, the nature and degree of pressure on them. All the information about the slopes is stored in the cloud in a personal profile; it can be compared with the results of other skiers and sent to friends or a coach.

Life Fitness and VirZOOM combine virtual reality with exercise bikes, offering to combine training with the following game areas: tanks, cycling, pegasus, air combat, western, rally, kayak. A similar project is being implemented by Holofit: virtual reality glasses are integrated into bicycle, elliptical and rowing machines. The user can select 3D views based on real and fantasy locations in nature, underwater and in space. The Zwift project offers several virtual worlds for cycling and running marathons at once. For example, in the summer of 2020, at the height of the pandemic, the company organized the first virtual Tour De France.

Kaaya Tech is developing a line of special HoloSuit suits that combine virtual reality with detectors and motion sensors. One of the company's offerings includes a training suit: every time an incorrect movement is made, the corresponding body part receives tactile feedback, which is used to passively teach motor skills, thereby muscle memory through virtual simulation is activated. The user's movements are recorded and stored: a detailed analysis can be carried out after the workout is completed. The program also generates reports of varying complexity, gives recommendations for correcting errors. The company simulates workouts for a variety of sports, including golf, cricket, and baseball.

Another manufacturer of smart clothing, Athos, produces shorts, breeches and long-sleeved T-shirts from a special conductive synthetic fabric equipped with sensors. The kit includes a wearable module with an accelerometer. All collected information is transmitted to the smartphone via Bluetooth. Sensors are used to monitor muscle fibers, breathing and heart rate. Through them, the technique of performing exercises is controlled, overloads are prevented. Experts note that clothing provides a higher measurement accuracy than watches or bracelets.

3. CONCLUSION

As a result of the analysis, innovative trends in the development of the fitness industry can be formulated.

1. Digitization of training and displacement of a live coach. A digital coach helps to set the right goals, offers a plan for achieving them and a schedule that takes into account the individual characteristics of a person, and sets motivational factors.

2. The high role of big data. Modern training is no longer possible without detectors and sensors that are integrated with smartphones and allow you to prepare a variety of reports.

3. Gamification. The competitive element has always been at the heart of the sport. Today, even such simple disciplines as running or exercises on the horizontal bar can be diversified with elements of competition with friends or app partners, and thanks to virtual reality, make them as exciting as possible.

4. Change in the financial model and redistribution of the market. Any innovation requires funding. Most modern technologies allow fitness clubs to save on operating costs: some classes are transferred home, which saves on rent and exercise equipment; classes are conducted by robots, therefore, the most expensive item – wages – is reduced. However, such modernization requires significant capital investments. It can be assumed, that in the medium term only large players with the appropriate capabilities will remain on the market. The market share of small clubs will move to "home" fitness. At the same time, the share of servicing and repayment of loan obligations will increase in the composition of the costs of players who remain in business.

5. Increasing competition. The variety of technological solutions makes the consumer more and more demanding of the final product. The best results can be achieved by a company that offers its customers the maximum possible range of services. Very soon, just online training with a detailed report and recommendations based on the results will not be enough, you will need to use a whole set of sensors, offer several virtual training scenarios, organize competitions not only with other clubs in the network, but also in an international format. By analogy with the previous paragraph, this trend leaves few chances for small players, and the one who can consolidate the available technological and marketing capabilities as much as possible will win.

So, digitalization is seriously changing the landscape of the fitness industry, making its product more diverse and interactive, but also requres serious investments and a quick response to changes. The main challenge in these conditions may be the preservation of human labor. Robots will better and more accurately monitor the training process, offer a new training program, nutrition and treatment faster. They will be able to train at any time of the day or night for an unlimited number of clients, and will not make mistakes or show inattentive attitude. However, one should not underestimate the importance of live communication, the need for an individual approach, the experience of a professional trainer, taking into account psychological characteristics and the specifics of human motivation by a person. These aspects can be considered in more detail in future studies.

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Research interests: sport economics, sport management, finance and investments in sports, development strategies for sport entities.
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The article was submitted on 12.10.2021; revised on 1.11.2021 and accepted for publication on 10.11.2021. The authors read and approved the final version of the manuscript.


ISSN 2618-947X
9 772618 947008