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战略决策和风险管理

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Proactive management education for a technological breakthrough

L.D. Gitelman[1]
A.P. Isayev[1]
M.V. Kozhevnikov[1]
T.B. Gavrilova[1]
[1] Ural Federal University Named after the First President of Russia B.N. Yeltsin (Ekaterinburg, Russia)

Abstract

The article reasons the need for changing the model of management education and corresponding tools and approaches to bring them in line with the challenges of a technological breakthrough and organisational transformations in the national economy that is going through an unprecedented overhaul of global economic ties and is restricted by sanctions. The authors suggest a paradigm of proactive training that is characterised by its focus on foreseeing changes by having a breakthrough research agenda, a quick conversion of research results into the educational content, research projects and activities, the flexibility of the content and formats of the educational process. The conceptual mechanism of a system for the anticipatory training of managers has been designed; potential methodologies have been identified for building educational modules for bachelor's and master's degree programs. By analysing the methodologies it was possible to develop a comprehensive approach to creating high-value educational products. The article describes some of the proprietary technologies that the authors use when implementing proactive education programs in practice.

The scientific novelty of the article lies in the formulation of the training concept for managers aimed at solving complex interdisciplinary tasks of a technological breakthrough. In terms of the practical value, the article presents a mix of educational technologies for the implementation of the concept. It includes electronic proactive leaning system, conveyor of continuous competence enhancement, digital modular architecture of the learning process, "module-in-module" technology.

Keywords: management education, proactive training, educational paradigm, technological breakthrough, proactive management, cross-disciplinarity, learning module.

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技术突破的积极主动管理培训

L.D. Gitelman[1]
A.P. Isayev[1]
M.V. Kozhevnikov[1]
T.B. Gavrilova[1]
[1] 俄罗斯联邦首任总统叶利钦命名的乌拉尔联邦大学（俄罗斯叶卡捷琳堡）

摘要

当前，国民经济处于全球经济关系和制裁限制前所未有的变化模式。本文章证实了改变管理教育的模式、方法和工具的必要性，以应对经济中技术突破和组织变革的挑战。作者提出一种积极主动培训的范式，其特征是：通过突破性的科学议程来预先料到变化，将科学成果快速转化为教育内容，设计和研究积极性，教育过程内容和形式的灵活性。已制定管理人员积极主动培训系统的概念机制。强调了形成本科和硕士生课程培训模块的可能方法。在此基础上，开发了一种有助于创

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造高价值教育产品的综合方法。描述了作者在积极主动培训的实际实施中使用的原始技术。
这篇文章的科学新颖性在于它提出了培训能够解决技术突破复杂跨学科任务的管理者的概念。实际意义在于为实施这一概念开发了教育技术系统，包括：用于积极主动培训的电子培训中心，管理专长持续发展的渠道，教育过程的模块的灵活架构，“模块中的模块”。
关键词：跨学科性、跨学科的专长、技术突破、管理教育、前馈控制、积极主动培训、系统工程，培训经理的方法论。

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该研究得到了俄罗斯联邦教育与科学部的支持根据“优先2030”战略学术领袖计划在以叶利钦命名的乌拉尔联邦大学发展框架内。

Introduction

Big changes are taking place in business, and they are associated not only with digitalisation, the introduction of artificial intelligence technologies and smart industries [Trachuk, Linder, 2020; Bogachev et al., 2022], but above all, with the ongoing tectonic shifts in the architecture of economic systems, the energy crisis, changes in supply chains in world markets, sharply tightened requirements for ensuring the reliability and environmental friendliness of production, cybersecurity. Undoubtedly, at the same time, ties with continuously updated information technologies will be strengthened, and breakthroughs will occur, as a rule, at the intersection of new knowledge in the field of IT, engineering, social and natural sciences [Brenner, 2018; Savastano et al., 2019].

The ongoing changes are no longer described by a linear paradigm, and the total human intellect does not yet have time to comprehend their complex dynamics. In such conditions, science is on the cutting edge of a breakthrough, and the management paradigm must be flexible [Gitelman et al., 2017], opening up a choice of opportunities, and, of course, aimed at the future, at anticipatory strategies. The manager is forced to become a researcher not only of problems and trends, but of trends in context change and a developer of new production systems. He must analyse the organisation as a metasystem and the external and internal tendencies and forces acting on it. He, more than ever, needs to anticipate changes in the near future in various areas of activity, which only yesterday only indirectly affected the functioning of the business, and begin to immediately prepare for them [Senge, 2011].

Breakthrough technologies will continue to rapidly penetrate even into traditionally conservative industries, radically changing the industrial landscape, business models and economics of enterprises [International trends.., 2015; Can the universities.., 2018]. An illustration of this trend is the volume of the world market of “pure” information technologies (for example, software). According to IDC, CompTIA and Gartner estimates in 2019, it was $3.8-4.0 trillion, and taking into account converged solutions and so-called emerging technologies, today the market can be valued at about $5-5.5 trillion [Minton et al., 2018; IT Industry Outlook.., 2019; 2022].

The very concept of an “industry” is expanding – its boundaries are moving and significantly expanding, new sectors are emerging, and competition is shifting to an inter-industry level [Porter, Heppelmann, 2014; Bessonova and Gonchar, 2019]. The main competitive advantage is no longer products as such, but the innovative systems and technological platforms that connect them [Pereira et al., 2018].

In this regard, management education is designed to link scientific research, design, innovation and training into an integral system. The authors call this educational paradigm proactive learning, the main difference of which is the focus on anticipating changes through a breakthrough research agenda and the rapid transfer of scientific results into educational content.

A number of previous articles by the authors [Gitelman et al., 2019; Gitelman et al., 2020b; Gitelman et al., 2020c]. In this study, the emphasis is on the mechanism and original technologies for organising educational work, without which, in reality, advanced learning is impossible. These technologies should solve the main task of a technological breakthrough - a large-scale transformation of the country’s economy, providing in a short time to obtain results in various industries and areas of activity that are qualitatively superior to existing ones.

1. Technological breakthrough as an object of advanced learning

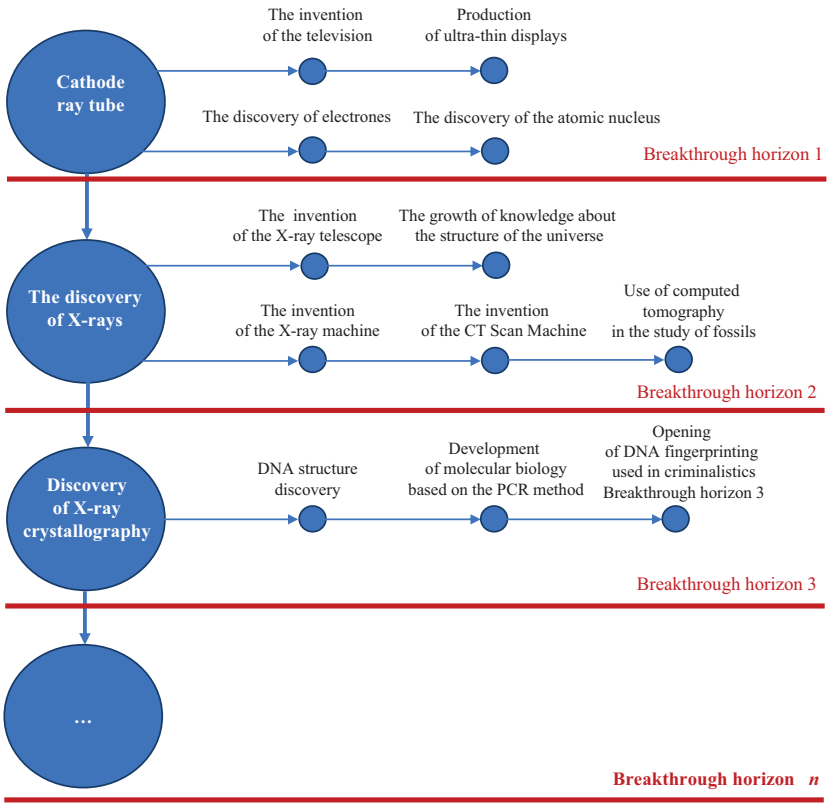
The authors understand a technological breakthrough as a systematically organised process of radical changes in the engineering and technical base of production based on the latest scientific and technological achievements. Of course, such a process can be carried out with accompanying transformations in the production, economic and social systems, that is, with an organisational breakthrough. A technological breakthrough implies the introduction of fundamentally new product, technological and organisational solutions, as well as the accelerated creation of the intellectual potential of a human resource for industries and sectors of the economy to enter the leading market positions, as a result of which the efficiency of activities is significantly increased: new markets are created, and existing industries are either transformed dramatically or disappear altogether [Edquist, Henrekson, 2006; Seba, 2009; 2014].

When a breakthrough is made, the role of science sharply increases, which should specify what the breakthrough will lead to (what new opportunities will open up), whether there are specific features of each of the stages of the breakthrough, how these features should be taken into account in engineering and management, and finally, what are the risks of uncontrolled development technologies and new systems leading to potentially negative socio-economic consequences [Falkenberg et al., 2022]. At the same time, science is called upon to perform three key functions:

1) to develop mechanisms for the search and selection of breakthrough innovative ideas;
2) to form methodologies for the implementation of a technological breakthrough;
3) to determine the most balanced format for the interaction of various areas of scientific knowledge in terms of their necessary proportions, organisation of their exchange, approbation of new solutions in practice [Brooks, 1994; Martinez, 2018; Byun et al., 2020].

The interdisciplinary nature of the technological breakthrough is illustrated in Fig. 1. So, X-rays, invented at the end of the 19th century and which became an undoubted breakthrough in medicine, are now widely used in non-invasive diagnostic methods, in particular in computed tomography, which, in turn, have found application in other

Fig. 1. A chain of technological breakthroughs caused by a sequence of scientific discoveries



Source: adapted from: Science and technology on fast forward. https://undsci.berkeley.edu/understanding-science-101/what-has-science-done-for-you-lately/science-and-technology-on-fast-forward/.

areas of science – archeology, paleontology , astronomy, physics. Another example is the discovery in the structure of DNA, which had a huge impact on the technological development of agriculture, biology, and ecology.

New scientific knowledge and technologies from different fields are thus deeply intertwined and feed off each other.

The creation of the concept and methodology of a technological breakthrough is the basis for the staffing of Russia's transition to the mode of accelerated innovative development. The problem under consideration has an extremely high social significance, which determines the state security of the country. Obviously, it is especially relevant for the basic infrastructure sectors of the economy and high-tech industries.

From a management standpoint, a technological breakthrough inherently requires proactive management actions, that is, proactive management [Gitelman et al., 2017]. Its organisation actualises a whole range of systemic problems, both in terms of technological and instrumental equipment, infrastructural innovations in terms of knowledge-intensive service, and, of course, profound changes in the training of managers – management education. This concerns, first of all, the increase in the role of fundamental knowledge and the flexibility of thinking [Gitelman et al., 2022b], interdisciplinarity [Gitelman et al., 2022a], and the introduction of anticipatory learning, which is significantly different from the traditional one.

2. The paradigm of advanced management education

Advanced education (training) is understood as an organised process of formation of knowledge and competencies to solve future problems that correspond to global trends and national development programs, taking into account modern realities: sanctions restrictions, breaking traditional economic ties, the need for import substitution, strengthening the security sector. The purpose of advanced training is to provide specialists with knowledge to work in the conditions of technical, organisational and economic systems created in the foreseeable future, based on new principles and functioning in an external environment characterised by increased turbulence and aggressive competition.

Anticipatory learning, unlike the traditional one, is focused on the formation of a different scale of vision, the ability to systematically take into account various industry, market and technological contexts, use tools for early diagnosis of threats and opportunities, apply interdisciplinary analysis and conceptual project synthesis, think and act strategically, preventing the emergence of crisis phenomena and ensuring the sustainable development of business, company and industry in the foreseeable future.

At the same time, the creation of an attractive research environment and an appropriate tool base for involving students in the full cycle of the innovation process is one of the first steps in building a system of advanced learning. Thus, advanced learning is impossible – and this should be emphasised – without a targeted research component integrated into the educational process: obtaining knowledge and competencies in context analysis, monitoring scientific and technological achievements, foresight forecasts of structural changes in the economy.

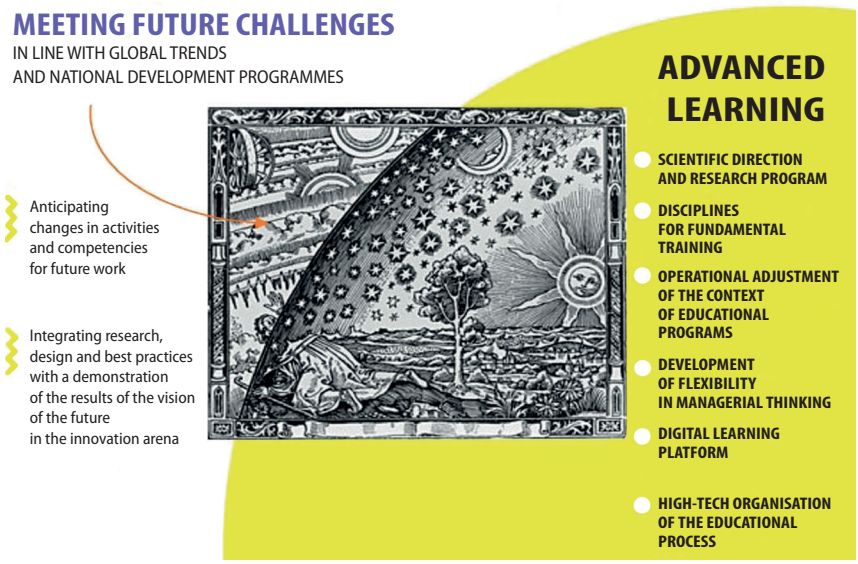
Advanced learning is carried out in an integrated scientific and educational circuit and sets the vector of knowledge aimed at creating a new image of the industry (company), embodying the advanced achievements of scientific and technological progress and organisational and economic innovations. An important emphasis in advanced training is placed on the mechanisms that protect the industry from external challenges and threats. Unlike the traditional training of managers to solve today's problems, advanced training aims to produce a new type of managers: innovative designers with the competencies of conceptual designers of new systems and their implementation in existing production. At the same time, it is important to emphasise that different categories of managers require different proportions of advanced and traditional training.

In this regard, anticipatory learning is focused on identifying the relationship between the current business situation, the prospect of its development and the image of the desired future. Without understanding these links, it is impossible to build a realistic picture of the future, and most importantly, without this, it is impossible to develop an effective plan for implementing a strategy to achieve it. The organised process of transforming a problematic and unstable situation into a qualitatively new one, organically integrated into the technological landscape being created, is one of the key clusters of abilities formed in advanced learning. The formation of such abilities presupposes the possession of skills for the priority use of intellectual and sociocultural resources in the systematic solution of innovative problems.

The objects of advanced learning are complex interdisciplinary problems that require the continuous generation of new knowledge. We will demonstrate them on the example of the electric power industry.

- Methodology for designing complex systems saturated with innovative elements: an electric power system with full automation of control and regulation up to the consumer, which has structural flexibility to introduce new elements based on the latest information technologies; a wholesale energy and capacity market with automatic protection against violations of the rules by market participants, with pricing mechanisms adequate to the efficiency of

Fig. 2. Visualisation of the proactive learning mechanism



generation, transmission and use of electricity, with a strong motivation to attract investment in new construction of energy facilities.

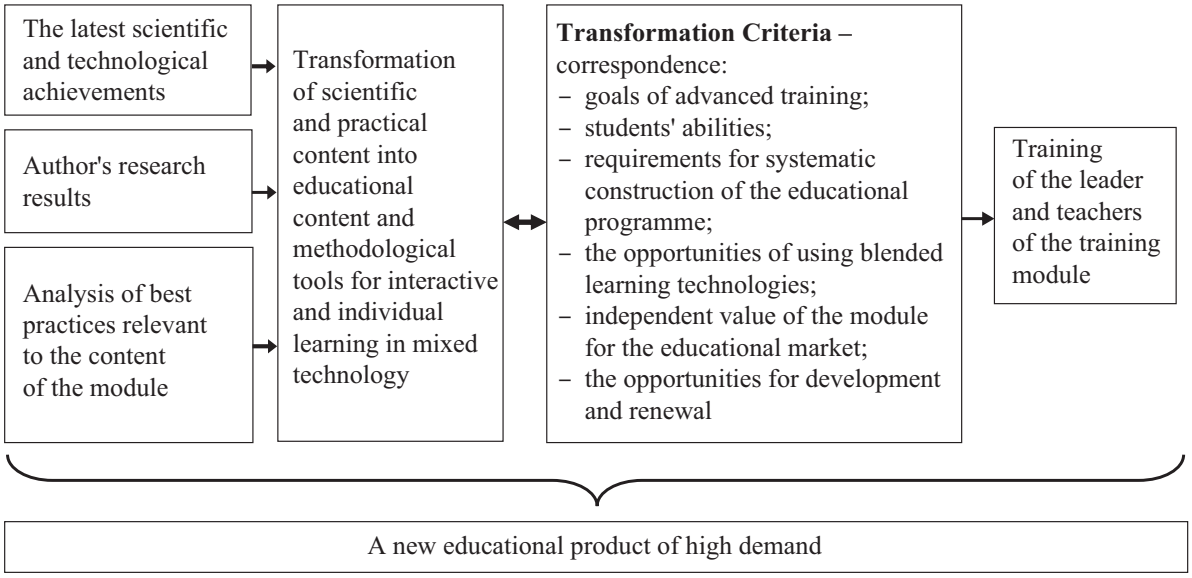
- Changes in the industry context, primarily in terms of global trends in scientific and technological progress and, of course, world-class problems - energy transition in the context of the global energy crisis and the necessary transformation of the electric and thermal power industry to fulfill the climate agenda: distributed generation, smart grids, safe nuclear power plants, economically competitive RES, polymodel concept of wholesale and retail electricity markets, interdisciplinary criteria (environmental, economic, energy) when making decisions on the development of energy systems.
- Forecasts of resource constraints and environmental turbulence: personnel, fuel, technology, financial and currency volatility, etc.
- Proactive management methods that neutralize the turbulence of the external environment, overcome resource and environmental constraints and stabilise the competitiveness (financial and economic efficiency) of the business.
- The quality of the human resource and its readiness for change.
- Leadership development, which sees a general shift from outstanding individuals to distributed leadership and collective intelligence that contributes to high results, as well as increasing the importance of a visionary approach based on global thinking and consideration of a wide context.
- Interdisciplinary teamwork involving specialists from different subject areas of science and practice in solving problems of increased uncertainty and complexity, including on the basis of virtual communications.

It is important to emphasise that the introduction of innovative management competencies into the educational programme of monitoring trends in technological and organisational development, foresight analysis, designing the future, strategic planning, the introduction of smart technologies and systems with artificial intelligence is not enough to create the effect of advanced learning.

The basis of advanced learning is a new significant component, namely the integration of research, design, best practices. In this regard, in order to create an integral system of advanced training for managers, it is necessary to:

- an educational and research complex based on a scientific direction and a research programme aimed at anticipating changes in strategy, organisational activities and competencies for future work;
- a block of disciplines for fundamental training, contributing to the formation of a systematic vision of changes in professional activity, understanding of upcoming changes;
- regulations for the operational adjustment of the content of educational programs in connection with the emergence of new knowledge;
- restructuring the methodological arsenal of all forms of training sessions and especially independent work to develop the flexibility of managerial thinking;
- a digital educational platform for the operational management of constant changes in educational content and the formation of individual learning trajectories;

Fig. 3. Organisational and methodological scheme for the development of training modules



- high-tech organisation of the educational process, updating educational products "to the task" (scientific and educational platform, conveyor technology, network of communication platforms, training complex with electronic courses, modular architecture) (Fig. 2).

3. Organisation of advanced (proactive) training

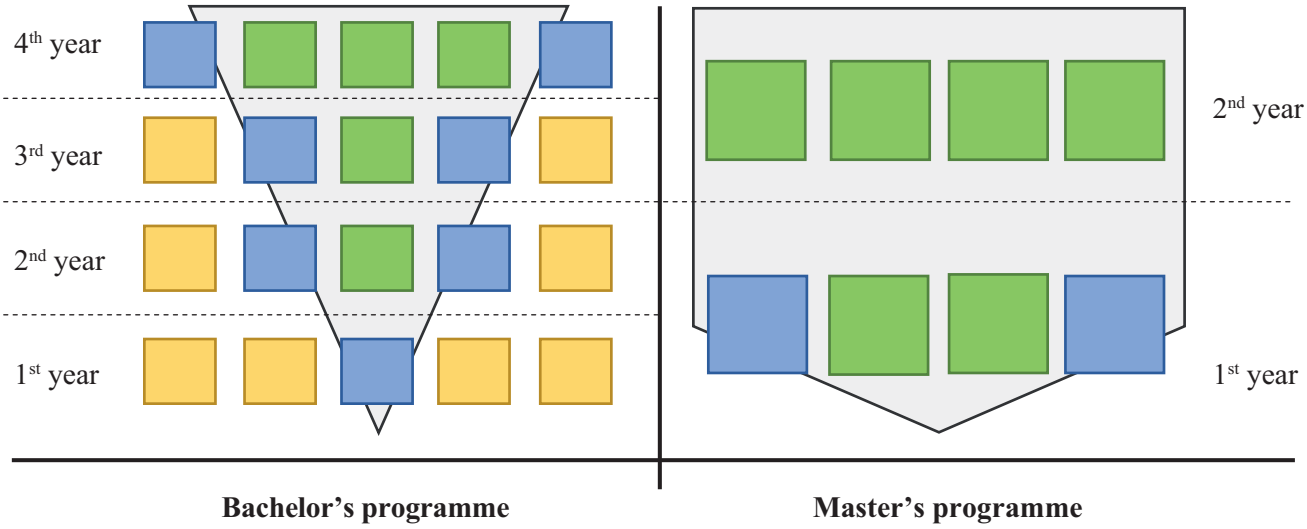
An important element of advanced learning is the modular architecture of educational products, which responds to the growing market demand in terms of customisation and flexibility of the educational process. It should be emphasised here that the formation of training modules in educational programmes is a certain methodological task that can be solved on the basis of different approaches and principles.

An analysis of the literature and the experience of educational activities allows us to identify three possible methodologies [Baranov et al., 2020; Gitelman et al., 2020a; Chantarasombat, Rooyuenyong, 2020].

1. Competence-based, currently implemented in federal state educational standards. The competencies that students need to master as part of the educational programme are grouped into the so-called learning outcomes. Each module corresponds to one or more learning outcomes. The disadvantages of the approach are its excessive rigidity and focus on fixing current rather than promising competencies.
2. Market. Based on the needs of the market and specific customers. Competences are important here, but they are secondary – promising areas of knowledge come to the fore, often in short supply, actually not represented in the educational landscape and in need of new teaching methods. This methodology requires constant interaction with practice, involvement of business representatives and qualified practitioners in the educational process. It has more novelty and relevance, it is more attractive from a commercial standpoint. Its shortcomings are the difficulty in finding highly qualified teachers and creating an educational project team.
3. Research. Modules are formed based on the scientific direction in which the project team works. Such an approach can be implemented if there is a strong scientific background and a mechanism for the rapid transfer of scientific results into educational content. This is the most difficult methodology to implement, but also the most in demand for preparing managers for the economy of the future. Among the advantages are a high degree of elaboration of the issues under study, a variety of options for project work, and an orientation towards breakthrough scientific and technological achievements. Cons – the research agenda does not always correlate with the current requests of the customer and the needs of employers.

For advanced learning, the most adequate approach to the formation of training modules is a comprehensive one, combining all three of these methodologies. The key elements of an integrated approach are shown in Figure 1. 3. These include: (1) authoritative research results on the profile of the module, available to its authors; (2) knowledge, competencies and scientific and

Fig. 4. Modular structure of educational programs
(triangle and pentagon designate areas of proactive learning content)



methodological groundwork for the transformation of scientific and practical content into educational content, the availability of proven tools for advanced learning. The first condition is ensured by the presence in the structural unit (it the department of learning, division) of breakthrough scientific areas and experience in their implementation for five or more years. The second condition is formed in the process of creating innovative educational products of a new generation, including digital learning technologies.

When developing and implementing a training module in the educational process, the following requirements are taken into account:

- interdisciplinarity, providing integration with other modules in the educational programmes of master's and MBA programmes;
- flexibility – the ability to adapt modules to different programmes and consumers;
- constant updating of content based on monitoring the scientific and educational environment, as well as the results of our own research;
- continuous improvement of technological and methodological tools for work in the module, increasing its relevance;
- instrumental and methodological equipment, which allows to adapt the educational work in the module to the needs and individual characteristics of the trainees.

The specifics of the modular approach in advanced learning ensures a dramatic increase in the quality of educational services due to the correspondence of training

Table 1
Examples of modules in educational programs implemented by the authors

Type of module	Bachelor's degree (programme "Management in energy and high-tech industries")	Master's degree (Programme "Innovation Management in the Digital Economy")
1	"Ideological foundations of professional activity", "Organisational and managerial decisions in professional activity"	—
2	"Strategic management of the organisation", "Fundamentals of energy business"	"Digital Economy Management", "Digital Revolution"
3	"Energy business development management"	"Management of the development of digital systems", "Consulting and engineering in the industry of the future"

Fig. 5. The device of the educational and training complex

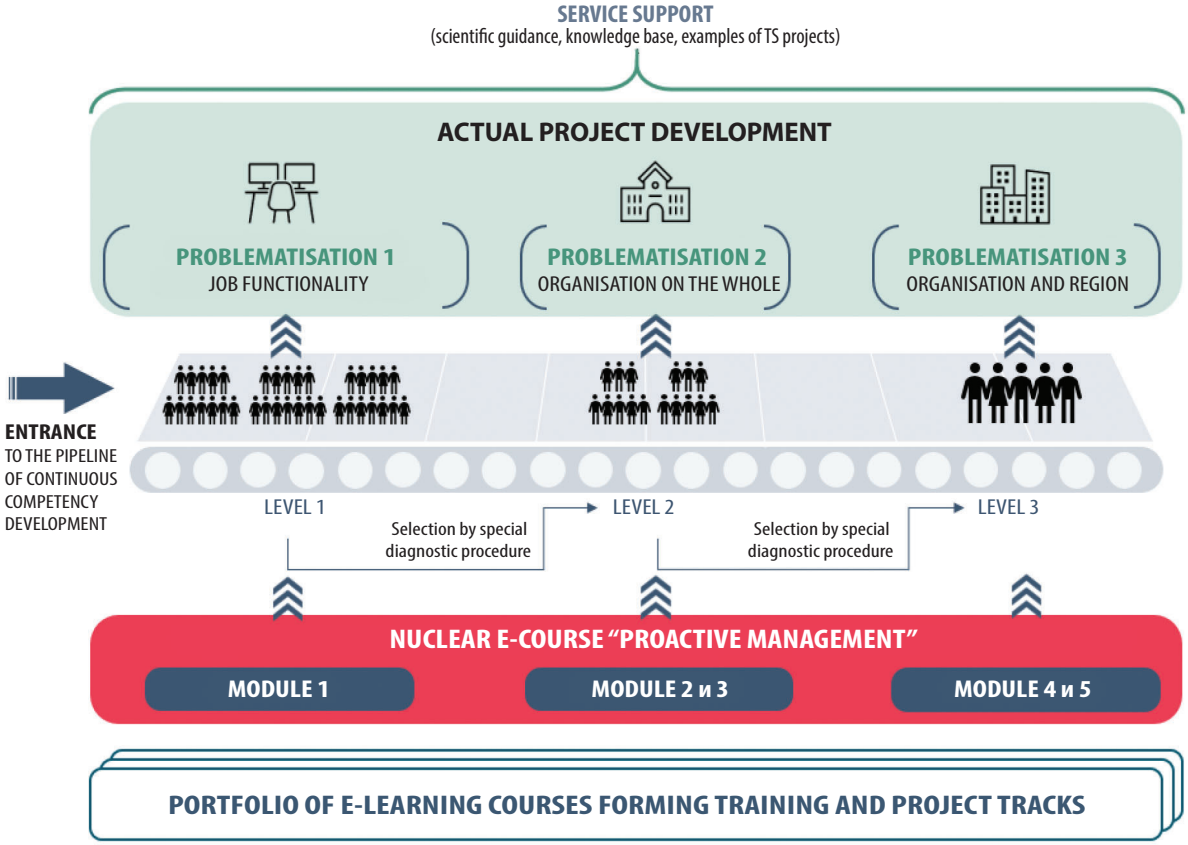
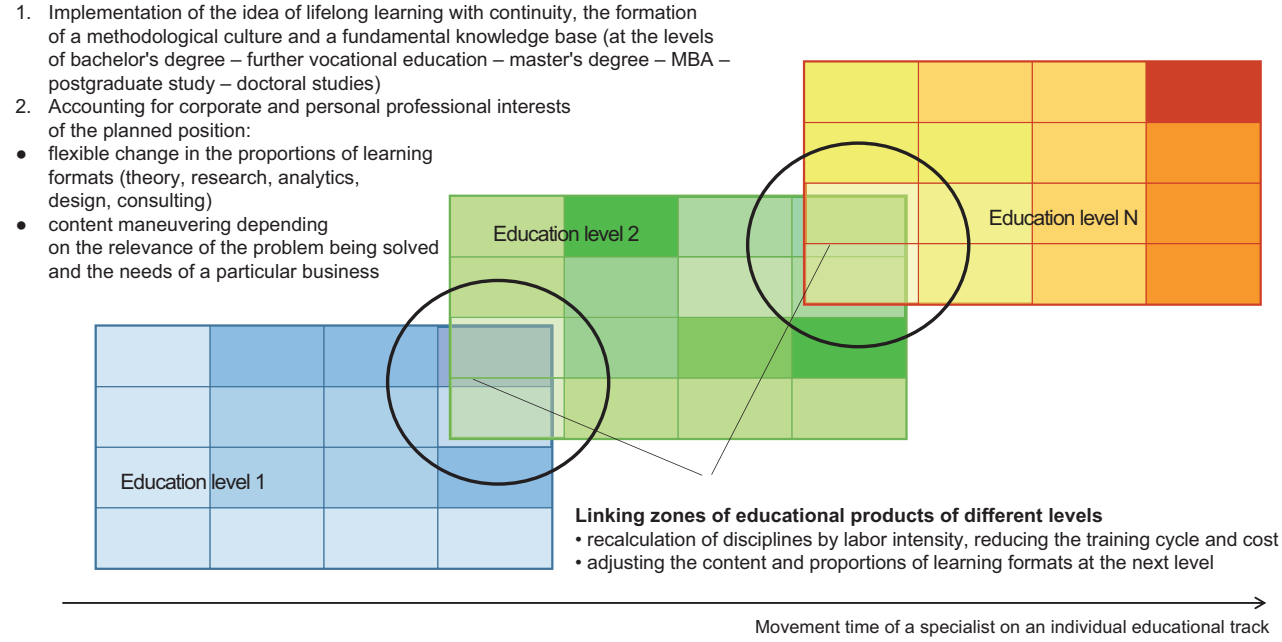


Table 2
Assessments of competencies by importance in practice

Competence	Average score	Rank
To implement proactive management actions based on early diagnosis of threats and opportunities	4.56	**1**
Ability to adapt and achieve results in a dynamic and uncertain environment	4.54	**2**
To assess the costs, risks and efficiency of resource use in the implementation of innovative projects	4.44	**3**
To perform multi-criteria assessments of design solutions and complex analytics of the problems being solved	4.38	**4**
To develop leadership strategies and organise proactive staff training	4.36	**5**
To develop integrated solutions at the intersection of management, engineering, economics, IT technologies and other areas of knowledge	4.33	**6**
The ability to adequately self-assess one's professionalism for solving non-standard tasks and continuous self-learning	4.31	**7**
To apply special methods to develop the company's vision for the future and business models	4.28	**8**
Ability for interpersonal communication, productive collaboration and teamwork in a digital environment	4.28	**9**
To organise technological modernisation processes and manage project portfolios	4.23	**10**

Fig. 6. The essence of the pipeline technology for continuous development of competencies



modules to current market needs, advanced scientific and technological achievements, and a greater ability to meet the interests of consumers of services through original tools. At the same time, an educational programme that implements advanced learning may contain three types of modules, the share of which in the total volume of the programme differs depending on the level of education (Fig. 4).

Modules of the first type (in Fig. 4 they are colored yellow) are aimed at the goals of educational standards that are not related to advanced learning. Modules of the second type (blue) are associated with both educational standards and advanced learning. Modules of the third type (green) are fully associated with proactive learning.

Thanks to this composition of modules, students develop knowledge of approaches to solving problems

Fig. 7. Examples of author's programs implemented in the pipeline logic

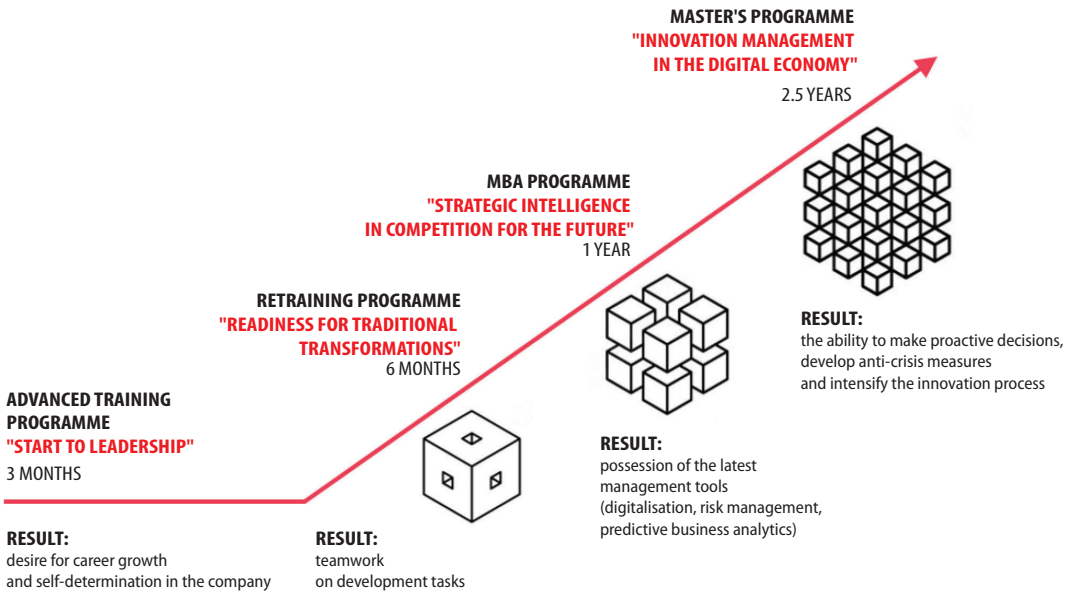
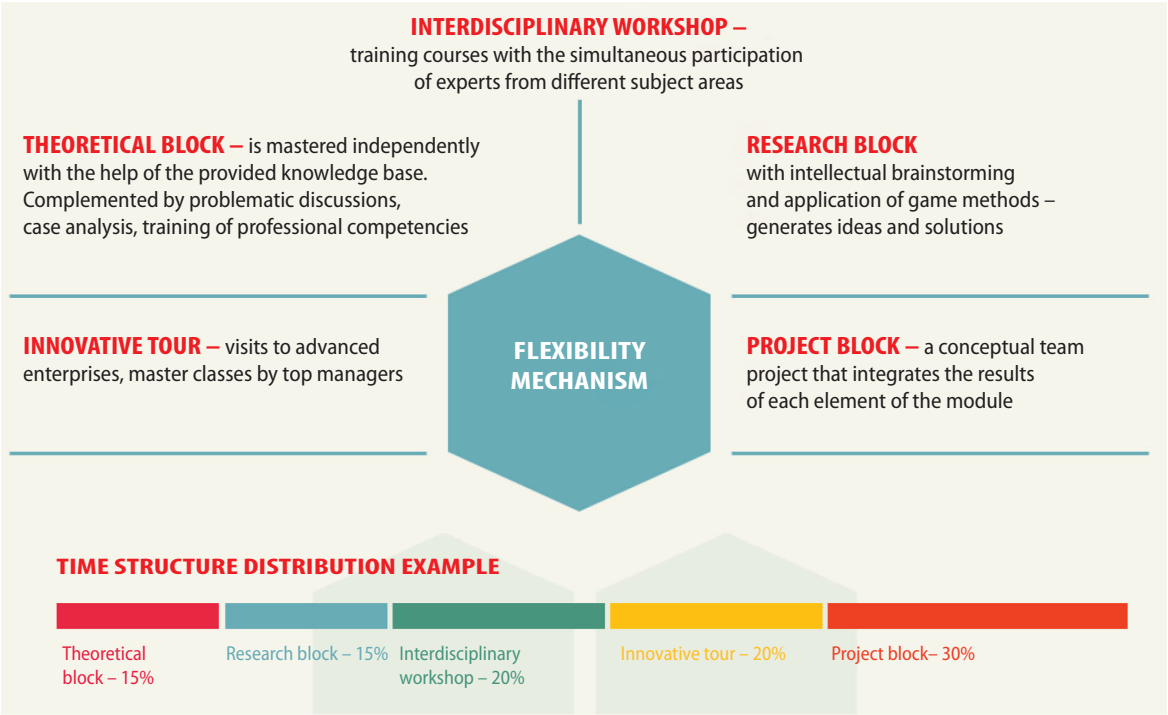


Fig. 8. "Module-in-module" technology



of current activities, the ability to explore and create a picture of the future, an understanding of the relationships and dependencies between the problems of today and the possibilities of implementing plans to achieve the future in accordance with its built image. Examples of modules of each type are given in Table. 1.

In addition, proactive training is a mechanism for the formation of a new self-awareness of managers, which is characterised by responsibility for their professional readiness to solve new problems and proactive actions in situations of emerging threats and new opportunities. As our research shows, achieving such a result is a difficult task for traditional training programmes. The results of a survey of qualified managers of a high-tech company with work experience and potential for professional growth showed that almost all of them verbally well understand the need for continuous (lifelong) training, but only 15% of them implement this understanding in specific plans and actions that reflect the internal need and level of professional consciousness. Students of the Master's Degree in Management, who are studying for the second year in an educational program with an integrated advanced training circuit, demonstrate higher rates in a similar survey – at the level of 54%.

In general, the experts we interviewed (both practitioners and master's students, 60 people in total) in the process of comparing the significance of different competencies for their professional activities on a 5-point scale give particular preference to the competencies of proactive training – predictive management, engineering, economic and engineering and management (Table 2).

To implement and develop the concept of advanced training, a new methodology for training managers is being formed, which uses the best practices of traditional training and develops new organisational and methodological tools, which are clearly insufficient so far. In this direction, the authors have developed a number of technologies used in the training of managers and breakthrough teams in large energy, industrial enterprises, and universities.

Electronic educational and training complex of advancing training. This is a system that integrates for users educational content, methods, information and service support for advanced learning, focused on the study of development problems and early management decision-making for non-standard situations of the future (Fig. 5).

Conveyor of continuous growth of competencies. The technology makes it possible to realise the idea of lifelong learning with the observance of the continuity of different levels of education, which is provided on the basis of re-credits of the material covered at the previous stages (Fig. 6, 7). At the same time, personal professional and

corporate interests, the planned position of the student are taken into account, and the content and formats of training can be flexibly changed in accordance with the specifics of the tasks being solved. Technology is the foundation for designing curricula that involve the development of several educational levels in a short time (bachelor's + master's, master's + MBA, master's + postgraduate), which corresponds to the practice of the world's leading universities.

"Module-in-module" is a technology that is an integration within one block of academic disciplines of various activities, the proportions of which vary directly in the course of training depending on the preferences of the students (Fig. 8).

The uniqueness of the technology also lies in the fact that it cannot be implemented without powerful service support. For example, to master the theoretical block, a digital knowledge base has been developed, which includes more than 50 textbooks, manuals, monographs and 300 articles by our team's teachers. As part of the project block, a special project repertoire has been created for students, which, in turn, is closely related to the research agenda of the breakthrough scientific direction "Proactive management in actively developing industries and sectors of the economy". Among the topics of the project repertoire there is an organisation of the strategic process in the digital environment, strategic intelligence of the organisation, readiness for systemic changes based on the design of the future, asset management under conditions of uncertainty, environment and competencies for a breakthrough to the markets of the future, breakthrough teams and systems for cultivating talented people and leaders.

Conclusion

The proactive learning paradigm has a significant potential for a variety of approaches and concepts for its implementation. It meets the new requirements for high-tech business leaders focused on technological breakthroughs and the creation of proactive management systems. The faster and more unpredictably the changes occur, the more acute the need for radical changes, the higher the demand for advanced training in the training of managers. In this regard, the relevance of advanced learning is so high that, in fact, it becomes a task of extreme national importance.

The transition from the traditional educational process to the advanced learning system is a complex and time-consuming task that requires:

1) expanding the range of goals for training graduates, including a qualitatively new composition of competencies and personal qualities;
2) creating educational programmes with an integrated contour of advanced training, providing a balance of the ability to solve current problems and promising problems of the development of the organisation in an unstable environment;
3) determining the content of training modules and disciplines based on an integrated approach that combines competence, market and research, to create a balanced composition of modules, taking into account their intended purpose;
4) development of a methodology for advanced learning, including the modernisation and adaptation of known methods to new educational content and the goals of preparing for proactive management, as well as the creation of special tools for organising educational, research and project work of students;
5) the introduction of a digital educational environment that increases the dynamism and flexibility of the educational process, its content and methodological development.

To successfully solve these problems, an innovative research environment with a baggage of significant scientific achievements and experience in organising search and conceptual design activities is required, in which students, interns, young scientists are easily involved, as well as a platform for partnerships with businesses interested in a breakthrough. All this requires considerable effort and creativity, but the intellectual and physical costs are fully justified, because, as the experience of the authors shows, a graduate of the advanced training programme is able to:

- quickly adapt to solving a variety of tasks of the management of the company's current activities;
- engage in the development of programs and projects for the vision of the future of the organisation and strategic planning for their implementation;
- be responsible for your level of professionalism and increase your readiness to solve new managerial tasks in line with development trends.

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About the authors

Lazar D. Gitelman
Doctor of economic sciences, professor, head of the Department of Energy and industrial management Systems, Ural Federal University Named after the First President of Russia B.N. Yeltsin (Ekaterinburg, Russia). WOS Research ID: AHB-8473-2022; Scopus Author ID: 55806230600.
Research interests: proactive management, organizational transformations, sustainable energy, management education.
ldgitelman@gmail.com

Alexander P. Isayev
Doctor of economic sciences, professor of the Department of Energy and Industrial Management Systems, Ural Federal University Named after the First President of Russia B.N. Yeltsin (Ekaterinburg, Russia).
Research interests: managerial professionalism, design of educational systems, programs and technologies, innovative leadership.
ap_isaev@mail.ru

Mikhail V. Kozhevnikov
Candidate of economic sciences, associate professor of the Department of Energy and Industrial Management Systems, Ural Federal University Named after the First President of Russia B.N. Yeltsin (Ekaterinburg, Russia). WOS Research ID: AAB-6693-2020; Scopus Author ID: 55805368400; ORCID: 0000-0003-4463-5625.
Research interests: knowledge-intensive service, innovative industrial development, management education.
m.v.kozhevnikov@urfu.ru

Tatyana B. Gavrilova
Candidate of economic sciences, associate professor of the Department of Energy and Industrial Management Systems, Ural Federal University Named after the First President of Russia B.N. Yeltsin (Ekaterinburg, Russia). Scopus Author ID: 57190430748.
Research interests: systems engineering, business analytics, information technology in management.
ems_2005@mail.ru

作者信息

Lazar D. Gitelman
经济学博士，教授，能源和工业企业控制系统教研室主任，俄罗斯联邦首任总统叶利钦命名的乌拉尔联邦大学（俄罗斯叶卡捷琳堡）。WOS Research ID：AHB-8473-2022；Scopus Author ID：55806230600。
研究领域：电力、热力行业能源业务，前馈控制，组织变革、管理教育。
ldgitelman@gmail.com

Alexander P. Isayev
经济学博士，能源和工业企业控制系统教研室教授，俄罗斯联邦首任总统叶利钦命名的乌拉尔联邦大学（俄罗斯叶卡捷琳堡）。研究领域：管理职业性，教学系统、程序和技术设计，创新领导力。
cap_isaev@mail.ru

Mikhail V. Kozhevnikov
经济学副博士，能源和工业企业控制系统教研室副教授，俄罗斯联邦首任总统叶利钦命名的乌拉尔联邦大学（俄罗斯叶卡捷琳堡）。WOS Research ID：AAB-6693-2020；Scopus Author ID：55805368400；ORCID：0000-0003-4463-5625。
研究领域：知识密集型服务业，产业创新，管理培训。
m.v.kozhevnikov@urfu.ru

Tatyana B. Gavrilova
经济学副博士，能源和工业企业控制系统教研室副教授，俄罗斯联邦首任总统叶利钦命名的乌拉尔联邦大学（俄罗斯叶卡捷琳堡）。Scopus Author ID：57190430748。
研究领域：系统工程，商业分析，管理中的信息技术。
ems_2005@mail.ru

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Evaluation of the DMDK GIS implementation results based on interviewing participants in the circulation of precious metals, precious stones and products made from them

L.N. Ivanova[1]
O.V. Umgaeva[1]
[1] Financial Research Institute of the Ministry of Finance of the Russian Federation (Moscow, Russia)

Abstract

The authors conducted a comparative analysis of the opinions of the target group of respondents to assess the results of implementing the state integrated information system of precious stones, precious metals. The results of the analysis are summarised, conclusions are formulated, proposals are developed that take into account the interests of both business and consumers, and in general, contribute to the implementation of an effective state budget policy.

Keywords: interviewing, questioning, precious stones, precious metals, information system.

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采用贵金属和宝石国家综合信息系统的结果评估，基于对贵金属、宝石及其制品流通参与者的采访

L.N. Ivanova[1]
O.V. Umgaeva[1]
[1] 俄联邦财政部金融研究所（俄罗斯莫斯科）

摘要

作者对目标受访者群体的意见进行了比较分析，以评估采用贵金属、宝石及其制品国家综合信息系统的采用效果。总结了分析结果，制定了结论，提出了兼顾企业和消费者利益的建议，并有助于实施有效的国家预算政策。

关键词：采访，调查，贵金属，宝石，国家综合信息系统。

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该文章在俄联邦财政部金融研究所进行政府任务的科研中编写的。

The creation of a unified information platform for the interaction of participants in the market of precious metals and precious stones is an urgent need for digital reality. Despite the adopted and current legislative acts regulating the sphere of circulation of precious stones and metals, it is possible to ensure the efficiency and thoroughness of their implementation only with the introduction of a full electronic document management. Moreover, such a turnover is intended not only to translate reporting into digital form; its task is to ensure full control at all stages of the circulation of precious stones and metals from the moment they are mined to the moment they are scrapped.

The unified state integrated information system for precious metals and precious stones (hereinafter referred to as GIIS DMDC), which began its work on March 1, 2022, along with refining, trading and other organisations of the business community, provides for the work of state control and supervision bodies, as well as other interested federal executive authorities[1]. An important factor in the introduction of the GIIS DMDC system is the protection of the rights of consumers of jewelry: the introduction of digital marking technology makes it possible to verify the authenticity of jewelry on the site. Thus, buyers of jewelry products have the opportunity to become participants, users of the system.

In general, the purpose of introducing an integrated system is to create an effective tool for ensuring the traceability of precious raw materials and goods, preventing the legalisation of counterfeit and fakes, and hiding income for tax purposes.

The functionality of GIIS DMDC is constantly expanding and being adapted by developers to the interests and needs of all interested participants. To understand the requests of participants in the circulation of precious metals, precious stones and products from them, the FRI of the Ministry of Finance of the Russian Federation conducted interviews and questionnaires, which are the most common methods of social research. In a generalised form, they can be defined as methods for collecting primary sociological information based on direct, in the form of an interview, or indirect, in the form of a questionnaire, socio-psychological interaction between the researcher and the respondent. The answers to the questions offered to the respondent provide the necessary information [Frolov, 2008].

The form of closed questions was chosen for the questionnaire. According to the methodology, such a survey has a number of types, from which a dichotomy was chosen – a variant containing only two answers: “yes” or “no” [Tatarova, 2002]. The generalised data of the questionnaire made it possible to reasonably approach the interview, clarifying why the majority of respondents gave one or another answer. This form of research was chosen consciously, as it most objectively reflects the process of introducing the GIIS DMDC system from different positions: mining, refining, production, trade, pawnshops, acceptance of scrap containing precious metals, control and regulation of the turnover process. When interviewing, as well as when questioning, the principle of confidentiality is respected, which increases the degree of its reliability.

As of July 1, 2022, 22,398 participants were registered on the GIIS DMDC platform. Of these, a surveyed sample of participants was formed: 311 respondents in 42 regions of the Russian Federation. The sample of groups is proportional to the lines of business in the area under study and, accordingly, is representative.

As of July 1, 2022, 22,398 participants were registered on the GIIS DMDC platform. Of these, a surveyed sample of participants was formed: 311 respondents in 42 regions of the Russian Federation. The sample of groups is proportional to the lines of business in the area under study and, accordingly, is representative.

Thus, 1.3% of the total number of DMDC registered on the GIIS platform was surveyed. This percentage ratio approximately (±0.8-3%) is maintained in the sample of survey respondents by type of activity. The largest group

[1] Official website of GIIS DMDC: https://dmdk.ru/about/.

consisted of retail trade organisations, the smallest – enterprises engaged in the extraction of precious stones and metals (Table 1).

Table 1
Distribution of survey participants by type of activity

Type of activity	Number of respondents	Percent of respondents (%)
Affination	7	2.3
Pawnshop	84	27.0
Production	73	23.5
Scrap recycling	37	11.9
Retail	110	35.3
Total	311	100.0

Source: compiled by the authors.

Most of the organisations and individual entrepreneurs (hereinafter referred to as individual entrepreneurs) were interviewed. 120 are registered in the Central Federal District (hereinafter referred to as the Central Federal District), which is 38.6% of the total number registered on the GIIS DMDC platform. As of June 27, 2022, 6704 organisations of the Central Federal District were registered on the platform – 29.9% of the total number of organisations, which is also proportional to the sample. Approximate proportions are also observed in terms of the timing of the implementation of activities. Most of the interview participants are organisations with extensive experience and an established understanding of economic processes, problems, prospects and effective directions for the development of the sphere of circulation of precious metals, precious stones and products from them (Table 2).

When sampling respondents, the organisational and legal forms of organisations are taken into account, which is important in the accounting and reporting system. It should be noted that in retail trade, the largest number of forms of registration is LLC, and in the purchase of office equipment scrap and pawnshops, the numerical advantage is for individual entrepreneurs (Table 3).

The variation of forms of taxation allowed businessmen to choose the most profitable form of activity for their field. At the same time, the choice of the form of taxation can be used as the basis for an analysis in order to find parity between supporting entrepreneurship and replenishing the state budget. The results of the survey confirmed that, despite the fact that only pawnshops, retail trade and acceptance of scrap office equipment work with individuals, there is a request to legalise the admission of individuals to the sphere of refining. In practice, this means that a small business, accepting metal alloys or scrap from individuals, without violating the law, is ready to independently produce and sell jewelry made of precious metals and stones. Today, only 8.3% of the surveyed manufacturers officially work with individuals, respectively, 91.7% of jewelry manufacturers and almost all refining organisations do not work. In our opinion, there is a reserve here for increasing production volumes and, possibly, legalising the production of precious metals and products made from them. The survey confirmed that the majority of craftsmen and individual entrepreneurs do not test their products during the production and alteration of jewelry by individuals and do not enter the GIIS DMDC system.

83% of all respondents believe that a necessary element for integrating programmes for accounting for their turnover on a single platform with subcontractors, controlling and regulating government agencies: 33.3% of refineries, 100%

Table 2
Distribution of survey participants by period of activity

Activity in the DMDC market	Number of respondents	Percent of respondents (%)
Less than a year	8	2.6
From 1 to 5 years	99	31.8
From 5 to 10 years	90	28.9
More than 10 years	114	36.7
Total	311	100.0

Source: compiled by the authors.

Table 3
Distribution of survey participants by organisational and legal forms

Organisational and legal form	Number of respondents	Percent of respondents (%)
LC	47	14.2
LLC	104	31.4
Sole proprietor	126	38.1
Production cooperatives	54	16.3
Total	331	100.0

Source: compiled by the authors.

of pawnshops, 81.3% of manufacturers and 70% of retailers. A sufficiently large proportion of positive responses is certainly a prospect for expanding the platform's capabilities and supporting business. The presence of negative answers is an element of misunderstanding of the platform by users. Therefore, the question is logical: "Do you understand the official website of the GIIS DMDC?" All respondents answered in the affirmative form. At the same time, the answers to subsequent questions indicate that, despite the clear interface, the task of technical support is not solved quickly enough. Visitors to the GIIS DMDC website are forced to look for the necessary information on other information resources.

Minor difficulties in registering on the GIIS DMDC website arose among 36% of respondents who did not properly prepare the constituent documents. Moreover, the largest share – 50% – belongs to representatives of retail trade, represented in all regions of the Russian Federation. Objective difficulties caused by the specifics of trade, requiring the input of commodity balances into the system, are known. Therefore, the deadlines for registration in the retail trade system were shifted.

It should be noted that 64% of the respondents, who noted the absence of difficulties in registering on the site, indicated the need for re-registration with an increase in activities or, for example, assistance in registration from allied colleagues, including employees of executive authorities.

94.2% of respondents contacted the technical support of the GIIS DMDC and other official websites of the participants. This is a lot, given the task of the system – the simplification and efficiency of accounting for the movement of products. A large percentage is also from the standpoint of work experience: almost all respondents are not beginners and are familiar with software products, own various digital tools. It is logical to conclude that there is no proper methodological explanation for various groups of participants. Indeed, the introduction of new tools always requires training and retraining [Blinova, 2017]. For the digital economy, this is also an objective reality, which is reflected in the relevant regulatory documents. The task of the scientific community is to support all areas of development of the sphere by methodological support of the adopted programme and, accordingly, regulatory documents.

65.3% of respondents found answers to their questions on the forum of the GIIS DMDC website (without contacting the support service). Cross-comparison with the answers to previous questions shows that the respondents who found answers on the forum are clearly less likely to contact technical support. The conclusions are obvious: there were many questions and they arose from users more than once.

Interest in the operation of the system was shown not only by the participants in the turnover, but also by state structures of control and accounting. Accordingly, explanatory work is carried out on their official websites. For an ordinary buyer, the opportunity to check the quality of the purchased jewelry is provided along with the official website of the platform and on the official website of the Federal Assay Chamber (hereinafter referred to as FAC). Actually, the very process of checking the quality of goods by a barcode is not new for Russians, and the pros and cons have long been known [Bogdanov et al., 2018]. FAC also provides technical support to DMDC turnover participants: 53.1% of respondents applied for it and received a response. The remaining 46.9% did not apply to the FAC website.

The same percentage of respondents is observed in requests on the official website of the Ministry of Finance of the Russian Federation: 53.1 to 46.9%. In fact, the information posted on the sites is duplicated, there are cross-references. At the same time, both sites lack summary information on the operation of the GIIS DMDC system, for example, the total number of those registered in the system, which complicates the design of any scientific analysis with mandatory references to sources. In general, requests to the websites of departments could be excluded by automatic redirection to the GIIS DMDC website, created to support the platform.

The analysis of the answers on interaction with the websites of the FAC and the Ministry of Finance of the Russian Federation predictably assumed a large proportion of statements – 41.8% of respondents - about the lack of technical and information support for the work of the GIIS DMDC platform. Pawnshops are most dissatisfied with technical support – 74.5% of respondents. This is explained by a large proportion of small enterprises and individual entrepreneurs working in this area of activity. As a rule, such organisations have a small staff, and the increased workload requires additional time and financial costs from them.

70% of participants agree to e-mailing about all system innovations. Based on marketing theory, this is a very good percentage. Taking into account the negative answers of the respondents and a large package of clarifications on the site forums by the participants of the GIIS DMDC system, this request should be satisfied, especially since an alternative form of support when working in the GIIS DMDC system (participant chats, articles in magazines, assistance from allied workers, etc. .) are used by 94.2% of respondents. This fact once again confirms the current request of the participants for clarifying the work on the new platform.

Simplification of workflow in connection with registration on the GIIS DMDC platform is noted by 10.6% of participants, which is a high proportion, given the large number of questions respondents have when working in the system. This fact should be emphasised when conducting explanatory work with participants in order to avoid hidden sabotage of the implementation of the software product.

Additional software products in connection with registration in the system or the need to improve its operation were purchased by 90.4% of respondents. Such a high percentage was due to 100% positive responses from representatives of the retail trade network and pawnshops, who were faced with the need to automatically enter product balances into the GIIS DMDC system.

Additional office equipment and other equipment in connection with registration in the system or the need to improve its work was purchased by 91% of respondents, which was caused by the need to create an additional workplace (s) and its equipment with office equipment.

In connection with registration on the GIIS DMDC platform, 54% of respondents said that their staff increased. It is logical to assume that the rest increased the workload of existing specialists or took advantage of the assistance offered, including paid assistance.

The increase in the turnover of funds in 7.1% of respondents from the moment of registration on the GIIS DMDC platform is associated with the competent activities of the enterprises themselves and the macroeconomic situation in the world and in the country, rather than with work in the system. Otherwise, it is logical to assume that the share would be much larger, especially in retail, which is, in fact, an indicator of consumer demand. This did not happen - trade showed an increase in only 20% of respondents.

Since registration on the GIIS DMDC platform, the turnover of marketable products has increased for 3.5% of respondents, again in the retail sector. Comparison with the previous answer means several things at once. Firstly, an increase in prices for certain types of products, since domestic jewelry manufacturers did not show an increase in their volumes. Secondly, this share is determined by the increase in imports[2] and the sale of balances to simplify (reduce) the volume of input into the system.

Summary data of the GIIS DMDC system by types of activity are of interest to 67.2% of respondents. Here, all groups of respondents are unanimous, being in constant competition and looking for new sources of economic growth to make a profit. The 100% positive response of representatives of refineries also reflects the search for stable suppliers of raw materials for uninterrupted work. The competition in this direction is the most acute, and the possession of information allows you to make forecasts and build production plans based on them. At the same time, 81.7% of respondents agree on the openness of their reporting data in the GIIS DMDC system for all registered users, which is surprising, but can be explained by the desire to have a comparative characteristic not only in their area of activity, but also for the entire set of organisations working in the DMDC sphere.

The GIIS DMDC system needs further improvement – 100% of respondents think so. This is explained not only by its shortcomings, but also by the prospects for work that the survey participants saw for themselves and which were clarified by them already during the interview.

Among the unresolved issues that make it difficult to work in the system, it is necessary to note those that are repeated by more than two respondents. The questions were grouped by topic and by type of the activity of the respondents.

Thus, refineries noted:

1) the impossibility of transferring the shipment of samples containing precious metals using the existing functionality, similar to the shipment of finished products;
2) frequent blocking of boilers when transmitting values of the chemically pure mass of precious metals according to the data of the refinery;
3) the impossibility of transferring the data of the calculation passport for several batches of incoming raw materials.

Specialised commercial organisations that provide loans to citizens on the security of their jewelry, as well as their storage on a reimbursable basis – pawnshops note among the problems:

1) the need to simplify the input of the balances of collateral and own reserves;
2) the problem of integration with the JewelerSoft software;
3) lack of step-by-step technological instructions.

Jewelry manufacturers face unresolved issues in terms of:

1) registration: when applying for special registration, the programme provides for one main type and two additional ones, all subsequent types of OKVED must be entered with the status “Other”;
2) lack of proper technical support and step-by-step technological instructions;
3) input of balances stored in warehouses and not transferred for sale.

The most time-consuming transition to work in the GIIS DMDC system, judging by the results of the interviews, turned out to be for retail trade organisations, which noted the following errors:

1) technical errors when filling in data for registration;
2) withdrawal of marked products from circulation;
3) labeling of commodity residues.

All three of the above groups of respondents note:

1) the inability to go to the websites in the personal accounts of the Federal Tax Service, the Federal Financial Monitoring Service, the Federal Customs Service;
2) the inability to transfer from the GIIS DMDC platform to the websites of the Federal Assay Office, the

[2] Russian jewelry industry state, problems and risks. https://uvelir.info/media/files/rossiyskaya-yuvelirnaya-promyshlennost-sostoyanie-problemy-riski.pdf?ysclid=la6ut5epor838639138.

Ministry of Internal Affairs of Russia, the Ministry of Industry and Trade of the Russian Federation and their integration;

3) a long wait for answers (up to a month) from technical support.

In the course of interviewing individual entrepreneurs in the type of activity "Collection, transportation, processing and disposal of waste of hazard classes I-IV", it was clarified that in this direction, under the current legislation, computer equipment, office equipment, household appliances and other equipment that has lost their consumer properties. As a rule, a small business with a stable reputation, established partnerships and, accordingly, extensive work experience operates in this area. The market is uncompetitive due to low profits. For example, the largest gross revenue of an individual entrepreneur for 15 years of operation amounted to 2,800 thousand rubles. Entrepreneurs seek to reduce production costs; the average number of employees in organisations with the specified type of activity is three people.

The specifics of the work is as follows: in the process of equipment recycling accepted for disposal, scrap of electronic circuit boards and other components containing precious metals is generated. Since the equipment transferred for recycling in 99% of cases is imported office equipment with a low content of precious metals, the income from the sale of scrap containing it is no more than 3% of the gross income of the enterprise. The gold content in the scrap of electronic circuit boards obtained from the dismantling of imported office equipment is within 0.01%, while refineries make payments at a gold content of 0.041% or more[3].

It is also necessary to note the peculiarity of the calculations: the cost of precious metals contained in imported equipment is not reimbursed to the customer due to their low percentage in scrap and high costs for their extraction. Another situation is with the old Soviet-made equipment that contains precious metals coming in for recycling. Precious metals in this case were put on a special account. To write them off the register, the customer needs a passport of the actual content of precious metals from the refinery. When accepting such equipment for recycling, the processor is obliged to transfer the received electronic boards and radio components to the refinery, provide the customer with a passport-calculation for the extracted precious metals and return the cost of precious metals. To fulfill these requirements, the processor needs an agreement with the refinery. Prior to the introduction of the GIIS DMDC system in 2021, the transfer of scrap to a refinery required only special registration with the assay office and registration on the Rosfinmonitoring portal.

Despite the complexity of the accounting system, there are no difficulties in registering in the GIIS DMDC system for entrepreneurs working in this direction; only difficulties in obtaining a license were noted [Grishin, 2018].

It should be clarified that entrepreneurs who have not received a license from the Assay Office due to objective reasons are not deprived of the opportunity to dispose of computers and office equipment. They have the opportunity to transfer electronic scrap to enterprises with a license for the processing of precious metal scrap, which, in turn, after additional processing, transfer enriched raw materials to refineries.

Offers from a business working with the collection and processing of scrap, which the authors support:

1. Placement on the official websites of departments of sample documents required to obtain a license would greatly simplify and reduce the cost of the process.
2. Operational transfer from the Arshin system to the GIIS DMDC. Today, when purchasing scales with a fresh release date, a license applicant may be faced with the need to wait until the verification data is reflected in the State Register of Measuring Instruments of the FSIS "Arshin". It is necessary to integrate the two state integration systems.
3. One of the possible ways to bring illegal mining and production out of the shadows is to allow the legal sale of electronic circuit boards and other electronic components containing gold and other precious metals to individuals – owners of Soviet-made equipment. The question is debatable, but relevant.

In the course of monitoring the responses of the participants in the GIIS DMDC system, the authors conducted comparisons with the sites indicated in the questionnaire, studied participants' forums, thematic articles in specialised journals. To assess the results of the interviews, consultations with interested ministries and departments directly working in the system were very useful. The Federal Assay Office (FAO) described the emerging problems in detail by operation. The information was worked out and included in the interview report.

For a wide range of researchers, it is necessary to note the slowness of the system when requesting general information necessary for departmental analysis. Actually, the search itself is difficult. For example, it cannot be carried out according to the given criteria. In the course of interviews with FAO specialists, shortcomings were also noted in terms of maintaining special records: the elimination of duplication in the event of the identity of the name or full name of the head, founder, the inability to change the organisational and legal forms of individual entrepreneurs and organisations already registered in the system. Also, the system must take into account that upon termination of activity, and then its resumption in the IFTS, the TIN of individual entrepreneurs

[3] Inventory of electronic scrap and secondary raw materials containing precious metals sent to JSC "Shchelkovsky Plant VDM". Official website of the Shchelkovsky VDM plant: http://zavodvdm.ru/wp-content/uploads/2019/10/opis-jel.loma.docx.

remains unchanged, while the OGRNIP changes. The working conditions of organisations are also changing. Their history is also impossible to trace on the site by regulatory authorities.

Based on the analysis of the survey work done, the authors prepared a number of proposals that complement the proposals of the respondents.

Thus, we believe that in order to improve the work of the GIIS DMDC system, it is necessary to organise the collection of proposals from participants around the clock with public reflection on the site and the possibility of commenting by users. Such a scheme of work is already being implemented, but the collection of proposals is inactive due to the inertia of the participants. Meanwhile, it is irrational to conduct such survey research on a regular basis by scientific institutions, even with the use of administrative resources.

The development of the digital space, the creation of state electronic systems in other areas allows not only to borrow successful solutions to programme problems, but also to integrate interconnected programs. We consider it not only possible, but also necessary to integrate the GIIS DMDC with the programmes of the following departments:

1. Federal Tax Service (FTS):
   – automatic pulling up of the exact location of a legal entity address from the Unified State Register of Legal Entities;
   – automatic pulling up of OKVED codes from the extract of the Unified State Register of Legal Entities / USRIE and their reflection in the special accounting card;
   – automatic replacement of pull-up OKVED codes from the USRLE/USRIE extract with OKVED codes with the necessary explanations/comments (if necessary) for special registration.
2. Ministry of Internal Affairs of Russia:
   – automatic check of the status of the passport of the Russian Federation, indicated by the individual entrepreneur / head of the legal entity;
   – checking and obtaining a criminal record certificate;
3. State information system "Typical cloud solution for automating control (supervisory) activities" of the Federal Financial Monitoring Service:
   – automatic pull-up of the necessary information for obtaining a license, making changes to the register of licenses, terminating licenses from GIIS DMDC to the Federal Financial Monitoring Service;
   – automatic pulling of information about the license from the the Federal Financial Monitoring Service to the register of licenses of the GIIS DMDC;
   – automatic introduction of changes to the register of licenses directly by GIIS DMDC – the Federal Financial Monitoring Service, excluding Public Services and Functions Portal, as is currently the case.

In order to reduce the burden on the jewelry industry entities that are members of the national anti-money laundering system, within the framework of fulfilling the requirements of the legislation, the federal service uses the personal account to: obtain a list of organisations and individuals in respect of which there is information about their involvement in extremist activities or terrorism, weapons proliferation mass destruction; a list of organisations and individuals in respect of which measures to freeze (block) funds or other property have been applied or should be applied; decisions of the interdepartmental coordinating body that performs the functions of combating the financing of terrorism. If there is integration between GIIS DMDC and the Federal Financial Monitoring Service, automatic information exchange is possible.

The "Arshin" and "Public Services" systems can become an interconnected platform, additional solutions are needed to integrate the "1C Accounting" programme into the system, which today employs almost all financial workers in the studied area.

The proposed integration must be carried out promptly, in accordance with the requirements of business and the interests of the state. It is clear that for the further development of information platforms it is necessary to attract commercial developers. Even now, in periodic electronic articles published on the websites of the Jewelry Trade Navigator, Jewelry Portal Service, etc., paid options for solving emerging problems and additional software to facilitate work in the GIIS DMDC system are offered[4]. Considering the large number of small businesses, individual entrepreneurs with small turnovers and a small staff of employees working in such areas as scrap collection, pawnshops, trade, a cardinal solution is needed that corresponds to the task of supporting small businesses. In fact, this direction requires additional theoretical study on the part of the scientific community and practical proposals for their implementation.

The results of the interviews can be useful in the development of guidelines, user manuals, step-by-step instructions, etc. documents designed to simplify the use of GIIS DMDC for participants. At the same time, the results of the interviews clearly demonstrated the demand of users for the digitalisation of processes, the facilitation of the document flow of organisations, the hope for the possibility of making more accurate forecasts for the development of their own business. An analysis of the responses allowed the authors of this paper to conclude that the system needs to be adapted as soon as possible to the current demands, including from the state and executive authorities operating in the interests of all Russian citizens.

[4] Outline: CA. https://kontur-ep.ru/support-dmdk?utm_source=yandex&utm_medium=organic&utm_from=adv-link-enquiry-ca-25290-4108; JewelerSoft. https://uvelirsoft.ru/blog/registratsiya-v-giis-dmdk-lichnyy-opyt/?ysclid=l8j3fhq3fy158059644.

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About the authors

Ludmila N. Ivanova

Candidate of economic sciences, head of the Center for Research in the Field of State Regulation of the Precious Metals and Precious Stones Industry, Financial Research Institute of the Ministry of Finance of the Russian Federation (Moscow, Russia).
Research interests: turnover of DMDC and products made from them, state budget policy.
lyudmila.iv08@mail.ru

Olga V. Umgaeva

Candidate of economic sciences, associate professor, leading researcher, Center for Research in the Field of State Regulation of the Precious Metals and Precious Stones Industry, Financial Research Institute of the Ministry of Finance of the Russian Federation (Moscow, Russia). SPIN-code: 6978-6926.
Research interests: regional, sectoral economics, territorial planning, theoretical foundations of economics, budget policy.
umgaev@yandex.ru

作者信息

Ludmila N. Ivanova

经济学副博士，俄联邦财政部金融研究所贵金属和宝石行业政府监管研究中心主任（俄罗斯莫斯科）。
研究领域：贵金属和宝石及其产品的营业额，国家预算政策。
lyudmila.iv08@mail.ru

Olga V. Umgaeva

经济学副博士，副教授，俄联邦财政部金融研究所贵金属和宝石行业政府监管研究中心主要科研人员（俄罗斯莫斯科）。
研究领域：区域经济，分支经济，空间规划，理论经济学，国家预算政策。SPIN-code: 6978-6926。
umgaev@yandex.ru

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Strategies of business units of diversified industrial companies at different stages of the life cycle

A.V. Kolobov[1]
[1] "Severstal" JSC (Cherepovets, Russia)

Abstract

The paper considers the models of organisational development of multidisciplinary companies and their business units. It is shown that the existing models need to be supplemented with two enlarged managerial competencies – management of incremental (modification) innovations and management of radical innovations. The proposed model of a business unit assumes that their development is structured as a progressive passage of the organisation through the stages of housing and communal services by developing the necessary managerial competencies for the next stage. The developed general models are used to form models of organisational development of the "Severgroup" multidisciplinary corporation and its business units. The strategic portfolio of business units, its parameters and position within the framework of the matrix of housing and communal services of the industry are determined. The result of the study was the formulation of two strategies – "growth to the core" and "growth to the peak". Models of organisational development of the corporation (changes in the composition and characteristics of the portfolio of business units) and models of transfer of managerial competencies have been developed for each strategy.

Keywords: multidisciplinary organisations, industry, organisation life cycle, industry life cycle, innovation management, organisational development.

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多元化工业公司在生命周期不同阶段的业务单元策略

A.V. Kolobov[1]
[1] 北方钢铁（"谢韦尔钢铁"）股份公司（俄罗斯切列波维茨）

摘要

文章研究了多元公司及其业务单位的组织发展模式。结果表明，现有的模式需要补充两个扩大的管理能力——管理渐进式创新和管理激进式创新。建议的业务单元模型假定，它通过发展下一阶段所需的管理能力，在组织生命周期的各个阶段逐步开发。所开发的一般模型被用来为多元的Severgroup公司及其业务单位形成组织发展模型。确定了业务单位的战略组合、其参数和在"组织生命周期——行业生命周期"矩阵中的位置。这项研究的结果是制定了两项战略——"发展到核心"和"发展到高峰"。对于每一项战略，都制定了公司组织发展的模式（改变业务单元组合的构成和特点）和管理能力转移的模式。

关键词：多元业务机构，工业，组织生命周期，行业生命周期，创新管理，组织发展。

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Introduction

Despite the fact that life cycle theory is a fairly developed area of research, there is a limited amount of work in the literature on the life cycle of multidisciplinary organisations. The life cycle theory assumes that the birth, development and behaviour of an organisation can be described by a process model of organisational changes inherent in each stage of the life cycle. However, the same cannot be said for a multidisciplinary organisation, in which the business units that make up the multidisciplinary organisation may be at different stages of the life cycle. What strategic changes must occur to grow the entire multidisciplinary organisation?

This article attempts to fill a gap in Russian research in the field of the theory of the life cycle of diversified industrial organisations in order to clarify the patterns of development of each business unit of Russian diversified organisations and identify management strategies at different stages of the enterprise life cycle (hereinafter referred to as the ELC).

1. The theory of the organisation life cycle. Basic provisions

The first studies of organisational development stages appeared in the 1960s. For example, the authors of [Downs, 1967; Lippitt, Schmidt, 1967] identified three stages of development: inception – flourishing – decline. More recent studies based on the study of organisational development began to distinguish five or more stages. For example, L. Greiner's model [Greiner, 2002] contains five stages of the life cycle, W. Torbert's model - nine stages [Torbert, 1974], I. Adizes' model - ten [Adizes, 1979]. At the same time, the authors highlight the unique characteristics of each stage, the sequence of their implementation, and pay attention to the fact that each next stage is a consequence of the previous one [Greiner, 2002].

Further research focused on empirical analysis of life cycle stages and identification of their unique characteristics. For example, in the work of W. Scott [Scott, 1976], it is indicated that at the stage of inception and early development, companies are single-product and have survival as their goal; in [Lyden, 1975; Lorange and Nelson 1987; Greiner, 2002] this stage is characterised as entrepreneurial and innovative, since the main goal of the company is to occupy its niche in the market. In [Adizes, 1979; Kimberly, 1979] indicates the main goal of this stage as the search for financial resources. As for the organisational characteristics of this stage, for example, in [Adizes, 1979] it is called the "one-man show", since it is the founder of the company at this stage who takes responsibility for all aspects of management; similar conclusions are contained in [Torbert, 1974; Grainer, 2002], which point to the importance of building formal and informal interactions, as well as strong power and leadership.

The next stage is characterised by researchers as the stage of expansion and growth, the emergence of the ability to produce more than one product [Scott, 1976]. The company grows and there is a need for planning [Downs, 1967], organisational formalisation of all procedures, more formalisation of the management structure [Katz, Kahn, 1978], functional specialisation and departmentalisation [Scott, 1976].

The maturity stage is characterised by significant diversification, but at the same time a decrease in innovation and flexibility [Hanks et al., 1993]. As for the organisational structure, branched departmentalisation leads to the need to create a rigid organisational structure, and this, in turn, reduces the ability to make changes and flexible adaptation [Lippitt, Schmidt, 1967]. Greiner in his work recommended the use of a matrix organisational structure to increase flexibility [Greiner, 2002], and Scott wrote about the need to develop a multi-product line and use decentralisation and diversification [Scott, 1976].

The decline stage occurs precisely due to the organisation's low ability to adapt and structural change [Peters, Waterman, 1982], as well as due to structural rigidity and cultural inertia [Lorange, Nelson, 1987]. The organisational structure is characterised by poor communication, adherence to the old strategy, conformity, conservatism and lack of trust [Adizes, 1979; Pfeffer, 1981; Nystrom, Starbuck, 1984; Lorange and Nelson, 1987]. In the future, all these will lead to an increase in conflicts and "management paranoia" [Adizes, 1979; Pfeffer, 1981].

After passing through the stage of decline, the organisation either ceases to exist or enters the stage of renewal and complete reorganisation [Adizes, 1979].

2. General model of organisational development in a diversified commercial organisation

The main type of tools for studying and modeling the organisational development of a diversified commercial organisation is currently the matrix model of a corporation's strategic portfolio [Alimov, Gichiev, 2008; Udo-Imeh et al., 2012]. Matrix models usually distinguish two dimensions that order the business units of a corporation, most often depicted as circles. The size of the circle reflects the volume of activity (revenue) for each business unit. The organisational development of a corporation in such models is understood as a change in the characteristics of business models (and their positions within the matrix), so that the overall parameters of the portfolio of business units improve. The most famous model of this type, the Boston

Consulting Group Matrix, uses measurements of the market growth rate and the relative market share of a business unit [Gridnev, 2010]. The McKinsey / General Electric matrix is based on measurements of industry attractiveness and firm competitiveness [Luzhnova, 2017]. The Arthur D. Little matrix is based on measurements of the market life cycle and the company's competitive position [Kuzmin, Vysokovskaya, 2015]. Technology matrices are also used with two dimensions - the current competitive position and the stage of the technology life cycle (or in other cases, the speed of technology development), technology matrices with measurements of the nature of the market (existing, interconnected or new) and the nature of technologies (existing, interconnected and new)[1] and so on. In most cases, in such matrix models, one dimension reflects generalised characteristics of the business units, the second - the market/ industry/technologies business units are associated with.

The first dimension reflecting the characteristics of business units can be the staging of the organisational development model shown in Fig. 1 (without allocation of dysfunctional stages). The second dimension should relate to a generalised parameter of the external environment of business units, should not correlate with the first dimension and reflect a parameter that allows to optimise the organisational development of a diversified company. It would also be extremely useful if this measurement could be operationalized, led to a quantitative scale or a qualitative model with a categorical scale. Here we can propose to tie the second dimension to the life cycle of the market. The market (industry, segment) life cycle model is currently an established and well-developed scientific concept [Karniouchina et al., 2013] with the possibility of reasonable identification of stages [Golikova, 2011; Kochelaba, 2015]. The market and industry life cycle model is actively used both in scientific research [Novitskaya, 2012] and in practical management [Ibragimov, Golovkin, 2017]. The possibility of using this measurement is confirmed by the popularity of the Arthur D. Little matrix model. The possibility of combining characteristics of different types of life cycles (products, technologies, organisations) in one model is shown in [Dresvyannikov, 2008].

The assumption that the stages of the life cycle of the market and the company can correlate (at the early stages of the development of industries and markets, young companies dominate) has no clear confirmation or mention in modern scientific literature [Shirokova et al., 2007; Rozanova and Kataykova, 2012]. Even a little knowledge about the development of various markets reveals examples of the opposite. In the early stages of market development, different stages of a company's life cycle may operate, with more mature companies may dominate (for example, Yandex in the taxi aggregator market). Mature companies, like young ones, are entering new markets. At the same time, young companies are also appearing in mature markets (for example, VkusVill has noticeably squeezed out such established leaders as X5 Group and Magnit). The work [Popov et al., 2016] presents a hypothesis that at different stages of the life cycle of an industry, different organisational structures of diversified companies begin to develop. But this hypothesis has not been further tested on empirical data. The authors do not provide a single case confirming it, and most importantly, the hypothesis itself suggests that at certain stages of the industry life cycle, various types of organisational structures begin to develop, but do not become dominant or attractive and do not cease to be used by companies at subsequent stages.

Thus, as a general model of organisational development, we can offer the matrix shown in Fig. 1.

The stages of the life cycle of a market/industry in Russian science have different terminology. The terms proposed by [Bakanov, 2012][2]. are used here. This staging also seems to be the simplest (in some works, the growth stage is divided into "growth acceleration" and "growth slowdown" or into "growth" and "knocking out" [Popov et al., 2016]).

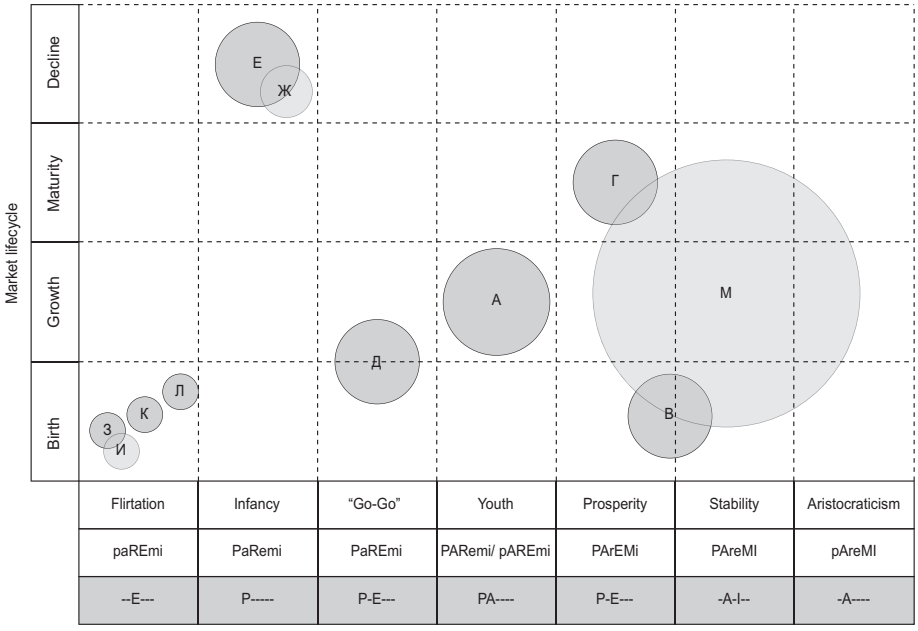
The simplest method for determining the stages of the market life cycle is based on an assessment of total revenue or production volumes [Rychikhina, 2013]. But this approach is now recognised as simplified [Bakanov, 2012]. The metrics of the dynamics of companies leaving and entering the market, innovations, company survival, etc. are also used. [Klepper, 1997]. As a more substantiated and practically acceptable alternative, one can use the expert method based on the assessment of typical stage features [Benda et al., 1993; Novitskaya, 2012].

The staging of the life cycle can also be determined on the basis of various quantitative indicators, such as the age of the company, the increase in market share, the growth rate of revenue, profit, etc. [Nazarenko, 2014]. But these indicators are not tied to the Adizes model, which offers its own survey form[3]. It is this form that is used in the present study. To ensure validity, the assessment of the stage of the life cycle should be carried out by three to five experts who have complete and reliable information about the company's activities.

On the proposed model, it is recommended for ease of use to highlight the functional and dysfunctional combinations of managerial abilities inherent in each of the Adizes life cycle stages. Business units are traditionally depicted as circles, the size of which reflects the share of the company's revenue in the total revenue of the diversified organisation. The affiliation of the organisation of a particular stage for

[1] https://www.wikipro.ru/wiki/matrica-rynoktehnologiya/.
[2] This work is the most cited in Google Scholar and searched for the term "industry life cycle".
[3] https://adizes.me/life_cycle_test/.

Fig. 1. The model of organisational development in a multidisciplinary company



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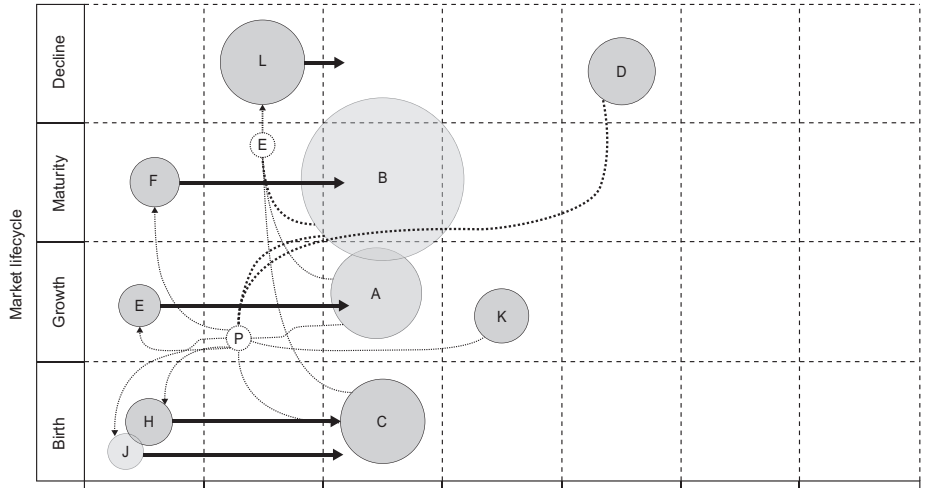
companies with large revenues and, accordingly, a larger circle size (company M in Fig. 3) is determined by the center of the circle. It is allowed, but recommended only if there are grounds for the location of the company between different stages, as shown by the example of companies D and C in Fig. 3. If several business units are located in one of the segments of the matrix (companies E and G in the "infancy – decline" segment, as well as companies Z, I, C and L in the "courtship – birth" segment), it is advisable to place them inside the segment in accordance with the ranking of assessments of belonging to the stages (beginning, middle or end of the stage). If there are no grounds for such gradations, then placement is allowed that facilitates the visual perception of business units on the model, without considering the gradation. If there are various cases of placement within the segment (with real and conditional gradations), they should be explained.

The corporation development model suggested in Fig. 3 provides an opportunity to identify and use synergistic effects based on the connectedness of the managerial abilities of the business units of a diversified company. But at the same time, there can be a huge number of connectivity options, taking into account the various stages of the life market, and, most importantly, among them many options can be identified that provide an increase in the efficiency and sustainability of the corporation as a whole. In other words, there may be a lot of trajectories of the organisational development in a corporation, in terms of the model presented in Fig. 3. Let us dwell only on some of them – on the trajectories arising from the results of previous studies.

As the first direction, we can single out ensuring the similarity of the managerial abilities of the corporation's business units. There can be three sub-options here: (1) moving towards the main business unit (or group of those), (2) moving towards the advanced business unit (or group of those), (3) moving towards the optimum (flourishing and stability stages).

Moving towards the main business unit (1.1) involves identifying in the strategic portfolio of a diversified company one business unit that is noticeably larger in terms of activity than all the others. An example is company M in Fig. 3. There can be several business units at the same stage of the life cycle with a large total volume, and they can operate in markets with different stages of the life cycle. It is not at all necessary that these business units are at the peak of functionality in terms of the Adizes model, that is, they are at the stage of stability. So, Figure 2 shows the core of a corporation of major business units, the combined volume of activities of which is clearly more than half of the volume of its activities. Companies A, B, and C are in the go-go stage and are placed in different stages of the market life cycle. The rest of the companies are in other segments of the matrix. The recommended development trajectory in this case would be the progressive movement of all business units located to the left of the core, while stabilising the position of all other business units. Business units lagging behind the core must be actively developed or replaced as part of M&A activity, so that they "grow" to the core. And this is the main focus of organisational development. This is shown by arrows in Fig. 2.

Fig. 2. The model of organisational development in a multidisciplinary organisation, assuming the option of moving to the main business unit (development of managerial abilities)



Lifecycle stages of an organisation, their functional and dysfunctional combinations of managerial capabilities

Fig. 2. The model of organisational development in a multidisciplinary organisation, assuming the option of moving to the main business unit (development of managerial abilities)

It is expedient to make this effort using the managerial abilities that have developed in the core, which are required for lagging business units for their development. Thus, for company L, an enhanced development of entrepreneurial ability (E) is required, which can be done by using this ability from the core companies and companies K and D. Companies E, H, F and J need to be brought initially to the infancy stage through active development of competence manufacturer (P), which all other business units can assist in, since all of them have a highly developed ability (P). And only after the transition to the stage of infancy, it is necessary to transfer companies E, H, F and J to the "go-go" stage through the development of ability (E). Transfers or scaling of managerial competencies from one business unit to another are shown in Fig. 4 with dotted arrows.

Assistance with the development of the required capabilities from donor companies in practical terms can be:

- transfer of managers and management teams to recipient companies;
- training of managers of recipient companies, including through internships;
- formation of informal expert communities to transfer the best experience;
- mentoring/supervising the managers of the recipient companies by the donor companies or the management company;
- scaling business processes, procedures, standards, documented or algorithmic practices;
- scaling information systems that regulate portable practices;
- formation of knowledge bases or centers of best practices related to relevant abilities, etc.

The best practices transfer activity is organised and coordinated by the management company or headquarters, but it is implemented with the active involvement of business units with the building of horisontal links.

The transfer of best practices naturally becomes a certain additional burden on donor companies, so it is important to identify transfer options that would not weaken donors and the corporation as a whole. For example, from the variants of ability transfer (P) in Fig. 2, it seems preferable to use company D in the first place. This company operates in the market at the stage of decline, and, accordingly, the expansion of this company is not appropriate. It is also a good option to transfer capability (P) from company B. This business unit is the largest, has the most resources, and in a mature market, this company does not seem to be expected to grow rapidly. Similarly, in the case of the development of competence (E) in company L, it is better to use company B, since company A and company C are at the stages of the market life cycle, suggesting a further increase in the volume of their activities. Preferred options for synergistic support for the development of managerial competencies are shown in Fig. 4 with thick dotted lines.

In the course of bringing all the lagging business units to the stage of the core of organisation life cycle, the level

of development of management organisations is equalised, which becomes the basis for a synergistic effect. In the future, the corporation develops through the systematic transition of the main group of already aligned business units to the subsequent stages of the life cycle up to the most functional ones - prosperity and stability.

Taking into account the difference in the stages of the market life cycle, it makes sense to supplement the model in Fig. 2 with proposals for organisational development in terms of the scope of activities. From modern scientific ideas about the life cycle of the market, it follows that the stage of decline is characterised by negative growth rates of production volumes, so the expansion of the activities of companies L and D does not seem appropriate. It makes sense to reduce their activities by moving resources to business units that are at more promising stages of the market life cycle. The stage of market maturity is characterised, as a rule, by extremely low growth rates tending to zero. Companies at these stages should also not be developed. How much they should be reduced, it is necessary to determine taking into account other considerations. For example, in Fig. 3 business unit B is the largest and is operating at the maturity stage. Thus, the diversified company becomes overly conservative, tied to a small growth rate at the stage of maturity. It makes sense to carefully move resources from company B to more promising ones. If you look at the overall distribution of activity volumes across the market life cycle stages, you can see excess volumes in the maturity and decline stages. The position of the corporation seems to be more stable, when most of the volumes are concentrated at the growth stage (with a natural presence at other stages). It is most convenient to shift the volumes of the corporation towards the growth stage at the expense of company B. Options for changing the volumes of company activities are shown in Fig. 2 by dotted circles.

Company F can be treated differently. It is relatively small and has a good potential for growth within the framework of the LCL. There is no need to hurry with the withdrawal of resources, but it is worth taking into account the prospects for the development of the market and the competitive position of the company. If the market does not stagnate in the short term, and the company has good competitive advantages, then it makes sense to allow the internal development of the company without expanding the volume of activities.

Also, the strategy in relation to company L requires caution. It is obvious that the company is already in a stagnating market, but it still has the potential for internal development. If a company can strengthen its competitive position, then moving it to the “go-go” stage can also lead to an improvement in its performance – increasing efficiency, maintaining (and possibly expanding due to less efficient competitors) its share even in shrinking markets.

Expansion of the volume of activities is advisable in companies at the later stages of the stage of origin and the stage of market growth. At the same time, it is better to expand the volume in companies that have the potential for internal development, that is, those that are at the stages of life cycle and infancy, “come on, come on”, and youth, and to a lesser extent – and flourishing. It is risky to develop companies at the courtship stage intensively. So, in Fig. 3 expansion of volumes is advisable for companies A and K, perhaps also for C.

Fig. 3. The model of organisational development in a multidisciplinary organisation in terms of volume changes

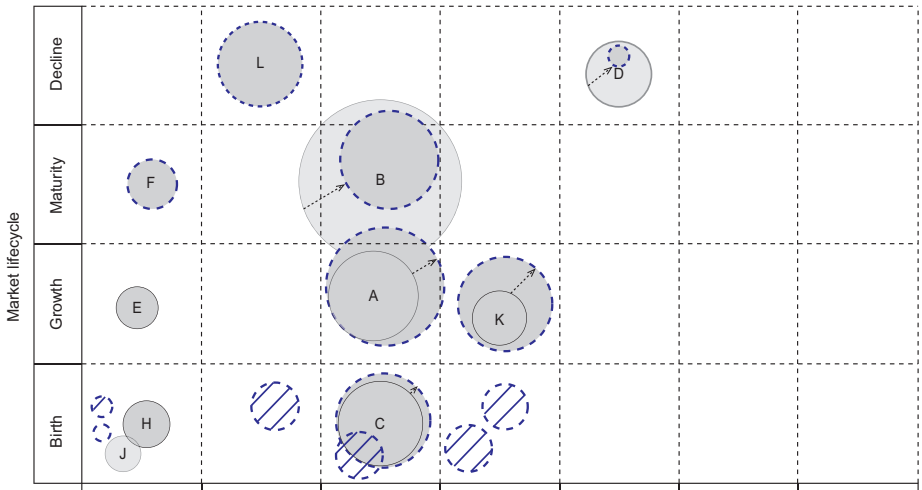


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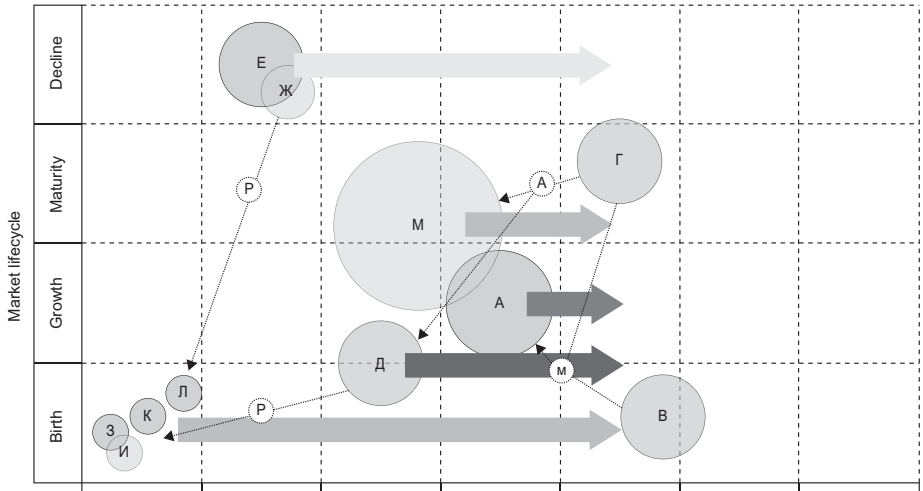
Fig. 4. The model of organisational development in a multidisciplinary organisation, assuming the option of moving to an advanced business unit



Flirtation	Infancy	"Go-Go"	Youth	Prosperity	Stability	Aristocraticism
paREmi	PaRemi	PaREmi	PARemi/ pAREmi	PArEMi	PAreMI	pAreMI
--E---	P-----	P-E---	PA----	P-E---	-A-I--	-A----

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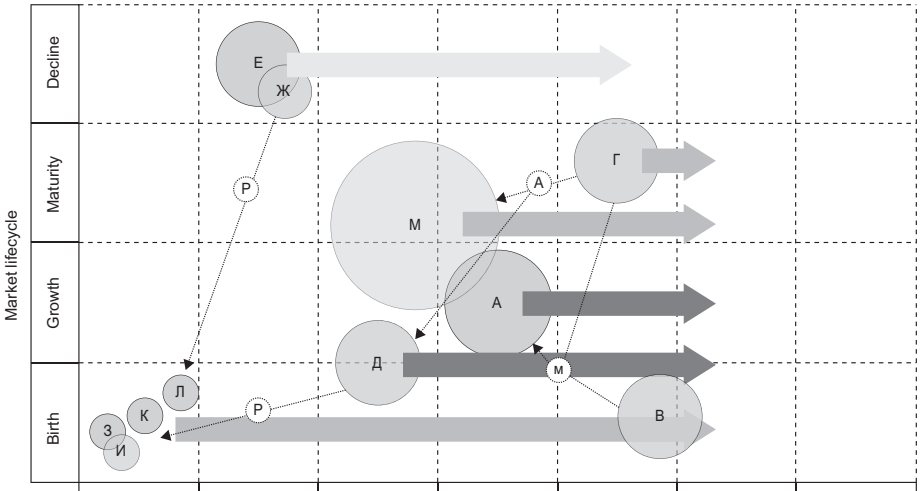
In many cases, attention should also be paid to the number of companies. For example, for the conditionaly considered corporations in Fig. 4 and 5 it seems to be an insufficient number of companies at the stage of the life cycle of the infant market. This stage is characterised by high "mortality", especially among companies at the initial stage of the life cycle. It is better to increase the number of companies at this stage of the market life cycle. And if it is possible to increase the number of companies by acquiring them, then it is advisable to acquire business units at the stages of infancy, go-go and adolescence, so that they have greater stability, but at the same time the potential for internal development. Acquisitions of companies in the courtship stage do not seem promising. Business units at this stage will arise in the case of the creation of new enterprises from scratch, in the course of corporate venture entrepreneurship. Options associated with the emergence of new business units are shown in Fig. 4 with hatched circles.

Moving towards a leading business unit (1.2) involves identifying one, and if possible several – not necessarily the main ones – business units that are at the most advanced stages of the life cycle, and a combination of efforts to bring all the rest. The development of the necessary managerial abilities is carried out by cross-transfer between different business units at different stages. For example, Fig. 5 shows the general direction of development of business units and individual options for the transfer and scaling of managerial competencies.

The colour intensity of the wide horisontal arrows reflects the priorities in the development of business units. The light arrow from companies E and G indicates the expediency of not the most active development of these companies, since they are at the stage of decline of their markets. The most intensive development is appropriate for companies in the growth stages and late stages of market emergence.

Compared to the trajectory of movement to the main business unit, the movement to the advanced business unit is characterised by potentially faster access to more functional stages of the life cycle. But at the same time, the consistency and, accordingly, the synergistic potential is somewhat lower. Business units will need more time to reach a state aligned in terms of the stage of the life cycle and the set of capabilities. But at the same time, in their development, they are aimed at more functional stages.

Fig. 5. The model of organisational development in a multidisciplinary organisation, assuming the option of moving to the optimal stages of housing and communal services



Flirtation	Infancy	"Go-Go"	Youth	Prosperity	Stability	Aristocraticism
paREmi	PaRemi	PaREmi	PARemi/ pAREmi	PArEMi	PAreMI	pAreMI
--E---	P-----	P-E---	PA----	P-E---	-A-I--	-A----

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Table 1
Assessment of the scope of activity, stages of housing and communal services of the branch of business units in the «Severgroup» multidisciplinary corporation

Code	Strategic business unit	Turnover estimates	Share in the total volume of the company	Stage of life cycle according to the Adizes method	Industry Life Cycle Stage
SS	Severstal	11.4 bln USD	47.88	Heyday	Maturity
L	Lenta	6.6 bln USD	27.72	Heyday	Late growth
PM	Power Machines	2 bln USD	8.40	Aristocracy	Early maturity
NG	*Nordgold*	1.82 bln USD	7.64	Youth	Maturity
T	*TUI Group*	1.1 bln USD	4.62	Witch-hunt	Decline
GS	Sveza Group	36 bln USD	2.61	Youth	Growth
TT	Severgroup TT (TalenTech)	15 bln USD	1.09	"Go-Go"	Early birth
M	Severmed	0.5 bln USD	0.04	Infancy	Late birth

Source: compiled by the author based on data from open sources.

Table 2
Directions of organisational development of business units of the «Severgroup» multidisciplinary corporation

Code	OLC stage according to the Adizes method	Current managerial competencies	Required Competencies according to the Growth to the Core Strategy	Required Competencies for Growth to the Peak Strategy	Industry Life Cycle Stage	Business Unit Scope Recommendations
SS	Heyday	PArEMI	_ _ _ _ _ _	_ _ R _ _ _	Maturity	Slow reduction
L	Heyday	PArEMI	_ _ _ _ _ _	_ _ R _ _ _	Late growth	Slow growth
PM	Aristocracy	pAreMI	P _ _ E _ _	P _ R E _ _	Early maturity	Volume maintenance
NG	Youth	PARemi	_ _ _ E M I	_ _ _ E M I	Maturity	Slow reduction
T	Witch-hunt	pAremI	P _ _ E M _	P _ R E M _	Decline	Reduction/output
GS	Youth	pAREmi	P _ _ _ M I	P _ _ _ M I	Growth	Expansion
TT	"Go-Go"	PaREmi	_ A _ _ M I	_ A _ _ M I	Late birth	Rapid Expansion Creation of new business units
M	Infancy	PaRemi	_ A_ E M _	_ A_ E M I	Early birth	Expansion Creation of new business units

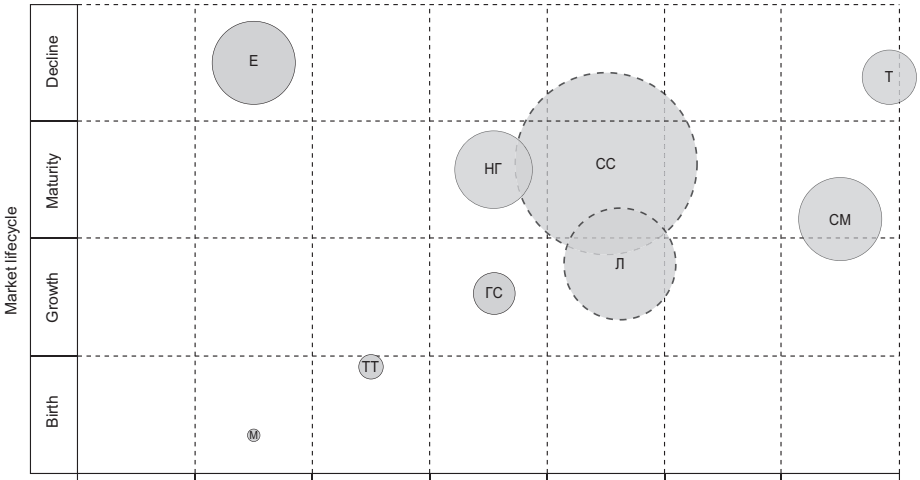
The speed of reaching the most functional stages of the life cycle is even higher, but there is also a noticeably lower synergistic potential for moving towards the optimum. This trajectory lies in the fact that all business units develop their abilities immediately towards the optimal stages – flourishing or stability, naturally, passing sequentially through the previous stages. Visually, this is shown in Fig. 5, where all business units develop at once towards the stability stage.

As in the previous trajectories, it is necessary to be cautious about the prospects for the development of companies in the stage of market decline and in the early stages of the life cycle at the same time. There is a high probability that they will not have time to reach the stage of stability, but it is possible that they will flourish. Business units exchange and support each other in terms of managerial abilities. But at the same time, business units have their own unique sequences of passing through the stages of the life cycle, which is accompanied by the fact that, in general, the entire strategic portfolio of the corporation only at the last stages of development becomes aligned with a set of managerial abilities.

3. The research of Severgroup Organisational Development Model

To build specific models of organisational development of the multi-profile organisation "Severgroup", enlarged business units are allocated, operating in various industries and uniting several legal entities. The volume of their activities is determined on the basis of data on annual turnover (revenue) from open sources. The share of the company's activity in the total volume of the corporation's activity is determined based on the same data. The stage of the life cycle is determined in relation to the business unit

Fig. 6. The model of the strategic portfolio of the «Severgroup» business units



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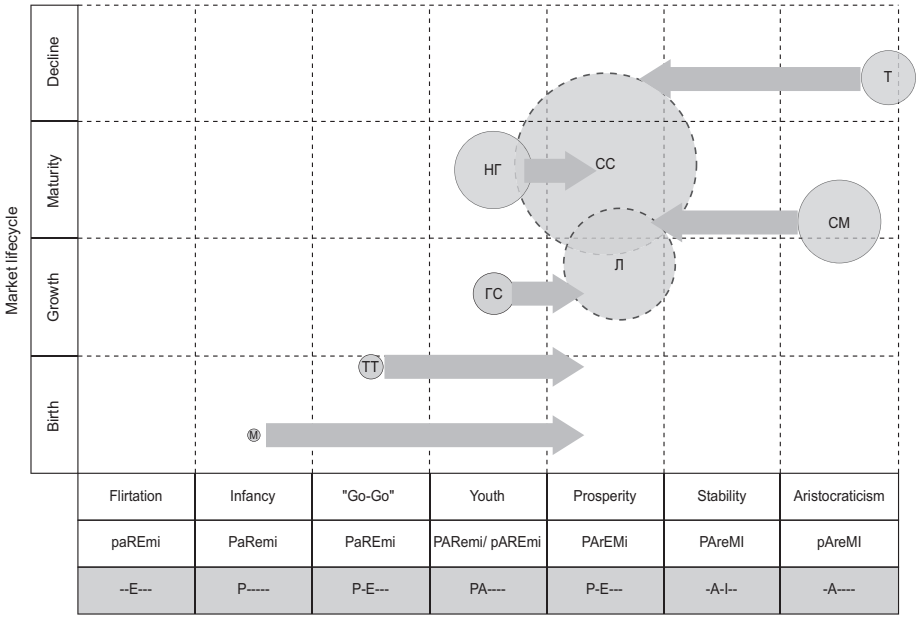
as a whole using a survey tool (https://adizes.me/life_cycle_test/) and expert judgments of the authors of the study and representatives of the company. The life cycle stage of an industry is determined based on the indicators specified by [Popov et al. (2016)] and data on them from open sources. The definition of the life cycle stage of the industry was determined by the authors of the study. The obtained estimates are given in Table. 1.

Fig. 6 presents a practical model of the strategic portfolio of business units of the diversified organisation "Severgroup" based on the estimates formulated in Table. 1. Severstal and Lenta business units can be identified as the core of the organisation (current affiliation to the organisation remains in question). They cover 75.21% of the overall activities of the organisation and are at the same stage of the life cycle. On Fig. 6 they are marked with a dotted line.

Based on the composition of the strategic portfolio of business units of the Severgroup organisation, two strategies for the organisational development of the corporation as a whole and its individual business units can be formulated. One strategy involves bringing all business units closer to the "core company" lifecycle stage, that is, to the heyday stage. The second strategy is aimed at achieving the peak of the functionality of all business units, which is characterised by the high development of all six managerial competencies. Due to the fact that the core is at a stage close to the peak of functionality and is characterised by a weak development of only one competence (R – competence in the management of radical innovations), the difference between the two strategies is not cardinal.

To determine the content and direction of the transfer of managerial competencies in the context of two strategies, the current compositions of managerial competencies were determined based on the model in fig. 2, which is a modification of the Adizes model. Based on the same model, the competencies that are needed to reach the target level of the life cycle of the company were determined. These are the competencies that are required to be acquired for the corresponding stage of the company lifecycle. Intermediate stages of the company lifecycle are not described for the sake of simplicity. On the basis of the same model and considerations outlined in the context of consideration of Fig. 5, proposals are formulated for expanding or reducing the volume of activities of business

Fig. 7. Graphical representation of the «growth to the core» organisational development strategy for the «Severgroup» multidisciplinary corporation



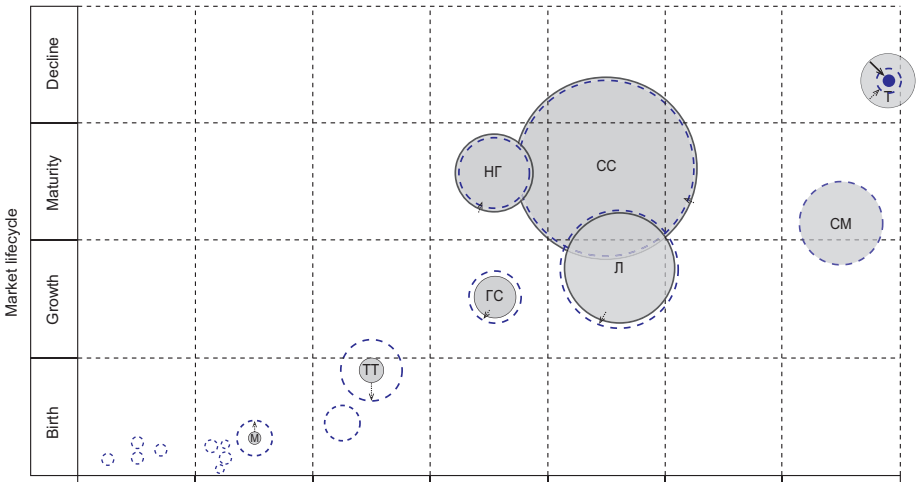
Lifecycle stages of an organisation, their functional and dysfunctional combinations of managerial capabilities

units. These proposals are based on the assessment of the life cycle of the industry in which the business unit operates. Proposals for the development of the competencies required to reach the target stages of the life cycle cycle and recommendations on the scope of activities are summarised in Table. 2.

The growth strategy towards the core in terms of competency development is shown in Fig. 7.

As can be seen from Fig. 7, the business units of Nordgold, Sveza, Severgroup TT and Severgroup Medicine must go through a path of progressive upward development from the current stages to more functional ones. The Severstal and Lenta business units are not undergoing any significant transformation. They act as sources of managerial competencies that are in demand in other business units. The Power Machines and TUI Group business units (the organization's ownership has not been fully clarified) are now at the dysfunctional stages of the life cycle, which implies their renewal through the development of managerial competencies necessary for a conditional return to more functional stages of the life cycle.

Fig. 8. Graphical representation of recommendations on changing the volume of activity of «Severgroup» business units



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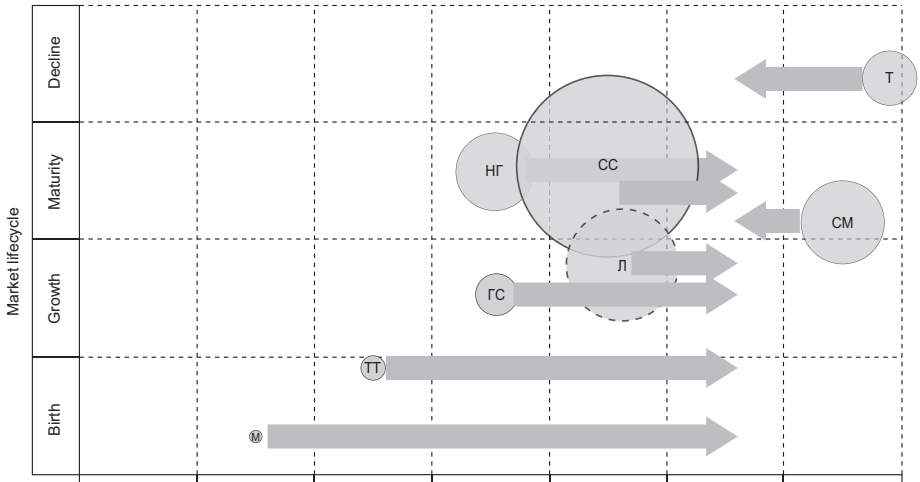
Directions for the transfer of managerial competencies within the framework of the organisational development strategy of the corporation "growth to the core" are shown in Table. 3. This table is a matrix consisting of the organisation's business units. The second column and the second row show the combination of available managerial competencies. The third line shows the competencies necessary for the business unit to reach the target stage of the life cycle cycle. So, for example, Power Machines needs to be strengthened by competencies P (producer) and E (entrepreneur) to move to the heyday stage. And to move to the same stage, the Severstal TT business unit requires managerial competencies A (administrator), M (modifying innovator) and I (integrator).

At the intersection of rows and columns, managerial competencies are shown that it is advisable to transfer from the business units indicated in the rows to the business units indicated in the columns. So, Power Machines can be "strengthened" by the competencies P (producer) and E (entrepreneur) from Severstal or Lenta. The competence of P can also be strengthened by a transfer from Nordgold, Severstal TT or Severstal Medicine. Competence E can also be strengthened by Sveza (GS). And the Severstal TT business unit can be strengthened by Severstal, Lenta and Power Machines (whose competencies A, M and I are

Table 3. Transfer of managerial innovations within the framework of the «growth to the core» strategy

		SS	L	SM	NG	T	GS	TT	M
		PArEMI	PArEMI	pAreMI	PARemi	pAremI	pAREmi	PaREmi	PaRemi
		_ _ _ _ _ _	_ _ _ _ _ _	P _ _ E _ _	_ _ _ E M I	P _ _ E M _	P _ _ _ M I	_ A _ _ M I	_ A _ E M _
SS	PArEMI		—	**P, E**	**E, M, I**	**P, E, M**	**P, M, I**	**A, M, I**	**A, E, M**
L	PArEMI	—		P, E	E, M, I	P, E, M	P, M, I	A, M, I	A, E, M
PM	pAreMI	—	—		M, I	M	M, I	A, M, I	A, M
NG	PARemi	—	—	P		P	—	A	A
T	pAremI	—	—	—	I		I	A	A
GS	pAREmi	—	—	E	E	E		A	A, E
TT	PaREmi	—	—	P	E	P, E	P		A, E
M	PaRemi	—	—	P	—	P	P	—	

Fig. 9. Graphical representation of the «growth to peak» organisational development strategy for the «Severgroup» multidisciplinary corporation



Flirtation	Infancy	"Go-Go"	Youth	Prosperity	Stability	Aristocraticism
paREmi	PaRemi	PaREmi	PARemi/ pAREmi	PArEMi	PAREMI	pAreMI
--E---	P-----	P-E---	PA----	P-E---	-A-I--	-A----

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at a high level of development), as well as Nordgold, TUI and Sveza (competence A).

It should be noted that the transfer of managerial competencies from business units should be linked to organisational development in terms of increasing or decreasing the volume of activities of business units. Fig. 8 graphically shows recommendations for changing the volume of activities of the business units of the corporation.

The activities of business units that are in decline (TUI), it is advisable to significantly reduce or completely exit from them. Severstal and Nordgold operate in already mature markets. Their activities should be carefully reduced. In Power Machines, it is possible to maintain the existing scope of activities. The activities of Lenta, Sveza, Severgroup TT and Severgroup Medicine should be expanded with varying degrees of intensity. It makes sense, however, to create a few companies in the early stages of the life cycle of courtship and infancy, and perhaps acquire a more mature company in the go-go stage. In general, the strategic portfolio of the organization is characterised by a lack of companies in the early stages of the life cycle and the early stages of the life cycle of the industry. Moreover, these companies do not have to be created in the same industries as Severstal Medicine or Severstal TT.

Based on the recommendations for changing the volume of activities of business units, it seems appropriate to actively transfer managerial competencies from companies that reduce their activities and not transfer them from companies that offer expansion of activities. This aspect is shown in Table. 3 with fill and bold. Shading shows inappropriate donors of managerial competencies. The darker the fill, the less appropriate it is to use the business unit as a competency donor. Thus, Sveza, Severstal TT and Severstal Medicine are not recommended to be used as a donor of competencies for most companies. Also, not the best option is to transfer competencies from the “Tape” (but the degree of inappropriateness is lower, respectively, and the fill is paler). The transfer of competencies from TUI, Nordgold and Severstal is most expedient.

You should also pay attention to the exception. For example, in Severstal Medicine, it seems appropriate to transfer competencies from Sveza and, to some extent, from Severstal TT. This is due to the fact that significant differences in organizational culture may arise between the already established Severstal (or TUI, or Nordgold) and the young Severstal Medicine. These differences will be less than between Severstal Medicine and Severstal TT (or Sveza). Bold font shows the migration options that seem to be the most preferred.

After reviewing the main aspects of the growth strategy, the key points of the growth-to-peak organizational development strategy are brought to the core. Graphically, it is shown in Fig. 9. The matrix of competencies transfer within the framework of the growth-to-peak strategy is shown in Table. 4.

As the peak of functionality, the situation is considered when all six managerial competencies are equally well developed. According to the Adizes model, such a state is not stable, but potentially achievable. Nevertheless, as the

target state of the discharges of this stage, the company lifecycle looks quite acceptable.

The interpretation of the above models of the growth strategy to the peak is similar to the models of the growth strategy to the core. Fig. 9 shows the general directions of the organisational development of business units in terms of the stages of the life cycle. Recommendations for changing the volume of activity of business units remain the same (Fig. 8), since they are determined by the dynamics of the development of industries, not business units. Table. 4 shows the direction and content of the transfer of managerial competencies from the business units indicated in the rows to the business units indicated in the columns. Bold indicates the transfer options that seem to be the most appropriate. Flooding marks options that look less appropriate.

Comparing the strategies of growth to the core and growth to the peak with each other, it can be noted that the latter seems to be a more complex and longer strategy in terms of implementation time. More business units need to be transformed. The organisational development of business units involves the passage of a greater number of stages of the life cycle. The number of transferable competencies between business units is greater, the directions of their transfer are more complex.

4. Conclusions and application of the results obtained in practice

In this article, general models of organizational development of diversified companies and their business units have been developed. The model of organisational development of a business unit is based on the Adizes life cycle model, while the latter is supplemented by two enlarged managerial competencies – management of incremental (modification) innovations and management of radical innovations. The proposed business unit model assumes that their development is structured as the organsation's progressive passage through the stages of the life cycle by developing the managerial competencies necessary for the next stage.

The model of organisational development of a diversified company is formulated as a two-dimensional matrix, one of the dimensions of which is the life cycle of the industry, and the second is the life cycle of the industry. Each of the business units is represented by a circle, the size of which indicates the share of activities in the total volume of the corporation's activities. Consideration of the development model of a diversified company made it possible to identify a number of available organisational development strategies: development to the main business unit, development to the advanced business unit, development to the optimal stage.

The developed general models were used to form models of organisational development for the diversified corporation Severgroup and its business units. The strategic portfolio of business units was defined, its parameters and position within the framework of the matrix of the life cycle of the organization – the life cycle of the industry. Based on the results of consideration of development options, two strategies were formulated – growth to the core and growth to the peak. For each strategy, models of the organizational development of a corporation (changing the composition and characteristics of a portfolio of business units) and models for the transfer of managerial competencies have been developed.

Further research should be aimed at studying the relationship between organisational development strategies and the most effective management tools at each stage of the life cycle.

Table 4. Transfer of managerial innovations within the framework of «growth to peak» strategy

		SS	L	PM	NG	T	GS	TT	M
		PArEMI	PArEMI	pAreMI	PARemi	pAremI	pAREmi	PaREmi	PaRemi
		_ _ R _ _ _	_ _ R _ _ _	P _ R E _ _	_ _ _ E M I	P _ R E M_	P _ _ _ M I	_A _ _ M I	_A_ E M I
SS	PArEMI		—	**P, E**	**E, M, I**	**P, E, M**	**P, E, M, I**	**A, M, I**	**A, E, M, I**
L	PArEMI	—		P, E	E, M, I	P, E, M	P, E, M, I	A, M, I	A, E, M, I
SM	pAreMI	—	—		M, I	M	M, I	A, M, I	A, M, I
NG	PARemi	**R**	**R**	**P, R**		**P, R**	**P**	**A**	**A**
T	pAremI	—	—	—	**I**		**I**	**A, I**	**A**
GS	pAREmi	R	R	R, E	E	R, E		A	**A, E**
TT	PaREmi	R	R	P, R, E	E	P, R, E	P		A, E
M	PaRemi	R	R	P, R	—	P, R	P	—	

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About the author

Alexander V. Kolobov

Candidate of technical sciences, director for the development of the "Severgroup" business system (Cherepovets, Russia), head of transformational projects to improve the efficiency of operational and organisational activities in the largest Russian companies.

Research interests: strategic and organisational development of large industrial organisations, organisational development of multidisciplinary structures, improving the efficiency and effectiveness of industrial business systems, tools for organisational development of multidisciplinary business systems.

avkolobov@severgroup.ru

作者信息

Alexander V. Kolobov

技术科学副博士，Severgroup 股份公司业务系统开发主任，俄罗斯主要公司运营和组织效率提高的项目领导人（俄罗斯切列波维茨）。

研究领域：大型工业组织的战略和组织发展，多元业务机构的组织发展，工业企业系统的效率和效益提高，多元业务系统的组织发展工具。

avkolobov@severgroup.ru

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Business profitability and monetary policy of the state

S.I. Lutsenko[1, 2]
[1] Institute for Economic Strategies of the Social Sciences Division of the RAS (Moscow, Russia)
[2] Corporate and Project Management Institute (Moscow, Russia)

Abstract

The author examines the features of the management policy and the monetary policy of the state on the profitability of the activities of Russian public companies (business profitability). The tightening of the monetary policy of the state (in particular, the growth of the key rate of the Bank of Russia without reference to the return on assets) may negatively affect the profitability of economic activity. The indicator of dividend payments is a signal for shareholders and potential investors. In addition, dividend payments are an indicator of the financial limitations of companies. Financial constraints are associated with the problem of adverse selection of financing - the choice of a source of financing taking into account its price. Effective management of current assets will allow rational use of them as an additional source of investment. The indicator of the contribution of management or internal growth allows you to evaluate external factors: market fluctuations, macroeconomic features, as well as the actions of financial speculators. This indicator establishes the real contribution of management to the value of the company. Systematic unprofitability of the company's economic activity is a consequence of short-sighted financial policy or erroneous strategic decisions on the part of management. Management acts in accordance with fiduciary duties of integrity and reasonableness in the interests of the company and its shareholders expecting an increase in the value of the business. Therefore, the management decision should be made from the position of maximising market capitalisation. Then Russian public companies will act in the logic of a precautionary motive, saving a significant part of the funds for subsequent investment in priority projects under conditions of financial restrictions and sectoral sanctions. The growth of sales provides additional opportunities for the company to invest. The Wald, Breusch – Pagan and Hausman tests were carried out in order to identify an adequate forecasting model.

Keywords: internal growth, monetary policy, financial constraints, dividend payments, precautionary motive, business profitability, financial policy.

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企业收益率与国家货币政策

S.I. Lutsenko[1, 2]
[1] 俄罗斯科学院社会科学部经济战略研究所（俄罗斯莫斯科）
[2] 管理企业与项目研究所（俄罗斯莫斯科）

摘要

本文考虑了与俄罗斯上市公司盈利能力相关的管理政策和国家货币政策的特点。国家货币政策的紧缩（特别是在不参考资产回报率的情况下提高俄罗斯银行的关键利率）可能会对经济活动的盈利能力产生不利影响。股息支付指标是股东和潜在投资者的信号。此外，股息支付是公司财务限制的一个指标。财务限制与资金逆向选择问题相关——当融资来源的选择基础与其价格。有效管理流动资产将允许其合理使用作为额外的投资来源。管理或内部成长贡献指标允许您评估外部因素：市场波动、宏观

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经济特征以及金融投机者的行为。该指标显示管理层对公司价值的真正贡献。企业经济活动的系统性无利可图是短视的财务政策或管理层错误的战略决策的结果。管理层按必须照诚信与合理原则行事，符合公司及其希望增加业务价值的股东的利益。管理决策应主要从市值最大化的立场出发。那么俄罗斯上市公司在金融限制和部门制裁的情况下将以预防动机（precautionary motive）的逻辑行事，节省可观的资金用于优先项目的后续投资。销售增长将为公司容许额外的投资机会。为了确定适当的预测模型，进行了沃德（Wald）、布伦斯和帕甘（Breusch–Pagan）及豪斯曼（Hausman）检验。
关键词：内部成长，货币政策，财务限制，股息支付，预防动机，企业收益率，金融政策。

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Introduction

The constraining factor in the economy is the reduction in investment in fixed assets. This is due to the rise in the cost of credit resources, which significantly limits investment demand. To revive investment activity, it is necessary to reduce the key rate of the Bank of Russia.

As noted in the National Security Strategy of the Russian Federation[1], in order to achieve the goals of the country's economic security, among other tasks, it is necessary to protect and encourage investment, as well as stimulate the use of domestic sources of investment.

In fact, money market rates influence other interest rates in the economy and the prices of financial assets, determining the decisions of economic entities regarding saving and investing. Easing or tightening monetary policy translates into the economy.

Key rate – the interest rate on the main operations to regulate the liquidity of the banking sector; it is the main universal indicator of the monetary policy pursued by the Bank of Russia.

The increase in the key rate and sectoral sanctions by the US and the EU against the banking sector lead to a sharp deterioration in the Russian financial market. An additional imprint is imposed by sectoral sanctions from the US and the EU against Russian public companies (in particular, the oil and energy sectors, which are included in the sample of the present study).

Changes in the state's macroeconomic and monetary policy (in particular, the operational benchmark of the Bank of Russia's exchange rate policy expressed in national currency or an increase in the cost of credit resources due to an increase in the key rate by the Bank of Russia without reference to the company's profitability) may adversely affect the profitability of a business, regardless of whether it sold products for export or in the domestic market[2].

It must be borne in mind that excessive debt financing worsens the financial position of the company, and also leads to an increase in the degree of its financial risks and adversely affects financial stability, reducing the level of equity[3].

Some authors noted that companies use their internal cash reserves for their subsequent investment in assets [Almeida et al., 2014]. H. Almeida et al. [Almeida et al., 2021] found that a company's financial limitations are associated with its high cash level (an element of investment resource).

R. Korajczyk and A. Levy [Korajczyk, Levy, 2003] consider the impact of macroeconomic conditions on the choice of funding source (taking into account financial constraints). They conclude that companies that are not financially constrained issue equity rather than debt when macroeconomic conditions are favourable.

S. Chang et al. [Chang et al., 2018] also consider the impact of macroeconomic factors and company characteristics on its issuing activity. They note that companies, regardless of financial constraints, carry out an additional issue of shares. At the same time, financially limited organisations issue shares much more than financially unlimited firms.

H. Almeida et al. [Almeida et al., 2016] studied the impact of dividend payments (an indicator of financial constraints) on a company's monetary policy. Their results showed that the dividend payout ratio is a metric for assessing a company's liquidity. In other words, with the help of this indicator, the company can manage the profitability of the shares.

The monetary form of capital, being the most liquid and mobile, allows the enterprise to use funds for the purpose of technical, technological and organisational improvement of production, investment in relevant projects, which ultimately increases the capitalisation of the company.

The works mentioned above did not take into account the impact of the contribution of management, sales, and the state's monetary policy on the profitability of the company's activities.

The indicator of the contribution of management or internal growth allows you to identify external factors: erroneous market estimates, macroeconomic factors, the actions of financial speculators. This measure represents the intrinsic part of the company's value addition and establishes management's real contribution to market

[1] The Decree of the President of the Russian Federation of July 2, 2021 No. 400 "National Security Strategy of the Russian Federation". http://www.kremlin.ru/acts/bank/47046.
[2] Resolution of the Eighth Arbitration Court of Appeal dated September 21, 2022 in case No. A81-10275/2017. https://clck.ru/32RPsx.
[3] Resolution of the Ninth Arbitration Court of Appeal dated August 27, 2021 in case No. A40-325813/2019. https://clck.ru/32RPvf.

capitalisation. Competent financial policy testifies to rational management in the field of profitability of the company. Otherwise, risky transactions and poor management can lead to a decrease in the value of the company and the welfare of its shareholders[4].

The value of the company is actually the indicator by which its financial position, stability in the market of certain goods (works, services), business profitability, attractiveness to buyers, as well as the welfare of the shareholder are assessed. Negative financial results of the company's economic activities are the result of unreasonable financial policy or erroneous strategic decisions on the part of management, which does not correspond to the economic interests of the organisation and its owners[5].

In relation to the behaviour of the leader, certain criteria have been developed. We are talking about the principle of good faith (estoppel) and the rule 'venire contra factum proprium' (no one can contradict their own previous behaviour), according to which a change by a party of its position to the detriment of a participant (shareholder, supplier), who previously reasonably and in good faith relied on the opposite behavior such party, deprives the head in the case under consideration of the right to object.

By virtue of the international principle of estoppel, which is recognised by the Constitution of the Russian Federation (we are talking about the observance of the principles and norms of international law – part 4 of Article 15 of the Constitution of the Russian Federation), the party is deprived of the right to invoke objections in relation to previously committed actions and transactions, as well as accepted decisions if the behaviour was evidence of its reality.

The current legislation and established court practice do not allow connivance with regard to controversial and dishonest management behaviour that does not correspond to ordinary commercial honesty (the estoppel rule). Such conduct is, in particular, conduct that is inconsistent with the prior statements or conduct of a party, provided that the other party reasonably relied on them in its actions.

The manager acts in accordance with his fiduciary duties in good faith and reasonably in the interests of the company and its shareholders, who expect to increase the value of the company[6]. In turn, the management decision should be made primarily from the standpoint of maximising the value of the business, since not only the absolute financial result of the operation of the enterprise (net profit), but also relative indicators (profitability of assets, investments, sales indicators, risks) to a greater or lesser extent affect to maximise the value of the business and can be considered as independent goals at a certain stage of the organisation's activities.

Another important factor in evaluating the profitability of a company's activities is the rate of sales growth. In a tough competitive environment and changing external circumstances, in order to ensure maximum liquidity of the company for the timely fulfillment of obligations to creditors, the budget, and suppliers, it is necessary to release working capital from inventory and receivables[7]. In other words, we are talking about the fact that the sales growth rate is a necessary factor for assessing the effectiveness of the use of investments in working capital. Sales growth opens up additional opportunities for the company in terms of investment directions.

The third factor influencing the financial result of the company is the monetary policy of the state represented by the Bank of Russia. As noted above, the tough policy of the Bank of Russia (an increase in the key rate) may lead to an increase in financial risks and adversely affect the financial position of an economic entity. Then Russian public companies will act in the logic of a warning motive (precautionary motive), saving a significant part of the money for subsequent investment in projects, taking into account their priority. In other words, as a precautionary measure, Russian companies are creating an internal cash reserve in order to offset losses associated with shocks that affect financial results.

Finally, another important factor affecting the profitability of a company is the indicator of dividend payments. This indicator is a reliable information signal regarding the prospects for future profits. Dividend payments are also an indicator of the financial limitations of companies. Companies faced with financial constraints are exposed to the problem of adverse selection of funding (choosing the source of funding in terms of its price). The payment of dividends should not result in the company raising additional debt financing or other costs that worsen its financial position.

1. Research methodology and data sampling

To assess the impact of internal growth, the key rate, sales and other characteristics of the company on business profitability (profitability of economic activities) 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 fodder), ferrous and non-ferrous metallurgy, mechanical engineering (production

[4] Decision of the European Court of Human Rights dated 07.11.2002 in the case Olzhak v. Poland. https://clck.ru/32RRAv.
[5] Resolution of the Ninth Arbitration Court of Appeal dated November 18, 2020 in case No. A23-6808/2016. https://clck.ru/32RRHb.
[6] Ruling of the Supreme Court of the Russian Federation dated June 8, 2021 No. 305-ES21-9270. https://clck.ru/32RRQq.
[7] Resolution of the Fifteenth Arbitration Court of Appeal dated April 23, 2019 in case No. A53-1473/2017. https://clck.ru/32RRWw.

of parts and accessories for cars and engines), electric power industry, construction (general construction works), trade (retail trade in food and non-food goods), transport (transportation through pipes, maritime transport), telecommunications (communication services). The sample included public Russian companies with a total income of more than 10 billion rubles.[8] The selection criterion is the availability of reports in accordance with international financial reporting standards. The company's shares must be traded on the stock market. The information about organisations was obtained from annual financial statements, issuers' reports, data on corporate websites, as well as data from PJSC Moscow Exchange. Key rate data was taken from the website of the Bank of Russia. The sampling period is 2018-2021. The number of observations for each company varies (for some companies – 2018-2021, for others – 2019-2021), so the data is unbalanced. Econometric calculations were made using the statistical package Stata.

When evaluating the econometric model, a dependent variable (explained variable) was used - the profitability (profitability) of assets (an indicator that assesses the profitability of a business).

As independent (explaining) variables were selected: the tangibility of assets, the overall level of dividend payments. We use these independent variables proposed in [Frank, Goyal, 2007; Chang et al., 2018; Almeida et al., 2021]. In addition, three independent variables are included in the model: the internal growth rate (the impact of management on business profitability), sales growth, and the key rate of the Bank of Russia.

Return on assets (ROA) (%) – the ratio of profit after tax (net profit) to the total value of assets.

The tangibility of assets (PPE/A) is calculated as the ratio of fixed assets to total assets. This indicator allows you to evaluate the source of funding.

The overall level of dividend payments (Dividend) is defined as the ratio of the amount of dividends paid to the total amount of assets. This indicator influences the behaviour of potential investors (includes an informational signal about the share price); it is also an indicator of financial constraints (because net income is the source of dividends and funds directed to the formation of various funds and capital growth of the company). Financial constraints arise from external shocks to the supply of capital – an asymmetry in the reliability of information between investors and the company. Management has more information than a potential investor.

The indicator of internal growth or the impact of management on business profitability (g) is fundamental. This indicator allows you to eliminate external factors (erroneous market estimates, macroeconomic aspects). It represents the internal part of the company's value growth and allows to identify the real contribution of management to the company's value [Daniel, Titman, 2006]. This indicator is calculated as

$$g_{i,t} = \log\left(\frac{ME_{i,t}}{ME_{i,t-3}}\right) - \log\left(r_{i,t-3,t}\right),$$

Where *ME* is the market capitalisation, *r* is the logarithm of the average stock return. The Russian stock market is unstable (especially under the conditions of external sanctions). The long-term period is considered as three years or more. This period makes it possible to take into account negative shocks (externalities) that may affect stock returns. Also, the indicator of internal growth allows you to assess the warning motive, that is, the readiness of the organisation to switch to internal sources of financing (in particular, internal cash reserves) in the face of financial constraints. Russian public companies that faced with financial constraints, are exposed to the problem of adverse selection of financing, that is, the choice of a source of financing, taking into account its price.

Sales growth (%) is defined as the ratio of the change in revenue to the amount of revenue at the beginning of the period.

Key rate of the Bank of Russia (Rate) (%).

All independent variables are lagged. The lag is one year. Descriptive statistics is presented in Table. 1.

Table 1
Summary statistics

Variable	Average	Standard deviation	Minimum value	Maximum value
Return on assets	7.716	9.913	-18.9	44.1
Asset tangibility	0.455	0.242	0.02	0.89
General level of dividend payments	0.041	0.051	0	0.22
Internal growth	0.071	0.207	-0.5	0.67
Sales growth	10.073	18.319	-55.4	66.5
Key rate of the Bank of Russia	6.355	1.457	4.25	7.75

[8] The Order of the Federal Tax Service of Russia dated May 16, 2007 No. MM-3-06/308@. SPS "Consultant Plus".

On average, the profitability of assets is 7.7% of total assets. The value of fixed assets averages 45.5 kopecks for each ruble of total assets. The average value of dividend payments is 4.1 kopecks for each ruble of total assets. The influence of management on business profitability is determined by an average of 7.1 p.p. On average, annual sales growth is 10%.

2. Evaluation and analysis of the model

Consider a regression model that evaluates the impact of internal growth, key rate, sales and other company characteristics on business profitability:

$$ROA_t = a_0 + a_1(PPE/A)_{t-1} + a_2(Dividend)_{t-1} + a_3(g)_{t-1} + a_4(Sales)_{t-1} + a_5(Rate)_{t-1} + \varepsilon_t,$$

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

For the model, panel data analysis was carried out to evaluate three types of regressions: end-to-end, with a random effect, and with a fixed (established) effect. When comparing end-to-end regression with regression with fixed effects, the Wald test was used; when comparing end-to-end regression with regression with random effects – the Breusch-Pagan test, when comparing regression with random effects with regression with fixed effects – the Hausman test. Testing was carried out to select the most adequate (qualitative) model with respect to forecasting (Tables 2, 3).

The most appropriate model for assessing the impact of internal growth, key rate, sales and other company characteristics on business profitability is a pass-through model (individual effects are not related to the selected independent variables). In addition, to improve the accuracy of the forecast, the regression model was tested for adequacy, heteroscedasticity and multicollinearity (robustness).

To test the model for adequacy, a Ramsey test was performed at a significance level of 5%. During testing, a significance level of 78.30% was revealed. The main hypothesis about the correct specification of the original model is not rejected. The model is adequate.

The test for heteroscedasticity was carried out using the White test. The significance level was 91.56%. The main hypothesis of homoscedasticity is not rejected at the 5% significance level. The hypothesis of the

Table 2
A model that considers the impact of internal growth, key rate, sales and other characteristics of the company on business profitability

Model	Regression					
	Pooled		Random effect regression		Fixed effect regression	
	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error
Asset tangibility	6.680 (1.86)*	3.600	6.680 (1.86)	3.600	6.885 (1.12)	6.146
General level of dividend payments	88.351 (5.23)	16.887	88.351 (5.23)	16.887	63.916 (1.86)	34.359
Internal growth	12.349 (2.96)	4.177	12.349 (2.96)	4.177	11.341 (2.39)	4.741
Sales growth	0.111 (2.22)	0.050	0.111 (2.22)	0.050	0.105 (1.89)	0.055
Key rate of the Bank of Russia	-1.740 (-2.81)	0.619	-1.740 (-2.81)	0.619	-1.723 (-2.71)	0.636
Constant	10.103 (2.49)	4.053	10.103 (2.49)	4.053	11.043 (2.20)	5.012
Number of observations	86	—	86	—	86	—
Determination coefficient R^2 (%)	42.47	—	—	—	19.74	—
F-statistics	11.81	—	—	—	3.49	—
Wald statistics	—	—	59.06	—	—	—

* The t(z) statistics are presented in parentheses, showing the level of significance of the model parameters.

Table 3
Choosing a model for the adequacy (quality) of forecasting

Indicator	Wald test	Breusch-Pagan test	Hausman test
Значение статистики (*p*-value)	0.59 (0.801)	0.00 (1.000)	1.20 (0.945)
Conclusion	End-to-end regression is preferable to fixed effect regression	End-to-end regression is preferable to random effect regression	Random effect regression is preferable to fixed effect regression

presence of heteroscedasticity is rejected (the hypothesis of the presence of autocorrelation of residuals, leading to a decrease in the accuracy of the forecast, can be rejected).

In addition, a test was carried out for the presence of a relationship between independent variables (multicollinearity – VIF (variance inflation factor), a multiplier that increases the variance). There is multicollinearity in the model if for one of the independent variables the value of the VIF coefficient is > 10. In this case, the largest value is much lower than 10 (VIF = 1.19), the average VIF value for all parameters is 1.11. There is no multicollinearity in the model (the hypothesis of multicollinearity is rejected).

All indicators, except for the tangibility of assets, are significant at a significance level of 5%.

In the context of financial constraints and negative factors (including sectoral sanctions), the management of Russian public companies will be active in achieving business profitability (positive relationship between internal growth, dividend payments and return on assets).

Dividends are a benchmark for potential investors. The growth of dividend payments corresponds to the level of profit in the future (positive relationship between dividend payments and return on assets). The position of the author coincides with the logic of Ch. Ham et al. [Ham et al., 2017]. In addition, it can be said that the growth of dividend payments reflects the reduction in risk [Grullon, Michaely, 2002], taking into account the indicator of internal growth. Dividend payments are an indicator of financial constraints, allowing the company to solve the problems of adverse selection - the choice of a source of financing, taking into account its price.

The management of Russian public companies in the face of financial constraints and tight monetary policy of the Bank of Russia is likely to act in line with the warning motive – focusing on domestic sources of investment financing (positive relationship between internal growth and profitability). Since the precautionary (saving) motive may be associated with financial instability, companies try to create a cash reserve [Myers, Majluf, 1984].

In addition, a positive relationship between internal growth and business profitability indicates a strong influence of management on the company's financial strategy. Management not only influences the share price, but also adjusts the level of risk taking into account information signals from the markets.

An increase in the key rate worsens investment prospects (negative relationship between the key rate and business profitability).

It is likely that the management of Russian companies will redistribute their own capital through a dividend policy, since dividends can be an investment resource.

Finally, sales growth provides the company with an additional opportunity to increase investment in current assets (positive relationship between sales and return on assets).

Conclusion

The consequences of the monetary policy of the Bank of Russia (in this case, the growth of the key rate, which does not take into account the profitability of Russian business and is not focused on the real sector) negatively affects the investment potential of companies. In line with the warning motive, Russian enterprises will strive to pursue a policy of retaining part of the profits (including redistributing their own capital) for further channeling it into investment projects, taking into account their priority, as well as paying off their debt and adjusting the debt level. Dividend payments, in turn, serve to signal profits to shareholders and potential investors. The management of Russian public companies actively respond to external negative signals by adjusting their financial strategy and implementing a policy of recapitalisation (changes in the capital structure) through the use of internal sources of financing.

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About the author

Sergej I. Lutsenko

Analyst at the Institute of Economic Strategies of the Department of Social Sciences of the Russian Academy of Sciences (Moscow, Russia), co-author of the document "National Security Strategy of the Russian Federation", co-author of the document "Development strategy of the electric grid complex of the Russian Federation", author of the project "Contours of the Concept of developing the financial cluster of the Russian Federation in the long-term period". ORCID: 0000-0002-0957-5375.

Research interests: corporate governance, financing companies, capital structure.

scorp_ante@rambler.ru

作者信息

Sergej I. Lutsenko

俄罗斯科学院社会科学部经济战略研究所分析师（俄罗斯莫斯科），"俄罗斯联邦国家安全战略"、"俄罗斯联邦电网综合体发展战略"合著者，"俄罗斯联帮金融集群长期发展的理论概念外形"起草人。ORCID：0000-0002-0957-5375。

研究领域：公司治理，公司投资，资本结构。

scorp_ante@rambler.ru

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Implementation of strategic infrastructure projects: Modeling of effects and results

L.V. Prikhodko[1]
E.V. Arsenova[1]
[1] Financial University under the Government of the Russian Federation (Moscow, Russia)

Abstract

The article describes the modelling of strategic infrastructure project effects and results using methods of analysing direct and indirect effects and helping to determine the feasibility of railway infrastructure project implementation. Neglecting this fact significantly reduces the overall efficiency of infrastructure projects, and in some cases leads to the wrong decisions that reject project implementation.

Investigations made by authors allow to identify, classify and quantitatively estimate the direct and indirect effects from the implementation of infrastructure projects, including integrated assessment of budgetary efficiency and an assessment of economic effects for the development of territories.

Among indirect effects the special attention was paid to the multimodal effects resulting from the redistribution of passenger and cargo flows and more rational capacity of the transportation system. The attention was paid to the multiplier effects caused in related sectors of the economy, agglomeration effects leading to increased connectivity of urban and suburban areas and the corresponding growth in employment, investment and productivity, the effects of optimising subsidies, etc.

Scenario forecasting procedures were used within the presented investigations. Macroeconomic effects, bottlenecks in the railway system impact on the level of undertransportation of goods as well as price arbitrage were determined for various scenarios.

Keywords: strategic management, infrastructural projects, railway system development, direct and indirect effects.

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战略性基础设施项目的实施：效应和结果的建模

L.V. Prikhodko[1]
E.V. Arsenova[1]
[1] 俄罗斯联邦政府金融大学（俄罗斯莫斯科）

摘要

该文章提出使用估计直接和间接影响的方法对战略性基础设施项目的实施效应和结果的建模。这些方法在确定铁路基础设施发展项目的可行性方面发挥了关键作用。如果不考虑这些效应和结果，基础设施项目的实际整体效率将被大大低估，在某些情况下会导致不实施这些项目的错误决定。

作者所做的计算已经确定并结构战略性基础设施项目的实施直接和间接的效应，对已其进行量化，包括对财政效率的全面评估和对领土发展的经济影响的评估。

在众多的间接效应中，特别注意的是由于客流和货运的重新分配以及更合理地使用运输网络而产生的多种形态效应；在相关经济部门引起的乘数效应；导致城市和郊区的连通性增加并相应增加就业、投资和生产力的集聚效应；补贴优化的效应等。

计算中使用了情景预测程序。对不同情景，确定了宏观经济效应并评估了铁路网络瓶颈对投资货物部门的货运短缺和价格套利的影响。

关键词：战略管理，基础设施项目，铁路发展，直接和间接效应。

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Введение

The key tool for economic growth and overcoming restrictions is the implementation of strategic infrastructure projects in the field of railway transport. At the same time, such projects are very capital-intensive and often cannot be implemented in full due to limited funding. This factor plays a particularly significant role in the current conditions of sanctions pressure.

Making a decision on the implementation of large infrastructure projects requires a thorough analysis of the socio-economic effects that accompany the implementation of such projects, as well as the development of the most effective tools to increase the socio-economic level of the development of territories through the implementation of infrastructure projects for the development of railway transport hubs [Jesionkiewicz, 2017; Cengiz et al., 2022].

The results of modeling various options for underfunding the development of railway transport and the formation of unsatisfied demand for transportation showed a significant slowdown in the pace of economic development in the presence of infrastructural constraints [Gorelik et al., 2022].

It is important that the calculations performed showed the importance of developing not only freight, but also passenger high-speed, rapid and suburban transportation, the level of which is directly related to transport opportunities and incomes of the population.

1. Effects from the implementation of strategic infrastructure projects

According to the Strategy for the Development of Railway Transport in the Russian Federation until 2030 railways will allow the Russian state, economy and society to achieve the following results:[1]

- acceleration of economic growth in Russia and multiplier effect on GDP growth;
- reduction of transport costs of economic entities and release of funds for the development of other areas of the domestic economy;
- formation of territorial industrial and scientific clusters and minimisation of disproportions in interregional development;
- Ensuring broad trade links between economic centers;
- increasing the overall competitiveness of the Russian economy and the country's attractiveness for business development and investment inflows;
- development of transport engineering and other interrelated sectors of the economy.

All generated effects can be classified into direct and indirect ones [Blanquart, Koning, 2017; Yan, Lee, 2021; Du et al., 2022].

Direct effects are measured through gross value added (GVA) [Buzulutskov et al., 2020], which is the difference between the cost of an industry's products and the cost of the resources needed to produce it, and is calculated as the difference between the output of goods and services and their intermediate consumption[2]. The following elements are distinguished in the composition of gross value added:

- payroll fund for employees (including social insurance);
- net profit;
- net mixed income;
- taxes on production;
- production subsidies (–);
- consumption of fixed capital;
- indirectly measured financial intermediation services (–).

The effects can be assessed both at the level of the country as a whole and for individual regions. In the first case, the input-output balance for the country is used, in the second - the processes of production and distribution of products of the corresponding region. At the same time, the regional intersectoral balance, as a rule, differs significantly from the intersectoral balance of the national economy. This is due to differences in the structures of outputs and final demand, as well as in the value of specific material costs. The latter is explained by the fact that in the same sectors of the national economy, different regions have industries

[1] https://annrep.rzd.ru/reports/public/ru?STRUCTURE_ID=4498.
[2] https://rosstat.gov.ru/bgd/free/b99_10/isswww.exe/stg/d010/i010810r.htm.

with different characteristics of the output structure and technologies used [Pyataev, 2016; Hanke, 2017].

Indirect effects take into account the demand that is formed in sectors that produce resources for the railway industry and supply it [Zhou et al., 2021]. Thus, in the course of the development of railway transport hubs, there is a corresponding increase in the costs of intermediate products (fuel, electricity, materials, etc.), which leads to an increase in production in related industries [Yu et al., 2019; Petri et al., 2021]. Further, through the costs of related industries, there is growth in almost the entire economy. An increase in gross output is accompanied by a corresponding increase in income: taxes, wages, profits, which are redistributed and transformed into an increase in the final demand of the state, business, and the population [Wu et al., 2021].

In the context of the generated effects, it is important to note the impact of transport projects on the real estate market, which is multidirectional: the construction of new infrastructure can lead to both a drop in real estate prices (due to an increase in noise levels, changes in view parameters, environmental pollution) and their growth (improvement transport accessibility and saving time) [Lapidus, 2013; Zhou et al., 2021].

In addition, when assessing the economic effects generated by the projects for the development of railway transport hubs, it is necessary to take into account the so-called external effects that arise in a situation where the social or economic activity of one structure has an impact on another structure (group of persons) and this impact is not taken into account or not compensated [Trachuk, Sayapin, 2014; Jhangiryan, 2021; Jiang et al., 2022]. Such effects can be both positive and negative.

In terms of railway transport, the former can be classified [Kumar, 2021]:

- saving time on the way for passengers and cargo;
- increase of safety of transportations of passengers and cargoes;
- reduction of emissions of harmful substances and noise level (when choosing alternative options);
- beneficial effects of public transport due to increased physical activity;
- social integration and barrier-free environment;
- subjective wellbeing – perception of the surrounding world or the level of happiness.

Negative effects are formed by the following components [Blanquart, Koning, 2017; Chen et al., 2021]:

- environmental pollution, climate change, increase in noise level;
- negative impact on nature and landscape.

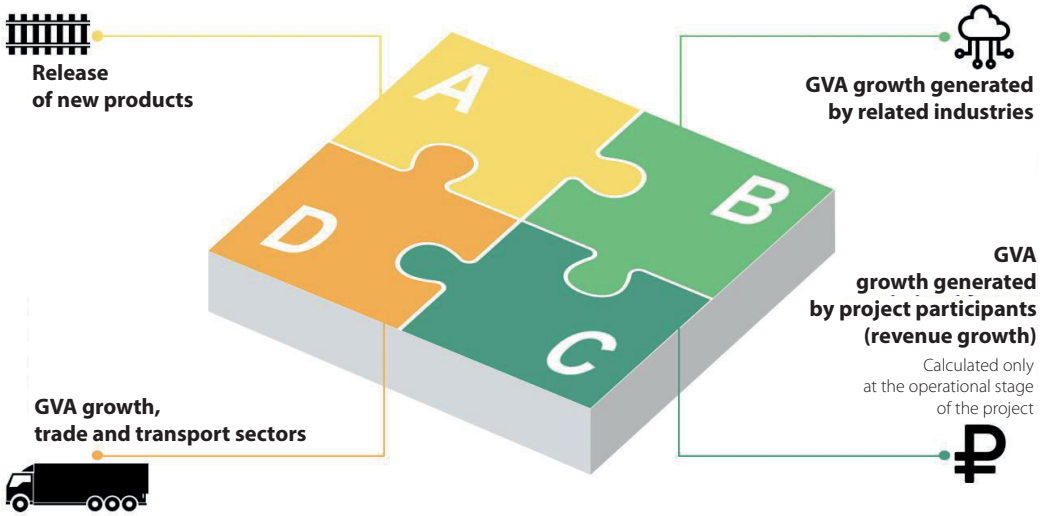
The final effect of the project implementation can be obtained by comparing the potential benefits and costs, including through a comparison of various alternatives.

Thus, the performance indicators for the implementation of infrastructure projects for the development of railway transport hubs can be classified into two groups: economic effects and social effects.

Within the first group, potential effects are achieved through an increase in gross value added in four areas (Fig. 1). The second group forms six potential effects, which are presented in Fig. 2.

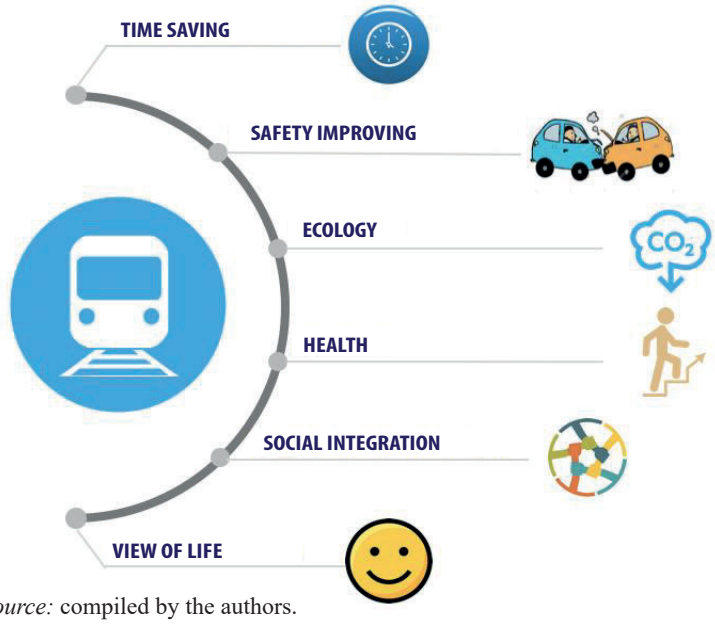
The quantitative measurement of the considered effects is possible on the basis of econometric modeling, which is characterised by a high degree of individuality for each individual railway project.

Fig. 1. GVA growth generated by implementation of investment and operational stages of infrastructure project



Source: compiled by the authors on the basis of the Methodology approved by the Decree of the Government of the Russian Federation of November 26, 2019 No. 1512.

Fig. 2. Positive effects generated by infrastructure projects in railway transport



Source: compiled by the authors.

2. Model of dependence of investments in the development of railway infrastructure projects and positive socio-economic effects

Most infrastructure projects are characterised by insufficient funding from both private investors and the state. In this regard, there is a need for a better justification of financing the implementation of infrastructure projects by building a model that allows for scenario forecasts to identify the most effective and efficient approaches to their implementation.

Such a model should reflect the principles of quality infrastructure investments, such as:

- compliance with the goals of sustainable development and ensuring the growth of the national economy;
- economic efficiency throughout the life cycle of the infrastructure project;
- minimal negative impact on the climate and the environment;
- resistance to natural and emergency events;
- compliance with socially oriented goals;
- managerial efficiency and transparency in making investment decisions [Kuzmin, 2020; Linder, Litvin, 2020].

In our opinion, to deeply analyse the relationship between investments in infrastructure projects for the development of railway transport hubs and the achievement of positive socio-economic effects, as well as an increase in the level of development of territories, a structured model of econometric equations based on the CDM model is most appropriate [Trachuk, Linder, 2016 ; 2020].

The structural model developed by us consists of three main parts.

1. The first part is an analysis of investments in infrastructure projects for the development of railway transport hubs.

The first group of equations of the model is designed to estimate the probability that the state, region or private investor will make a decision to invest in infrastructure projects for the development of railway transport hubs. In the case of a decision to invest it estimates the relative amount of investment (intensity) defined as the amount of investment related to the population of the region.

To specify the first part of the model it was decided to use Heckman's censored regression equations. A feature of this model is the ability not only to assess the probability of making a decision on investments in development projects, but also to calculate the relative value of these investments. The model consists of two relations. The first equation is a binary choice model that evaluates the binary decision "invest / not invest" depending on a number of factors that will be defined later in the text. The second ratio is a linear model that determines the relative amount of investment in infrastructure projects for the development of railway transport hubs. It should be noted that the advantage of the Heckman model is the ability to take into account not only the regions that are already investing in railway infrastructure development projects, but also those where it is only planned to invest.

Thus, the specification of the first part of this mathematical model has the form expressed by equations (1) and (2).

The first equation has a latent (unobservable) variable that describes a region's decision to invest in rail infrastructure:

$$D_i = \begin{cases} 1, \text{если } D_i^* = d_i x + \varepsilon_i > \vartheta \\ 0, \text{если } D_i^* = d_i x + \varepsilon_i \le \vartheta \end{cases}, \quad (1)$$

where D_i is an explicit variable that takes the value 1 if the region has decided to invest in the development of the railway transport infrastructure, and 0 if not; D_i^* is a latent variable that describes the probability of a region investing in railway infrastructure and is a conventional regression model that depends on a number of factors – independent variables; d_i are independent variables that are factors influencing a region's decision to invest in railway infrastructure; x – column vector of model parameters; ε_i – is a column vector of residual terms (random errors).

Heckman's censored regression uses the assumption that random errors are described by a normal distribution.

Regions are inclined to invest in infrastructure projects for the development of railway transport hubs if the explicit variable D_i is above a certain threshold value ϑ, which can be characterised as a selection criterion, for example, the projected amount of socio-economic effect from investing in railway infrastructure.

To determine the factors d_i that influence the region's decision to invest in railway infrastructure, an analysis of the Moscow and St. Petersburg railway transport hubs was carried out. Based on this analysis, a list of factors was compiled:

- d_1 – economic/financial factors due to the need to attract a significant amount of financing to the infrastructure project;
- d_2 – management factors due to insufficient support from the leadership of the region or the development strategy;
- d_3 – competence factors due to the lack of qualified personnel capable of developing and subsequently supervising the implementation of an infrastructure project;
- d_4 – regulatory factors caused by the pressure of regulatory bodies and other authorities;
- d_5 – technological factors due to the infrastructure readiness of the region, the deterioration of the existing railway networks and nodes.

The second relation in Heckman's censored regression describes the relative amount of investment when deciding whether to make investments in the first equation of the model, which is expressed as the amount of investment in the development of railway infrastructure, calculated per inhabitant of the region:

$$Inv_i = \begin{cases} Inv_i^* = i_i y + e_i, \text{если } D_i = 1 \\ 0, \text{если } D_i = 0 \end{cases}, \quad (2)$$

where Inv_i is an explicit variable that takes the value of the amount of investment in the development of railway infrastructure, if the region decides to invest, and 0 if not; Inv_i^* is hidden variable describing the amount of investment in the development of railway infrastructure; i_i are independent variables that are factors describing the relative amount of investment in railway infrastructure; y – column vector of model parameters; e_i is a column vector of residual terms (random errors).

2. The second part of the model describes the dependence of investments in various elements of the railway infrastructure on the intensity of investments in infrastructure projects.

According to the study [Kuzmin, 2020], the following areas of investment in railway infrastructure elements can be distinguished:

Modernisation of railway infrastructure in order to increase the speed of rolling stock. One of the most important indicators of the effective functioning of the railway infrastructure is the ability of rolling stock to reach its set speed on track sections. At the same time, general figures for the average speed weighted along the length of sections are often given, but the actual average section speed is ignored, which often turns out to be significantly lower due to the need for trains to accelerate or brake for a long time in front of sections with appropriate speed limits[3].

For example, according to the "Speed in Priority" study[4], the weighted average speed over the length of route sections is more than 70 km/h, while the average section speed is 40.9 km/h, which negatively affects the overall efficiency of the railway infrastructure.

Also, the speed of rolling stock is significantly slowed down due to the non-uniform electrification of railway tracks. When a train moves from tracks electrified with direct current to tracks using alternating current technologies, it is necessary to change the locomotive, inspect the train, etc., which significantly increases the total travel time.

Development of multimodal terminal and logistics centers. The development of such promising elements of the infrastructure of railway networks as multimodal terminal and logistics centers is capable of increasing freight and passenger traffic.

The lack of multimodal terminal and logistics centers leads to significant time losses in the accumulation of goods, their redistribution and also increases the range of rail transport, thereby reducing its attractiveness relative to road or sea.

The main areas of investment can be: the construction of new or improvement of existing container terminals, the provision of large hub terminals with smaller satellite terminals. It is also important to build new warehouses and revise approaches to the provision of warehouse services in order to increase the share of goods requiring special transportation conditions and, in general, to increase the comfort of using the railway infrastructure for shippers and consignees.

Development of transport interchange nodes. The development of transport hubs and other elements of passenger infrastructure can have significant agglomeration effects, expressed primarily in the growth of wages and, as a result, tax deductions in large agglomerations, as well as in a number of other indirect effects, such as improving the quality of life due to noise reduction, safety improvement, carbon emission reduction, real estate development, etc.

Modernisation of border crossing infrastructure. Train traffic often slows down when crossing border points. This

[3] Overview of the cargo transportation industry in Russia (2018). EY. https://assets.ey.com/content/dam/ey-sites/ey-com/ru_ru/topics/automotive-and-transportation/ey-overview-ofthe-cargo-industry-in-russia.pdf.

[4] Tsypleva N. (2017). Speed is the priority. Gudok, 155(26294), 6 Sept. http://www.gudok.ru/newspaper/?ID=1385773&archive=2017.09.06.

is due to many factors. For example, the need to change the gauge of the rolling stock from the railway gauge of 1520 mm to the gauge of 1435 mm greatly slows down the passage of the border crossing. As a result, it is necessary to spend time reloading containers on the rolling stock of the appropriate gauge or to change the bogies of the wagons, which as a result leads to costs on the side of consignors and consignees.

In addition, slowdowns may be due to the low processing capacity of the border crossing in general, as well as the lack of automation of customs processes and customs document flow.

Implementation of digital platform solutions. As noted above, the digitalisation of railway transport hubs will not only increase the efficiency of the transport system, the throughput of nodes, but will also have a beneficial effect on all market participants.

The introduction of digital platforms is designed to improve the ease of use of urban and intercity transport infrastructure for passengers, increase the efficiency of integrating rail transport into the urban transport system, improve the reliability and quality of services provided for consignors and consignees, the speed of customs checkpoints and border crossings, as well as increase the speed of the MTLC.

Thus, the specification of the second part is mathematically expressed by the relations:

$$SpeedInv_i = \overline{Inv_i} z + k_i \alpha + \epsilon_i, \quad (3)$$

where $SpeedInv_i$ is the region's investment in the modernisation of the railway infrastructure in order to increase the speed of rolling stock; $\overline{Inv_i}$ is the average volume of investments in the development of railway infrastructure, calculated per inhabitant of the region; k_i are independent variables that are factors describing investments in railway infrastructure elements; α is the column vector of model parameters; ϵ_i – column vector of residual terms (random errors);

$$MTLCInv_i = \overline{Inv_i} z + k_i \alpha + \epsilon_i, \quad (4)$$

where $MTLCInv_i$ is the region's investment in the development of multimodal terminal and logistics centers;

$$TRUInv_i = \overline{Inv_i} z + k_i \alpha + \epsilon_i, \quad (5)$$

where $TPUInv_i$ is the region's investment in the development of transport hubs;

$$PogranInv_i = \overline{Inv_i} z + k_i \alpha + \epsilon_i, \quad (6)$$

where $PogranInv_i$ is the region's investment in the modernisation of border crossing infrastructure;

$$DigiInv_i = \overline{Inv_i} z + k_i \alpha + \epsilon_i, \quad (7)$$

where $DigiInv_i$ is the region's investment in the implementation of digital platform solutions.

3. The third part of the model analyses the relationship between the relative amount of investment in infrastructure projects for the development of railway transport hubs and the achievement of positive socio-economic effects.

As noted by researchers earlier, the economic effects from the introduction of infrastructure projects for the development of railway transport hubs are complex and relate to many aspects of the functioning of the regional economy: the labor market, the productivity of industrial enterprises and small firms, and are also expressed in stimulating a direct expansion of sales opportunities, opportunities entering new markets or the emergence of new firms and, as a result, an increase in the number of jobs.

The combination of these factors leads to an increase in the activity of development companies in the region, which also increases the standard of living of citizens. The development of residential and commercial construction increases demand in the markets of labour and building materials, thus having indirect effects on other sectors.

In turn, an increase in supply in the real estate markets makes it possible to reduce the population density, which, coupled with the improvement of the transport connectivity of the districts, increases the standard of living of residents.

In addition, the current study identified a number of direct and indirect effects:

Direct Effects:

- increase in gross value added during the implementation of a non-structural project;
- increase in tax and other mandatory payments arising in related sectors of the economy.

Positive indirect effects:

- agglomeration effects expressed as wage growth;
- reducing costs and lost taxes by improving the safety of passenger and cargo transportation;
- reducing emissions of harmful substances and noise level;
- subjective wellbeing benefits.

Negative indirect effects:

- environmental pollution, climate change, increased noise levels;
- negative impact on nature and landscape.

Thus, the socio-economic effect from the implementation of infrastructure projects for the development of railway transport hubs can be described by the relation (8):

$$SocEff_i = VDS + Nal + Agl + Safe + Clean + \\ + Well - Waste - Distr, \quad (8)$$

where VDS is the increase in gross value added during the implementation of a non-structural project; Nal – increase in tax and other mandatory payments arising in related sectors of the economy; Agl – magnitude of

agglomeration effects; *Safe* – the magnitude of the effects of reducing costs and lost taxes by increasing the safety of passenger and cargo transportation; *Clean* – the magnitude of the effects of reducing emissions of harmful substances and noise levels; *Well* – the value of subjective welfare benefits; *Waste* – the amount of damage from environmental pollution, climate change, increased noise levels; *Distr* – the amount of damage from the negative impact on nature and landscape.

In turn, the relationship between the relative value of investments in infrastructure projects for the development of railway transport hubs and the achievement of positive socio-economic effects is described by equation (9):

$$SocEff_i = \overline{Inv_i}z + SpeedInv_i\beta + MTLCInv_i\beta + TRUInv_i\beta + \\ + ProgranInv_i\beta + DigiInv_i\beta + \sigma_i, \quad (9)$$

where $SocEff_i$ – socio-economic effect from the implementation of infrastructure projects for the development of railway transport hubs; α and β are the corresponding column vectors of model parameters; σ_i is a column vector of residual terms (random errors).

For a deeper analysis of the relationship between investments in infrastructure projects for the development of railway transport hubs and the achievement of positive socio-economic effects, as well as an increase in the level of development of territories, it was decided to consider two calculation scenarios in the analysis.

Scenario 1: Investments are made in the infrastructure of railway networks, nodes and necessary related facilities, while the level of digitalisation is minimal.

Scenario 2: Investments are made in the infrastructure of railway networks, nodes and necessary related facilities, as well as in the development of digital platform solutions.

2. Research Methodology

A preliminary telephone survey was conducted to verify the key provisions of the model, as well as to prepare questionnaires for subsequent data collection. A preliminary discussion was held with 15 representatives of companies implementing infrastructure solutions in the field of railway tracks and junctions, regional authorities, as well as consulting agencies.

In this case, the experts meet one of the following criteria:

1) the expert occupies a managerial position in a subdivision of an organisation engaged in the implementation of infrastructure projects for the development of railway transport hubs;
2) the expert is a competent consultant specialising in railway infrastructure projects;
3) the expert is a representative of the regional authorities responsible for the implementation of railway infrastructure projects.

After verification of the model and the questionnaire, questionnaires were sent to 204 experts selected according to similar criteria, of which 112 responded, the response was 55%. The characteristics of the sample is presented in Table. 1.

Table 1

Sample characteristics

Characteristics of expert companies	Number of respondents	Share of respondents (%)
Company implementing infrastructure projects:		
less than 5 years	23	21
from 5 years to 10 years	35	31
over 10 years	25	22
Consulting companies	17	15
Regional authorities in the field of transport	12	11

Source: compiled by the authors.

3. Research results

The results of the analysis using the two-stage censored Heckman regression (the first group of equations) are presented in Table. 2. The decision of the regions to invest in railway infrastructure projects was assessed using a probit model, where the independent variables were: economic/financial factors (*d*1), management factors (*d*2), competence factors (*d*3), regulatory factors (*d*4), technological factors (*d*5).

In addition, for the correctness of the calculations, control variables were included, such as the number of inhabitants of the region, the indicator of relations with other regions (binary variable: 1 – donor region, 0 – recipient region) and the regional budget.

The relative value of investments is defined as the volume of investments in the development of railway infrastructure, calculated per inhabitant of the region.

The results demonstrate the significant influence of financial and economic factors due to the high resource intensity of infrastructure railway projects. The decision to invest is significantly influenced by managerial factors.

In these scenarios, both the decision-making and the intensity of investments are significantly influenced by technological factors due to the state of the infrastructure, which is explained by the increased demand for investments in the event of deterioration of existing networks. Regulatory factors show a relatively smaller degree of influence for both scenarios.

The results of the investment analysis in the development of railway transport hubs with a breakdown

Table 2
Forces influencing the regions' decision making on investment in railway infrastructure projects

Exogenous variables	Scenario 1		Scenario 2	
	Decision on investment in railway infrastructure	Relative value of investments in railway infrastructure development	Decision on investment in railway infrastructure	Relative value of investments in railway infrastructure development
Method of analysis	The first component of the model is Heckman's censored regression			
	The first equation	The second equation	The first equation	The second equation
Economic/financial factors (d_1)	0.506 (0.101)	0.621 (0.132)	0.555 (0.106)	0.671 (0.125)
Management factors (d_2)	0.350 (0.092)	0.227 (0.062)	0.406 (0.096)	0.256 (0.088)
Competency factors (d_3)	0.331 (0.071)	0.161 (0.052)	0.321 (0.069)	0.154 (0.069)
Regulatory factors (d_4)	0.198 (0.056)	0.121 (0.048)	0.215 (0.060)	0.138 (0.056)
Technological factors (d_5)	0.244 (0.051)	0.321 (0.069)	0.380 (0.056)	0.357 (0.074)
Region size (log of number of inhabitants)	0.321 (0.069)	—	0.321 (0.069)	—
Relationship indicator (binary variable: 1 – donor region, 0 – recipient region)	0.125 (0.048)	0.129 (0.043)	0.135 (0.050)	0.142 (0.049)
Regional budget (billion rubles)	0.421 (0.087)	0.398 (0.079)	0.450 (0.089)	0.427 (0.075)
Number of observations	112		112	
Model quality assessment – Heckman's lambda	0.225 (0.110)		0.193 (0.102)	
Wald test for Ho, rho = 0	5.64		21.18	
Log-likelihood function	1453.24		3201.37	

Notes: 1. Numbers shown are marginal effect values. 2. Statistical significance of the coefficients: $p \leq 0.01$. 3. Robust standard errors are given in brackets.

Source: compiled by the authors.

by investment areas (the second part of the model) are presented in Table. 3.

The estimated value of the relative value of investments in the development of railway infrastructure has a moderate impact, with the largest values being achieved in the case of investments in the development of multimodal terminal and logistics centers and transport hubs in both scenarios, and in investments in the introduction of digital platforms in Scenario 2.

The implementation of public-private partnership programs has the strongest impact on investment across the board in both scenarios. This feature can be explained by the fact that the model of interaction between private investors and the state has established itself as one of the most effective mechanisms for investing in large infrastructure projects and allows the development of railway junctions as efficiently as possible: the competence of private investors in combination with state subsidies and benefits (in terms of providing access to land or infrastructure on favorable terms, project financing, etc.) allow you to achieve maximum results.

Interaction with representatives of consulting companies most strongly affects investments in multimodal terminal and logistics centers and transport hubs in Scenario 1, as well as investments in digital platform solutions in Scenario 2. This may be due to the fact that consulting companies have a greater understanding of the functioning of railway junctions as parts of urban and agglomeration infrastructure,

Table 3
Results of the railway hubs development investment analysis split in accordance with the areas of investment

Exogenous variables	Scenario 1					Scenario 2				
	SpeedInv (I)	MTLCInv (II)	TPUInv (III)	PogranInv (IV)	DigiInv (V)	SpeedInv (I)	MTLCInv (II)	TPUInv (III)	PogranInv (IV)	DigiInv (V)
1	2	3	4	5	6	7	8	9	10	11
Estimated value of the relative value of investments in the development of railway infrastructure	0.271 (0.062)	0.387 (0.085)	0.392 (0.100)	0.189 (0.058)	0.056 (0.024)	0.264 (0.067)	0.335 (0.079)	0.378 (0.096)	0.192 (0.054)	0.307 (0.084)
Implementation of public-private partnership programmes (1 – yes, 0 – no)	0.396 (0.097)	0.657 (0.142)	0.721 (0.154)	0.385 (0.094)	0.074 (0.021)	0.385 (0.100)	0.664 (0.138)	0.717 (0.162)	0.407 (0.091)	0.651 (0.123)
Interaction with representatives of consulting companies (1 – yes, 0 – no)	0.112 (0.051)	0.345 (0.078)	0.480 (0.102)	0.129 (0.035)	0.154 (0.048)	0.124 (0.060)	0.368 (0.090)	0.475 (0.119)	0.136 (0.039)	0.562 (0.145)
Interaction with specialised flagship universities (1 – yes, 0 – no)	0.208 (0.054)	0.125 (0.048)	0.214 (0.042)	0.201 (0.037)	0.167 (0.023)	0.199 (0.055)	0.146 (0.041)	0.224 (0.045)	0.197 (0.035)	0.343 (0.077)
Region size (log of number of inhabitants)	0.222 (0.067)	0.298 (0.061)	0.303 (0.075)	0.112 (0.053)	0.068 (0.012)	0.217 (0.051)	0.308 (0.069)	0.321 (0.069)	0.139 (0.042)	0.098 (0.034)
Relationship indicator (binary variable: 1 – donor region, 0 – recipient region)	0.117 (0.049)	0.135 (0.047)	0.154 (0.041)	0.122 (0.029)	0.057 (0.015)	0.110 (0.029)	0.123 (0.035)	0.168 (0.031)	0.134 (0.039)	0.112 (0.027)
Regional budget (billion rubles)	0.321 (0.084)	0.374 (0.093)	0.406 (0.121)	0.424 (0.107)	0.117 (0.028)	0.338 (0.082)	0.363 (0.077)	0.416 (0.089)	0.441 (0.094)	0.214 (0.063)
Number of observations	112	112								
McFadden Rsquared	48.31%	54.12%								
LR-statistic	71.23	66.14								
Prob (LR-statistic)	0	0								

Notes: 1. SpeedInv (I) – investments in the modernisation of the railway infrastructure in order to increase the speed of rolling stock; MTLInv (II) – investments in the development of multimodal terminal and logistics centers; TPUInv (III) – investments in the development of transport hubs; PogranInv (IV) – investments in the modernisation of the infrastructure of border crossings; Digi (V) – investment in the implementation of digital platform solutions. 2. Numbers shown have marginal effect values. 3. Statistical significance of the coefficients: $p \leq 0.01$. 4. Robust standard errors are given in brackets.
Source: compiled by the authors.

which allows them to provide effective assistance in the design of infrastructure solutions and lead to greater satisfaction of residents of the territories where these projects are implemented. Also, some consulting companies have extensive expertise in the deployment of industry 4.0 digital technologies, including platform solutions, the integration of which improves the accessibility and usability of the railway transport infrastructure for both the public and commercial users.

Interaction with specialised flagship universities plays the most significant role in the deployment of digital platforms in Scenario 2, since such educational institutions are also centers for the accumulation of competencies in this area and, in particular, serve as platforms for conducting research.

Thus, the results of the analysis show that the most sensitive to the nature of implementation and participants in the implementation of infrastructure projects are

Table 4
Ratio of investments in infrastructure projects aimed at railway transport hubs development and positive socio-economic effects

Exogenous variables	**Equation of socio-economic effects (dependent variable – socio-economic effect from the implementation of infrastructure projects for the development of railway transport hubs)**	
Analysis method – LSM (least squares method)	**Scenario 1**	**Scenario 2**
Estimated value of the relative value of investments in the development of railway infrastructure	0.089 (0.021)	0.096 (0.014)
The intensity of investments in the modernisation of railway infrastructure in order to increase the speed of rolling stock	0.172 (0.063)	0.186 (0.056)
Intensity of investments in the development of multimodal terminal and logistics centers	0.388 (0.102)	0.401 (0.127)
Intensity of investments in the development of transport interchange nodes	0.284 (0.079)	0.322 (0.082)
Intensity of investments in the modernisation of border crossing infrastructure	0.243 (0.058)	0.264 (0.067)
Intensity of investments in the implementation of digital platform solutions	0.112 (0.048)	0.357 (0.099)
Region size (log of number of inhabitants)	0.087 (0.012)	0.093 (0.027)
Relationship indicator (binary variable: 1 – donor region, 0 – recipient region)	0.135 (0.058)	0.144 (0.047)
Regional budget (billion rubles)	0.178 (0.083)	0.199 (0.075)
Number of observations	112	112
McFadden R-squared	48.31%	54.12%
LR-statistic	71.23	66.14
Prob (LR-statistic)	0	0

Notes: 1. The numbers shown have marginal effect values. 2. Statistical significance of the coefficients: $p \leq 0.01$. 3. Robust standard errors are indicated in brackets.

Source: compiled by the authors.

projects for the construction of multimodal terminal and logistics centers, transport interchange hubs and projects for the introduction of digital technologies in the railway infrastructure, since such projects require a wide range of competencies and taking into account the interests of various end users to achieve the maximum socio-economic effect.

The results of calculating the third part of the model - the impact of the relative value of investments in infrastructure projects for the development of railway transport hubs on achieving positive socio-economic effects are presented in Table. 4.

According to the results obtained for both scenarios, the volume of investments in railway infrastructure development projects is positively associated with the positive socio-economic effects achieved, which is consistent with the theory.

At the same time, the strongest positive relationship is observed for investments in the development of multimodal terminal and logistics centers (elasticity is 0.388 in scenario 1 and 0.401 in scenario 2) and transport hubs (elasticity is 0.284 in scenario 1 and 0.322 in scenario 2), and to digital platform solutions in Scenario 2 (elasticity is 0.357).

It should also be noted that the introduction of digital platform solutions in the railway infrastructure increases the efficiency of investing in its other elements, which can be explained by an increase in the connectivity and speed of the entire railway network due to digitalisation, as well as an increase in the level of convenience for both passengers and consignors and consignees.

4. Conclusions and further research

The article considers the main economic effects arising depending on the performance indicators of the implementation of infrastructure projects for the development of railway transport hubs. It was proposed to consider two groups of effects arising depending on the performance indicators of the implementation of infrastructure projects for the development of railway transport hubs: economic and social.

Economic effects include: release of new products; GVA growth generated by trade and transport sectors; GVA growth generated by the project participant (revenue growth); GVA growth generated by related industries. Social effects include: saving time; improving security; ecology; health; social integration; perception of the world.

The constructed econometric model for two scenarios showed that the volume of investments in railway infrastructure development projects is positively related to the positive socio-economic effects achieved, which is consistent with the theory.

At the same time, the strongest positive relationship is observed for investments in the development of multimodal terminal and logistics centers and transport hubs, as well as in digital platform solutions.

Thus, when implementing projects for the development of railway transport hubs, not only economic effects arise, but also social ones, which take into account the most important aspects for the state and society, such as increasing the level of security, improving the environment and public health.

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About the authors

Lilia V. Prikhodko
Candidate of technical sciences, associate professor, head of the Department of International Cooperation, associate professor of the Department of Management and Innovation of the Faculty of Higher School of Management, Financial University under the Government of the Russian Federation (Moscow, Russia). ORCID: 0000-0002-4548-1421.
Research interests: strategy and management of the company's development, international entrepreneurship, analysis of the effects of the implementation of strategic projects.
lvprikhodko@fa.ru

Elena V. Arsenova
Candidate of economic sciences, first deputy dean of the Faculty of Higher School of Management, leading researcher of the Department of Management and Innovation of the Faculty of Higher School of Management, Financial University under the Government of the Russian Federation (Moscow, Russia).
Research interests: formation of a company development strategy, entrepreneurship development, strategies for Russian companies to enter international markets.
earsenova@fa.ru

作者信息

Lilia V. Prikhodko
技术科学副博士，副教授，国际合作处主任，俄罗斯联邦政府金融大学高等管理学院管理与创新系副教授（俄罗斯莫斯科）。ORCID： 0000-0002-4548-1421。
研究领域：公司发展的战略和管理，国际业务，战略项目的实施影响分析。
lvprikhodko@fa.ru

Elena V. Arsenova
经济学副博士，俄罗斯联邦政府金融大学高等管理学院第一副院长，高等管理学院管理与创新系主任研究员（俄罗斯莫斯科）。 研究领域：公司的发展战略塑造，业务发展，俄罗斯公司进入国际市场的战略。
earsenova@fa.ru

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Strategic decisions in budget policy: Economic efficiency and economic feasibility

O.V. Umgaeva[1]

[1] Kalmyk State University Named after B. B. Gorodovikov (Elista, Russia)

Abstract

The well-being of people directly depends on both the economy of the state and the personal economy, the correctness of budget management. Therefore, it is quite understandable that all groups and categories of society are interested in economic processes. Interest, which, in today's changeable world, must be considered a request, does not decrease and requires clarification of categories that evaluate the economy and bring it to the right strategic decisions in budget policy. The economic categories of performance evaluation include economic efficiency and economic feasibility, the essence and difference of which, using specific examples, is evidently presented in this article.

Keywords: strategic decisions, economic categories, budget policy, economic feasibility, economic efficiency, regional budget, expected effect.

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预算政策中的战略决策：经济效率与经济可行性

O.V. Umgaeva[1]

[1] 卡尔梅克国立大学（俄罗斯埃利斯塔）

摘要

人民的福祉直接取决于国家经济和个人经济，预算编制的正确性。因此，我们可以解释社会所有群体和类别对经济过程的兴趣。在当今瞬息万变的世界中，对经济的兴趣成为一种不会减少的要求。有必要澄清评估经济并在预算政策中做出正确的战略决策的类别。评价结果的经济类别包括经济效率和经济可行性。本文通过具体实例介绍了它们的本质和区别。

关键词：战略决策，经济类型，预算政策，经济可行性，经济效率，地区预算，预期效果。

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The state of the modern world economy, the economy of Russia, leads to an understanding of the strategic importance of pursuing a competent and rational budgetary policy of the state, especially in the expenditure side of budget execution at any level. The issues of economic efficiency and economic feasibility were considered by the founders of the economic theory. J. M. Keynes [Keynes, 2015], G. Emerson [Emerson, 1992], W. Petty [Speranskaya, 1987] and others wrote about the effectiveness of their solution in relation to various economic situations. The category of economic efficiency is revealed and systematised in modern works [Abalkin, 1971; Alle, 1998; Smirnov, 2007; Zhemchugov, Zhemchugov, 2013; Shabashev and Batievskaya, 2014; Kriklivets, Sukhomyro, 2019] and many others. According to scientific and practical logic, the entire business

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community is involved in the calculations of these two categories and, of course, the state should be involved in search of the optimal use of resources and budget funds to meet the needs and improve the quality of life of its citizens.

Nevertheless, an analysis of the implementation of budgetary policy at the regional level in the sectoral sphere indicates the presence of numerous examples of the absence of a theoretical approach in the implementation of state tasks. Illiterate and unprofessional, and sometimes even criminal disregard of the legislation, which provides for strict observance of budget parameters, leads not only to misuse, theft, but also to inefficient and inappropriate use of budgetary funds.

In order to avoid the penalties that follow for the above violations, managers of budget funds who do not have the proper qualification, professional, educational training, sometimes simply sabotage state tasks, not fulfilling them and returning money to the budget.

For example, funds allocated for the purchase of apartments for orphans of the Republic of Kalmykia were returned to the federal budget. "In 2020, the republic received additional subsidies from the federal center in the amount of 50.1 million rubles. Of these, 48.4 million were never used. The reason is simple: there are no such apartments on the secondary market that would meet the requirements of the legislation in terms of comfort for orphans"[1]. Thus, the official reason is that they did not find apartments that meet the standards. They were afraid to look for non-standard solutions within the framework of the legislation, or simply responsible persons do not know how to think outside the box.

There are few reverse examples (refusal to implement inefficient, unnecessary activities, programmes, tasks for which funds have already been allocated or allocated to the region), or they appear when the funds have already been spent. "In Kalmykia, a verdict was passed in a criminal case on the theft of 300 million rubles allocated for the construction of the Levokumsky water pipeline and treatment facilities"[2]. Water supply is one of the most important and complex infrastructure tasks for Kalmykia, which, due to natural conditions, is the most arid region in Russia. One of the attempts to solve the problem was the Levokumsky water conduit project, which was supposed to deliver water from an underground source on the territory of the Stavropol Territory 200 km away to Elista. "The very idea of its construction, as we now see, turned out to be erroneous; in our case, a strategic decision is needed, such as a water pipeline from the Volga", said the deputy chairman of the government of Kalmykia[3].

How the efficiency of the project was calculated, the implementation of which was eventually abandoned, is probably a purely rhetorical question. After all, the performers have already been punished, and the designers, it turns out, do not bear responsibility for an error in assessing the effectiveness of a water supply project. Meanwhile, in accordance with the Budget Code of the Russian Federation, the adoption of a budget of any level is preceded by a multi-stage procedure of preparation and approval[4]. It is at the preparatory stage of the budget project that the calculation of efficiency is provided as well as the assessment of expediency. What is the difference? In accordance with the definition of the classics of economic science, "economic efficiency is obtaining the maximum possible benefits from available resources. The producer and consumer of goods strive for the highest efficiency, while maximising their benefits and minimising costs" [Samuelson, Nordhaus, 2014, p. 55]. In practice, this means that a business will be profitable, for which the economic efficiency indicator - result / cost – will be more than one. There is no point in running a business that is not profitable.

Developing the theoretical definition of the category "economic efficiency", modern researchers refine and detail the definition. Thus, the concepts of social, budgetary, commercial, technological, institutional and other efficiencies appeared, the division of economic efficiency into types, types, aspects, etc. The desire to explain the essence of the concept came primarily from the lack of alternatives to this category in economic theory.

Economic feasibility is a relatively new category for economic theory, and its definition in modern science very often duplicates, in fact, economic efficiency, which causes an active discussion. At the Forexdengi forum in the contest of the best answers (finance), the winner was the following definition: "The concept of expediency can be usefulness, reasonableness, rationality or appropriateness. The existing world currently lives in terms of commercial law, therefore, economic feasibility is a measure of the reasonableness of using modern developments when introduced into economic processes.[5]

There are also enough examples of the identity of the terms "economic expediency" and "economic efficiency" in economic journalism to conclude that it is necessary to clarify the essence of the categories. For example, the Internet portal BusinessMan.ru formulates economic

[1] https://vk.com/wall426414311_16381? ysclid=la427a2rym948539399 12 августа 2021 года.
[2] https://elista.bezformata.com/listnews/kalmikii-vinesen-prigovor-po-delu/94962166/?ysclid=la46ewd3np520947252.
[3] The solution of the water issue will be a historic event for Kalmykia: experts talk about the project of the Volga water conduit. https://eacs.center/discuss/reshenie-voprosa-s-vodoj-stanet-istoricheskim-sobytiem-dlya-kalmykii-eksperty-o-proekte-volzhskogo-v?ysclid=la46gokova907896523.
[4] Budget Code of the Russian Federation. https://base.garant.ru/12112604/?ysclid=la47bsm5r7352957620.
[5] Community of forex traders. https://forexdengi.com/forum/forum-treyderov/forekspediya-konkurs-luchshih-otvetov-finansy/131468-chto-takoe-ekonomicheskaya-celesoobraznost.

feasibility as "the possibility of a company making a profit after the sale of its products"[6], considering economic feasibility as a one-time measurement of economic efficiency.

Of course, both concepts are identical from the standpoint of evaluating the result, the expected effect of actions. However, the difference, in the opinion of the author, is obvious: in the case of economic efficiency, the indicator is quantitative, in the case of economic feasibility, it is qualitative. At the same time, performance indicators for the use of budgetary funds should work simultaneously.

The need for a theoretical justification for separating economic feasibility into a category different from economic efficiency is based not only on the emergence of new approaches to assessing any activity, but also on the desire of society to achieve non-commercial goals. In the case of the state budget, budgetary funds, the definition of efficiency does not work in a commercial sense, but within the framework of the state constitution, primarily because of different tasks: for business it is profit, for the state it is the maximum satisfaction of society needs. "The Russian Federation is a social state whose policy is aimed at creating conditions that ensure a decent life and free development of a person"[7], says Article 7 of the Constitution of the Russian Federation. In the case of spending public resources, we expect not just efficiency, but socio-economic efficiency. It, in turn, is measured by the degree of satisfaction of the material, social, spiritual needs of people, which guarantees a high level and quality of life. The indicators are largely relative and poorly correlated with the price measurement. Example: A consumer spent a certain amount to attend a famous artist's concert. The firm - the organiser of the concert, in the event that the proceeds exceed the costs incurred, considers its activities profitable or cost-effective. How to calculate the viewer's personal benefit, profit? Satisfaction of spiritual needs in the calculation of the category of economic efficiency is impossible. Unlike business, a person can only give a comparative assessment – "it was worth it" or "it was not worth it". At the same time, for each individual, the named estimates may include different parameters. The evaluative methods of interviewing and questioning used in economics are precisely aimed at identifying various aspects of the assessment in order to make appropriate decisions supported by the majority. It can be formulated differently: a concert will be cost-effective if at least a thousand spectators, at least one, cover the costs of it. The concert will be economically viable if it still has the number of spectators provided by the concert venue, and most of them will consider that the satisfaction from the concert corresponds to the cost of the ticket, that is, "it was worth it."

The same analogy applies to the calculation of budget parameters at the stage of its preparation. It is impossible to reliably calculate the economic effect of the allocation of funds, for example, to the social sphere. How to translate the effect of recovery into a monetary dimension when allocating funds, for example, for new furniture in a hospital? Comparative parameters are not applicable in the accounting policy, and even more so in the accounting policy of the state. In the example described, economic feasibility is discussed. Yes, the furniture is old, but it performs its function with sufficient quality. Hence, its replacement is inappropriate. It is better to allocate funds for the purchase of new medical equipment to replace obsolete ones.

Thus, the financing of the social sphere (education, healthcare, culture) at the stage of budget formation involves an assessment of economic feasibility. First of all, because in the social sphere, as well as in the areas of protecting law and order, the defense capability of the state, environmental protection, the goal prevails over the economic effect. Such a distinction is simply necessary to balance the state budget at all levels.

The regional budget of the Republic of Kalmykia, because of its subsidies, is regularly criticised due to incorrect emphasis on economic feasibility. For example, the only creative educational institution in the republic, the College of Arts named after V.I. Chonkushev, for which the regional authorities cannot construct a new building. The learning process does not stop, which is unsafe. Since the construction of the building – since 1976 – no major repairs have been carried out. According to the Ministry of Culture of Russia, "as per the passport of the investment project submitted by the region, the total cost of the work is 3.8 billion rubles. The term for commissioning the facility is 2028. It should be noted that there is no design and estimate documentation for the facility. At the same time, the ready-made project already available, the passport of which the federal ministry refers to, "unfortunately, was "hacked to death" by the head of the republic. There is no new project today"[8]. Almost all children's extended education facilities built in the Soviet era require major repairs: an art school, music and sports schools, most of the buildings of children's sports sections of the republic.

At the same time, within the framework of the federal programme "Development of physical culture and sports in the Russian Federation" and the federal project "Sport is the norm of life", the ice skating rink "Dzhungar" was

[6] https://businessman.ru/ekonomicheskaya-tselesoobraznost---eto-otsenka-ekonomicheskoy-tselesoobraznosti.html?ysclid=l8oq6olewv686989283.
[7] http://publication.pravo.gov.ru/Document/View/0001202007040001?index=3&rangeSize=1.
[8] https://kprf.ru/party-live/regnews/212755.html?ysclid=la726jdo8p941172152.

built. The object, of course, is not comparable in cost, but quite comparable in terms of expediency. "The cost of the rink, according to updated data, is estimated at 200 million rubles. At the same time, about 175 million are funds from the federal budget and a potential investor"[9]. The inefficient use of budgetary funds on the example of this object is also indicative. The prosecutor's office of Kalmykia opened a criminal case on the fact of embezzlement of 11 million rubles during the construction of the Dzhungar ice rink in Elista[10]. The ice rink has already been put into operation and works with high operating costs in the warmest region of Russia with the highest electricity tariffs among its neighbors. The skating rink involves the most expensive sports in terms of equipment, which clearly affects the number of visitors to one of the poorest regions in terms of living standards.

The above comparison of objects is selective: when adopting and executing the budget, the ice center "Dzhungar" was not opposed to the College of Arts and other socially significant objects. Such a choice is simply not worth and was not made due to the different departmental subordination of objects, different programmes, different levels of budgets. Nevertheless, the objects are located on the territory of the republic and are necessary for it in order to improve the quality of life of the population. That is why they are comparable with the position of the appropriate use of resources.

In the case of the social facilities of Kalmykia, the role and specifics of regional economic structures are clearly visible, designed to compare the goals of the development and existence of the region with the available resources. In this aspect, of course, economic efficiency comes to the fore. Lack of resources forces you to choose where they will work most effectively. At the same time, it is unacceptable to pursue an economic effect without comparing it with economic expediency. This is the basis of the economy – the Pareto law, which is formulated as "20% of efforts give 80% of the result, and the remaining 80% of efforts give only 20% of the result" [Koch, 2012]. In practice, the law is widely used as a basic setting in the analysis of the efficiency factors of any activity and optimization of its results: "By choosing the right minimum of the most important actions, you can quickly get a significant part of the planned full result, while further improvements are ineffective and may not be justified" [Koch, 2012].

For example, by annually increasing the areas of social assistance as measures to support families with children, the state does not achieve the economic effect – raising the standard of living – but realises the goal – material support. The state sets a goal, which means that in this case the category of economic feasibility is applicable. Other examples can be given where it is necessary to assess the economic feasibility and not take into account economic efficiency. In fact, these are all social payments and additional payments that have the purpose of supporting, encouraging, and not making a profit. At the same time, economic feasibility, of course, requires a financial assessment. After all, it may turn out that in the course of achieving the goal, not everyone was paid, not enough, and as a result, there are 80% of the dissatisfied. It must be admitted that with the additional payment for work in the red zone during the COVID-19 epidemic, adjustments were made several times both in the methodology for calculating the additional payments and in the list of recipients. As a result, payments to doctors (20% of efforts) during the epidemic did not leave us without medical care. Later refined financial actions (80% of efforts both in volume and in directions of expenditure) achieved only 20% of the result: there were not enough beds, medicines, orderlies, there were no scheduled appointments, and mortality did not decrease. It is clear that the ratio is relative, but nevertheless it allows to evaluate quantitatively, in percentage terms, the economic feasibility of the decisions being made. But even in this theoretically sound economic example, the emphasis is on the fact that the actions were expedient. Inaction is worse than ineffective action. This is a qualitative measurement of the social expectation of society, which was satisfied, and therefore expedient.

There are many examples of comparison, intersection of indicators of qualitative and quantitative assessments of performance in all spheres of life, sectoral and regional policy. Therefore, of course, the division of categories is an important stage in further theoretical research in the field of measuring economic feasibility. The philosophical basis of this category, defined as usefulness, reasonableness, rationality or appropriateness, in no way distorts its essence and allows justifying its application in the economy from an interdisciplinary, general scientific point of view in the development, adoption and execution of the budget of any level and any field of activity. The adoption of a theoretical justification for the separation of the categories of economic efficiency and economic feasibility, provided that they are jointly used in budget policy, will be a competent strategic decision.

[9] Steppe News 2019. August 20. https://tegrk.ru/archives/72542.
[10] Business vector https://www.business-vector.info/saratovskaya-kompaniya-mihaila-lysenko-144113/

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About the author

Olga V. Umgaeva

Candidate of economic sciences, associate professor of the Department of Economics at the Enterprise, Kalmyk State University Named after B.B. Gorodovikov (Moscow, Russia). SPIN-code: 6978-6926.

Research interests: regional, sectoral economics, territorial planning, theoretical foundations of economics, budget policy.

umgaev@yandex.ru

作者信息

Olga V. Umgaeva

经济学副博士，卡尔梅克国立大学企业经济部副教授（俄罗斯埃利斯塔）。SPIN 号码: 6978-6926。

研究领域：区域经济，分支经济，空间规划，理论经济学，国家预算政策。

umgaev@yandex.ru

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Risk management algorithm for ensuring the sanitary safety of the population in the area of the oil refinery

M.A. Fomenko[1]
G.A. Fomenko[2]
E.A. Skuratova[3]
[1] Scientific-Production Enterprise "Cadaster" Ltd. (Yaroslavl, Russia)
[2] Group of Companies Institute of Sustainable Innovations (Yaroslavl, Russia)
[3] ANO Research and Design Institute "Cadaster" (Yaroslavl, Russia)

Abstract

The article reveals the main features and characteristics of the algorithm of actions to ensure environmental safety of the population in the areas of oil refineries based on the mechanism of health risk assessment at all stages of the life cycle of environmentally hazardous production facilities. Methodologically, the algorithm implements the provisions of existing standards, regulatory documents and recommendations on health risk assessment of the population and is a sequence of procedures for making informed decisions on ensuring that health risk to the population exposed to potential negative environmental impacts meets the regulatory level. Application of the algorithm ensures compliance with the regulatory level of environmental impacts on the border of the sanitary protection zone of oil refineries and adjacent residential areas.

A special emphasis is made on the stages of design and operation of environmentally hazardous objects, when the level of created health risks is especially sensitive to the results of decisions made. Timely identification of hazards and assessment of health risks at the design stage helps to choose the location of environmentally hazardous facilities, considering created risks in specific industrial and urban conditions. At the operation stage, the areas with highest risk levels of the sanitary protection zone boundary and the industrial site are identified, as well as priority production facilities and chemical toxicants (in terms of created risks). This gives a reason for adjusting the programs of industrial and environmental control, for specifying the priority of investment programs and plans of environmental protection measures. In practical terms the specific features of actions in conditions of high risks are defined to ensure the health risk meets the regulatory level in functioning of environmentally hazardous oil refining object, avoiding significant financial environmental costs as a result of making ecologically insufficiently justified planning and technological decisions at the design stage. The algorithm is universal, because it can be used for the existing production facilities and new construction projects, regardless of industry specifics.

Keywords: risk management, health risk assessment from chemical air pollution, normative level of health risk, the most dangerous areas of the sanitary protection zone boundary, priority risk creating facilities, priority risk creating chemical toxicants.

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确保炼油厂附近居人群的环境安全的风险管理算法

Fomenko M.A.[1]
Fomenko G.A.[2]
Skuratova E.A.[3]

[1] “卡达斯特尔”研究设计院有限公司（俄罗斯雅罗斯拉夫尔）
[2] “可持续创新研究所”科学生产联合公司（俄罗斯雅罗斯拉夫尔）
[3] “卡达斯特尔”研究设计院有限公司（俄罗斯雅罗斯拉夫尔）

摘要

文章揭示了为确保炼油厂所在地区居人群的环境安全而采取的行动算法的主要特点和特殊性，其依据是对环境有害的生产设施的生命周期的各个阶段的健康风险评估机制。在方法上，该算法执行了现有的公共卫生风险评估标准、法规和指南的规定。该算法是一套连续的程序，用于作出明智的决定，以确保暴露于潜在不利环境影响的人群的健康有一个规范的残余风险指标。该算法的应用确保了炼油厂和邻近居群民区的卫生防护区边界符合环境影响的监管水平。

特别强调的是环境危险设施的设计和运营阶段，此时，所带来的健康风险水平对决策的结果特别敏感。在设计阶段及时评估健康风险，可以根据具体工业和城市环境中的危险性来确定环境危险设施的位置。在经营阶段，可确定卫生防护区边界和工业场地的最危险区域，以及优先（就产生的风险大小而言）的生产装置和化学毒物。这为调整工业控制和工业环境控制方案，以及明确环境保护措施的投资方案和计划的优先次序提供了依据。制定了在高风险环境中实际行事的具体内容，为确保环境危险的炼油生产设施运营期间对公众健康的残余风险达到监管水平。在设计阶段提供无害环境规划和技术解决方案的结果是将避免巨大的环境财政成本。该算法是通用的。它既可用于现有的生产基地，也可用于新建筑工地，不受行业限制。

关键词：风险管理，化学空气污染的健康风险评估，残余健康风险规范性水平，卫生防护区边境最危险的地区，有风险的优先装置，有风险的优先化学毒物。

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我们感谢所有分享他们的知识和经验以使所提出的算法客观和有用的专家人士：S.I. Avaliani 教授，S.I. Komarov，D.N. Kirillov，A.A. Rybin，E.V. Osipova，A.E. Borodkin 地理学副博士。

Introduction

In the modern world the creation of wealth is increasingly accompanied by the social production of risks [Beck, 2000], and billions of people, thinking about what is happening, experience confusion and anxiety, as past habits and traditions of managing are losing effectiveness before our eyes. A significant increase in recent years in the role of anthropogenic and natural risks [The global risks.., 2018; 2021; 2022] corrects the very basic understanding of sustainable development[1], which is increasingly seen as the ability of individuals, communities and geosystems[2] to survive; Moreover, the term itself is increasingly being supplemented, and even replaced by the concept of resilience, understood as the preservation of viability and the reduction of vulnerability in a risky external environment.

Such a vision of sustainability is especially relevant when it comes to the population of regions with a highly developed industry, especially mining, oil refining, petrochemical, metallurgical, mineral fertiliser production and heat and power generation industries. The burden of disease attributable to air pollution is now on par with other major global health risks such as tobacco smoking. According to WHO[3], every year exposure to polluted air leads to 7 million premature deaths and a catastrophic reduction in healthy life years. Up to 30% of deaths from the dominant non-communicable diseases (stroke, lung cancer and chronic obstructive pulmonary disease) and 25% of deaths from heart attack are associated with air pollution, with adverse health effects most pronounced among women, children, the elderly and the poor [Rakitsky et al. ., 2019]. Back in 2013, IARC[4] classified outdoor air pollution as carcinogenic to humans (Group 1). An increasing risk of developing lung cancer with increasing air pollution has been confirmed[5].

The size of the negative consequences and damage to health from the impact of industrial emissions on vital organs, at first glance, is incomparable with the situations of major man-made accidents and disasters. Nevertheless, the

[1] On October 20, 1987, at the Plenary session of the UN General Assembly, the Brundtland Commission adopted a resolution defining the basic principle of sustainable development: “This is development that meets the needs of the present, but does not jeopardize the ability of future generations to meet their own needs” [Our Common. ., 1989].
[2] Geosystem - a territorial entity that is formed in close relationship and interaction of nature, population and economy, the relative integrity of which is determined by direct, reverse and transformed links developing between the subsystems of the geosystem.
[3] https://www.who.int/europe/news/item/22-09-2021-new-who-global-air-quality-guidelines-aim-to-save-millions-of-lives-from-air-pollution.
[4] IIARC stands for International Agency for Research on Cancer and is part of the United Nations World Health Organisation.
[5] https://www.iarc.who.int/wp-content/uploads/2020/12/pr292_E.pdf.

available environmental and economic calculations indicate a fairly high, almost comparable level [Brody, Golub, 2014; Golub, 2021].

The rapid development of the oil industry dates back to the mid-1950s, when, according to J. Simon, oil became the most important source of energy in the world [Simon, 2005]. Oil refineries, many of which have historically been located near residential areas, are well-known sources of a wide range of air pollutants. The main recognised air pollutants include: sulfur oxides, nitrogen oxides, carbon monoxide and dioxide, volatile organic compounds (VOCs), volatile PAHs and various metals, especially arsenic, cadmium and mercury [Revich et al., 2004; Fomenko et al., 2010; Valeev et al., 2014; Kampeerawipakorn et al., 2017; Domingo et al., 2020; Marques et al., 2020]. According to IARC[6], some of these substances, such as arsenic, cadmium, and some VOCs and PAHs, are carcinogens; plant workers and people living near refineries are at increased risk of developing various types of cancer [Onyije et al., 2021].

According to Russian legislation, compliance with regulatory environmental requirements is established as one of the mandatory conditions for the operation of an industrial enterprise to exercise the rights of citizens to a favourable environment, reliable information about its condition and compensation for damage caused to health or property by an environmental offense (Article 42 of the Constitution of the Russian Federation). Particularly stringent requirements are imposed on environmentally hazardous facilities[7], which include oil refineries. During the commissioning of new and (or) reconstruction of existing facilities, as well as during their operation, along with ensuring that technological emission standards and (or) maximum allowable emissions[8] are not exceeded, responsibility is established for ensuring an acceptable level of health risk at the border of the sanitary protection zone (SPZ)[9]. Such a regulatory context presents new challenges to the management, management and line personnel of the refinery. Responsibility for the environmental well-being of the population of adjacent territories makes it necessary to consider and evaluate their environmental impacts and measures taken to reduce such impacts in the broad context of risk-based management, in the overall risk management system of the enterprise. It puts the task of reducing health risks among the priorities of effective corporate governance in accordance with the principles of environmental and social responsibility of ESG.

In the risk-oriented logic, ensuring the environmental safety of the population means that the actual value of the health risk created by industrial emissions at the border of the enterprise's sanitary protection zone (outside which residential areas are located) does not exceed the standard level. This health risk value is regarded as an acceptable residual risk[10]; the priority of corporate environmental management is to ensure the regulatory level of residual health risk at all stages of the life cycle of an enterprise / production facility: design, construction, operation (including construction of new facilities on the industrial site), decommissioning. The legislative consolidation of the mechanism of the best available technologies (BAT)[11] largely ensures this condition. Serious attention at the enterprises is paid to the implementation of special measures for the treatment of emissions into the atmosphere, wastewater treatment, waste recycling, which also contributes to the improvement of the environment in the old-developed regions and the reduction of negative impacts on public health. Meanwhile, the insufficiency of technological and environmental measures should be recognised, especially when it comes to the operation of existing enterprises or their reconstruction.

Practice shows that enterprises are often forced to solve the difficult task of achieving and confirming the acceptability of the residual health risk, that is, not exceeding the standard value. The situation is especially acute in the old-developed regions with historically developed fractional buildings, where residential areas are in close proximity to the industrial sites of existing enterprises. In fact, we are talking about the impossibility of reconstruction and modernisation, and sometimes the functioning of existing production due to the risks of exceeding the regulatory indicators of residual health risk, for example, during scheduled repairs, maintenance work, etc.

Under the current conditions undoubtedly there is a need for a serious adjustment in the approaches of the management of industrial enterprises, corporations and industrial groups when making decisions on the development of production activities – not only when choosing a site for new construction, but, above all, when operating existing industries with the possibility of their reconstruction and modernisation according to established environmental requirements. In fact, a universal set of consistently performed actions (procedures), integrated into the existing management systems is required, with the help

[6] https://www.iarc.who.int/wp-content/uploads/2018/07/pr221_E.pdf.

[7] Hazard categories I and II (Chapter VII SanPiN 2.2.1/2.1.1.1200-03 "Sanitary protection zones and sanitary classification of enterprises, structures and other objects").

[8] Art. 16, paragraph 6 of the Federal Law of May 4, 1999 No. 96-FZ (as amended on June 11, 2021) "On the Protection of Atmospheric Air".

[9] Sanitary protection zone is a special territory with a special mode of use, the size of which ensures the reduction of the impact of pollution (chemical, biological, physical) on the atmospheric air to the values established by hygienic standards, and for enterprises of hazard class I and II - to the values established by hygienic standards. standards, and up to the values of acceptable risk to public health (clause 2.1 SanPiN 2.2.1 / 2.1.1.1200-03 "Sanitary protection zones and sanitary classification of enterprises, structures and other objects").

[10] Recognition of the fact that no type of economic activity can be completely environmentally neutral ("presumption of environmental guilt").

[11] The Decree of the Government of the Russian Federation of December 24, 2014 No. 2674-r "On approval of the List of areas of application of the best available technologies", Decree of the Government of the Russian Federation of December 23, 2014 No. 1458 "On the procedure for determining technology as the best available technology, as well as the development, updating and publication of information -technical guides on best available technologies.

of which tasks will be solved to ensure the regulatory level of residual health risk at all stages of the life cycle of an enterprise / production facility.

Determination of approaches, development of specific methods for ensuring the normative level of residual health risk is a very difficult research task. Its solution requires the consideration of separate disparate methods of situational response as parts of a single system with the transfer of the target orientation of the analysis from the purely practical plane of effective decisions into the sphere of deep understanding of the issues related to ensuring the environmental safety of a person as the most important recipient of the negative environmental impacts of hazardous industrial facilities. Such understanding is carried out in the fundamental context of ensuring the viability (resilience) of anthropo-natural systems changed under the significant influence of hazardous industrial facilities [Fomenko, 2020].

Without claiming to exhaustively implement such theoretical concepts, as well as to fully cover all relevant aspects of sustainable corporate development within the framework of the ESG approach[12], the research was aimed at creating a decision-making algorithm to ensure the environmental safety of the population of oil refining areas based on the health risk assessment mechanism (hereinafter referred to as text – algorithm). They have been carried out over a number of years, taking into account the results of numerous design, consulting and research works carried out on the instructions of Russian oil refineries. They were taken into account as targeted projects (development of risk-based environmental management mechanisms [Avaliani et al., 2018], substantiation of the adequate boundaries of the SPZ of industrial enterprises and industrial centers [Fomenko et al., 2008], application of a risk-based approach to assessing and reducing vulnerability of ecosystems and the population[13]), as well as studies on a broader topic (identifying and assessing the actual level of negative environmental impact of industrial emissions from oil refineries in a specific urban situation, comparing it with regulatory requirements, determining measures to comply with standards and to organise appropriate control and monitoring of emissions[14]).

The algorithm is developed as a sequence of specific actions covering all stages of the life cycle of a production facility / industrial installation. This article provides a description of this algorithm, the detailed content of the stages, procedures and features of its application; specific mechanisms of health risk management and their practical significance are considered; the necessity of introducing the algorithm into the practice of corporate governance is substantiated.

1. Methods and information base

Methodologically, the research is based on the principles of risk management theory and the system of quality standards[15] and is widely used in corporate and public administration. In a generalised form, the risk management process is cyclical and includes: identification of hazards, their sources and created risks; risk assessment and their prioritisation according to the degree of significance; planning risk management measures (including avoidance, reduction of probability and/or materiality, acceptance, transfer, etc.); implementation of risk management measures (technological, operational, organisational and administrative, etc.); monitoring of residual risks. In relation to the environmental sphere, risk is interpreted as the probability of an occurring event that has adverse consequences for the natural environment and is caused by the negative impact of economic and other activities, natural and man-made emergencies[16].

In the field of ensuring the safety of the population from negative environmental impacts, the theory of health risks is being developed, the provisions of which, due to their high social significance and demand, are today the most normatively justified, with fixing in the legislative systems of a number of countries. At the same time, health risk assessment is considered as an obligatory part of the process of managing health risks from negative environmental impacts; moreover, it performs the function of monitoring the management process according to the relevant risk indicators (planned, current, normative, predictive). It should be noted that from a sanitary and environmental points of view, enterprises are responsible for the risk to society and are obliged to share it in proportion to their contribution [Olson, Desheng, 2008], which is most consistent with the modern risk management system[17] and represents the distribution of possible deviations from the expected results and goals due to the uncertainty of events in the external and internal environment of the enterprise. This vision of health risk is close to the majority of Russian researchers [Avaliani et al., 1996; Bolshakov et al., 1999; Avaliani, 2002; Onishchenko et al., 2003; Fomenko et al., 2010; Fomenko et al., 2018].

In accordance with the objectives of the study related to limiting the negative impact on the atmospheric air of

[12] https://corporatefinanceinstitute.com/resources/knowledge/other/esg-environmental-social-governance/.
[13] https://ntc-rik.ru/cases/8072/.
[14] The topics cover the environmental justification of new enterprises, new facilities as part of the reconstruction of existing industries, as well as the development of operational documentation for compliance with the environmental impact standards of existing enterprises, including environmental control and monitoring programmes.
[15] GOST R ISO 31000-2019 "Risk management. Principles and guidance" (national standard of the Russian Federation), ISO 31000:2018 "Risk management. Principles and guidance" (ISO 31000:2018 "Risk management – Guidelines", IDT) (international standard).
[16] Federal Law of the Russian Federation of January 10, 2002 No. 7-FZ "On Environmental Protection".
[17] By a modern risk management perspective, we mean a comprehensive, integrated and coordinated process within an organisation to manage all types of risk it faces.

oil refineries, methodological tools were used to assess the risk to public health when exposed to chemicals that pollute the environment, the provisions of which are normatively established by the "Guidelines for assessing the risk to public health when exposed to chemicals polluting the environment" R 2.1.10.1920-04 (approved by the Chief State Sanitary Doctor of the Russian Federation on March 5, 2004). This document prescribes a sequential (staged) study, including hazard identification, exposure assessment, assessment of the dose-response relationship, risk characterisation; in relation to each stage, the requirements for the composition and methodology of research, the data used are set out, and the obligation to perform an analysis of uncertainties is established. This ensures validation and verification requirements for the results obtained – intermediate and final.

The population health risk management algorithm is formulated in the logic of the sustainability of anthropo-natural systems with a focus on the interconnectedness and interdependence of the processes and results of various stages of the life cycle of an enterprise, from pre-project studies and design to the decommissioning of a production facility [Beck, 1994; Von Weizsaecker, Wijkman, 2018; Fomenko, 2021; Fomenko, Fomenko, 2022].

Mathematical modeling of the dispersion of average annual concentrations was carried out using the Ecolog Unified Programme of air pollution estimation, version 4.5, the calculation block "Average". Calculations of carcinogenic and non-carcinogenic risks were carried out using MS Excel 2007 and the calculation block "Risks", version 4.5, which implements Guideline R 2.1.10.1920-04. Cartographic work was carried out using a computer geoinformation system (Arc Gis 10.1). As the main initial data for mathematical modeling, the current volumes of "Maximum Permissible Emissions", sections of the "List of Measures for Environmental Protection" and projects of sanitary protection zones, programmes for the medium-term development of enterprises were used; information on the climatic and weather characteristics of the studied territories for the location of oil refining enterprises was provided by the regional Federal State Budgetary Institution "Hydrometeorological Center of Russia".

This study is based on the results of a number of projects completed and currently being carried out on the instructions of oil refineries located in various geographical areas of Russia. The territories of their location are characterised by specific natural conditions (climatic characteristics, primarily wind and temperature regimes; terrain; background state of atmospheric air, etc.) and socio-economic conditions (urban planning situation, proximity and location of residential areas; the number of people exposed to potential environmental impact, risk groups, exposure to diseases, etc.). Specific quantitative indicators in this article are given based on the results of a specialised project for the implementation of risk-based management of the environmental safety of an oil refinery.

2. Results

The decision-making algorithm for ensuring the environmental safety of the population of oil refining areas based on the health risk assessment mechanism is a set of sequential procedures to ensure the standard indicator of the residual risk to the health of the population exposed to potential negative environmental impacts. The algorithm illustrates a single iteration (cycle) as part of a continuous process of managing a manufacturing enterprise at all stages of its life cycle, with special emphasis on those where the level of health risks created is especially sensitive to the results of decisions made. Estimated values of health risk each time (except in special cases) are determined by the cumulative impact of all industrial site facilities – existing and new construction.

Stage 1 – design. The actions are aimed at preventing additional health risks through the timely adoption of rational design decisions on the master plan, during which the locations of new facilities on the existing industrial site are reasonably detected (by considering several alternative options), and a detailed check of the adopted option is carried out in terms of the magnitude of the residual health risk at the border of the sanitary protective zone of the enterprise with the identification of the nature of the most significant hazards to public health which form the corresponding risks.

1. Justified choice of the location of environmentally hazardous facilities on the existing industrial site based on the analysis of alternative options.

During the development of the reconstruction project, three alternative options for the location of the new environmentally hazardous production facility were developed. The most preferable one – with significant savings in financial costs and location of the unit on a site with good logistics and communications – turned out to be blocked due to a risk factor (according to the results of an express assessment of health risks). The placement option with the minimum value of the increase in the value of the health risk due to the lack of communications on the site was characterised by unacceptably high financial costs. In fact, when choosing an acceptable option, only two alternatives were considered – option 2 and option 3, since option 1, despite the obvious technical and economic advantages, turned out to be unrealisable due to the expected excess of the standard value of the residual health risk. Of the three alternative options for locating an environmentally hazardous new construction facility, according to the results of a cumulative express assessment (Table 1), option 3 was adopted as a compromise between technical, economic and environmental factors.

Table 1
Results of express assessment of alternative options for the placement of an environmentally hazardous new construction facility

Object placement option	Characteristics of the option	Assessment by factors			Aggregate score
		technological	economic	ecological (health risks)	
Option 1	The facility is located in the southern part of the industrial site. The site with good logistics is adequately provided with communications (transport, resource, etc.). Significant savings in financial costs (compared to option 2 and especially option 3). Guaranteed excess of the regulatory level of residual health risk (HI > 1,0; HQ > 1,0; ICR > 10^{-4})	2	2	–	–
Option 2	The facility is located in the northern part of the industrial site. The site is not logistically secured, it is practically not equipped with communications (transport, resource, etc.). Significant financial costs, the highest of all three options. Guaranteed provision of the regulatory level of residual health risk at the level (HI < 0,001; HQ < 0,001; ICR < 10^{-6})	0	0	2	2
Option 3	The object is located in the central part of the industrial site. Logistically, the site as a whole is more secure than option 2; there are communications (transport, resource, etc.). Financial costs are set at a level much more acceptable than in Option 2. Compliance with the regulatory level of residual health risk is expected (HI < 0, 1; HQ < 0,1; ICR ≤ 10^{-6})	1	1	1	3

Note. The following estimated values are accepted in the table: "–" – the factor blocks the implementation of the variant; "0" – the minimum evaluation level; "1" – average estimated level; "2" – the maximum estimated level.

2. A detailed check of the accepted option for locating an environmentally hazardous facility in terms of the magnitude of the residual health risk at the border of the sanitary protection zone showed that there was no excess of the standard values. This result was presented as part of a set of project documentation for the reconstruction of the enterprise[18] and served as one of the conditions for a positive decision based on the results of the state expertise.

The results of the risk assessment revealed the main, most significant aspects of the formation of health risks (geographical, technological, toxicological):

- Geographical aspect – areas of the industrial site, which are characterised by the greatest magnitude of created health risks, have been identified. These are hygienically significant receptor points and areas of the industrial site with the maximum risk load - points on the border of the SPZ and the residential area in the south direction and the north-eastern part of the industrial site;
- Technological aspect – a list of production facilities has been developed, which form the highest exposure and risk load on the population. These are new construction facilities – hydrocracking and sulfur production units; existing facilities – installation 35-11/300-2, installation complex L-24-T-6, installation L-24-200-86;
- toxicological aspect – a list of the most dangerous priority chemical toxicants that form health risks

[18] In accordance with Decree of the Government of the Russian Federation of February 16, 2008 No. 87 (as amended on December 1, 2021) "On the composition of sections of project documentation and requirements for their content".

has been compiled – 11 pollutants, including non-carcinogens: sulfur dioxide, nitrogen dioxide, hydrogen sulfide, kerosene, nitrogen oxide, vanadium pentoxide, xylene, benzene, black carbon (carbon black), benz/a/pyrene, ethylbenzene; carcinogens: benzene, carbon (soot), ethylbenzene, benz/a/pyrene.

Stage 2 – construction. Typical actions within the framework of public health risk management are not envisaged at this stage. The construction process is not accompanied by the formation of significant risks to public health due to the relative short duration of the work being carried out, and also does not belong to objects of I-II hazard classes, subject to compliance with regulatory requirements for the performance of construction work and when taking environmental protection measures as part of project documentation according to the classification of industrial facilities and industries.

Stage 3 – operation. Risk management actions are aimed at reducing the likelihood of occurrence and minimising the damage from public health risks posed by the enterprise's production processes. The possibilities and optimal directions for reducing the significance of various aspects of the occurrence of hazards to public health – geographical, technological and toxicological – are determined. On this basis, the programmes of production control and production environmental control at the border of the sanitary protection zone are adjusted (according to the places of measurements, the schedule of measurements, controlled substances, etc.); plans for the implementation of investment measures (including environmental facilities) are being specified, taking into account their potential to reduce the level of health risk; technical operational documentation is being specified in order to minimise the likelihood of exceeding the standard indicator of residual risk to public health; measures are planned to comply with the established regime for the use of the territory of the sanitary protection zone.

The results of the study revealed sections of the SPZ border, the most dangerous in terms of the magnitude of health risks created, which are located in the southern and northeastern directions (Fig. 1). The most hygienically significant receptor points are concentrated on these sections of the SPZ boundary; in these directions, the areas of the industrial site are localised, where the most significant risk-generating impacts are created. As a detailed analysis of the risk situation dynamics showed, even if the orientation and configuration of the zones of distribution of non-carcinogenic risks (an oval with a northwest orientation) is preserved, the area of distribution of risks expands with the introduction of new objects. At the same time, the belt of unacceptable individual carcinogenic risk does not undergo significant changes. The obtained results of the geographic orientation of risk fields located within the boundaries of the SPZ, correlated with the general plan of the enterprise (in relation to the task of locating new construction facilities), show that it is unacceptable to place new production facilities in the northwestern part of the industrial site.

The objects of new construction are ranked according to the contribution to the general indicators of non-carcinogenic and carcinogenic risks formed at the border of the SPZ, in order to identify the most risky ones. The most risky production units include: among new construction projects there is a hydrocracking unit and a sulfur production unit; among the existing facilities there is the 35-11 / 300-2

Fig. 1. Geographical distribution of health risk evolution in 2012–2020

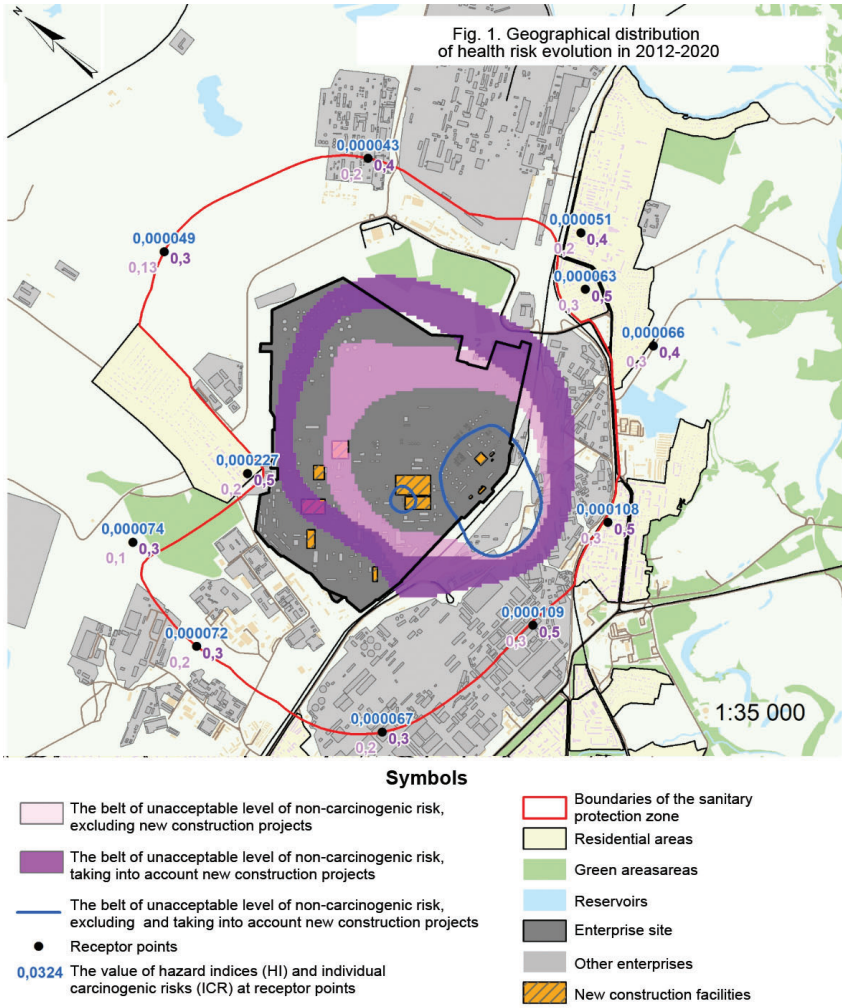
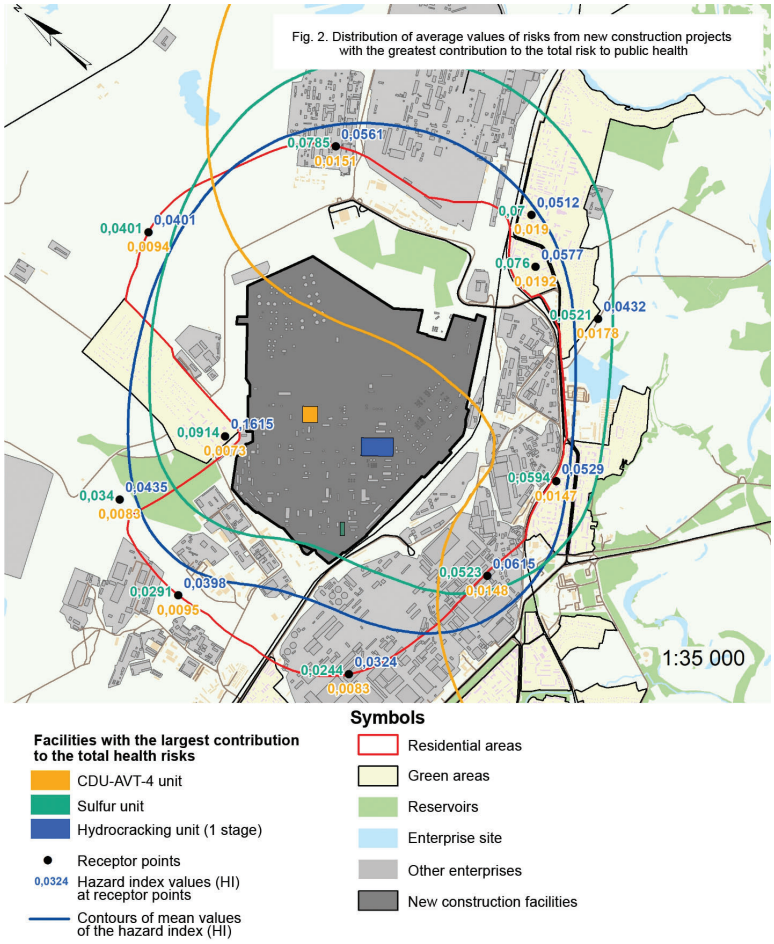


Fig. 2. Distribution of average values of risks from new construction projects with the greatest contribution to the total risk to public health



installation, the L-24-T-6 installation complex, the L-24-200-86 installation. All these facilities are considered as the most risky on the industrial site and require special attention when planning health risk management measures. As a detailed analysis showed, the first place in terms of riskiness is occupied by new construction facilities – a hydrocracking unit (14.5% of the contribution to the total indicators of non-carcinogenic and carcinogenic risks) and a sulfur production unit (13.8%); the existing facilities are rated approximately at the same level: the oil distillation unit CDU-AVT-4 – 3.2%, the automated timed loading of light oil products with a vapour recovery unit – 2.6%, the tar visbreaking unit – 2.1%. For the rest of the new construction facilities, contributions to the total levels of health risk are less than 2% (Fig. 2).

The most dangerous chemical toxicants out of 27 pollutants identified in the company's emissions, according to the results of research, include 11 substances with non-carcinogenic (sulfur dioxide, nitrogen dioxide, hydrogen sulfide, kerosene, nitrogen oxide, vanadium pentoxide, xylene, benzene, black carbon (soot), benz/a/pyrene, ethylbenzene) and 4 substances with carcinogenic effects (benzene, carbon (soot), ethylbenzene, benz/a/pyrene).

Table 2
Results of clarifying the priority of planned investment activities, taking into account the potential to reduce the level of health risk

Investment measures, including for environmental purposes (as part of the current programme)	Priority, rank		Indicator of the potential total hazard index (HI) as a result of the implementation of the activity*
	without regard to health risks	taking into account health risks	
Activity A	1	6	0,0392
Activity B	2	7	0,052636
Activity C	3	8	0,449484
Activity D	4	9	1,355
Activity E	5	1	0,000605
Activity F	6	5	0,00345
Activity G	7	3	0,002074
Activity H	8	4	0,00284
Activity I	9	2	0,002038

* *For comparison*: the same indicator (total hazard index (HI) for the industrial site) for the current situation without the implementation of investment measures amounted to 6.00786.

The programmes of production control and industrial environmental control of the enterprise have been adjusted taking into account:

– location of the most risky sections of the SPZ boundary and localization of industrial site sections, from where the most significant risk impacts are created;
– priority in terms of health risks created by production facilities;
– priority riskogenic pollutants.

Based on the results of the study, control points were selected where the maximum risk load is formed, including at the border of the SPZ and at the border of residential development / the border of normalised territories. Changes have been made to the sampling schedules: for each new construction facility, during the first year after commissioning, the number of days of research on the full list of characteristic toxicants has been determined. The list of analyzed substances at control points has been corrected to include the main non-carcinogenic pollutants, as well as enterprise-specific pollutants.

Adjustment of the plan for the implementation of investment measures (including environmental facilities), taking into account the reduction in the level of health risk, showed (Table 2) that among the 9 planned activities, the greatest reduction in health risk will be achieved when implementing the following activities: D – priority 1, I –priority 2; the smallest decrease – in the implementation of activities: C – priority 8 and D – priority 9.

The list of decision-making factors to prioritise the implementation of investment plan activities (financing programmes and other documents) has been supplemented with an additional one, reflecting the share of health risk reduction in the overall total risk of the enterprise. As the practice of a number of oil refineries shows, measures to prevent the loss of marketable products, for example, the construction of a plant for hermetic loading of oil products into railway tanks, have a high potential to reduce health risks in comparison even with targeted environmental protection measures.

Clarifications have been made to the operational technical documentation. Technological regulations, schedules of repairs, maintenance and other documents were analysed from the point of view of reducing the likelihood of exceeding the regulatory level of residual health risk with strict adherence to technological standards and industrial safety standards, for example, the non-simultaneity of short-term burst releases of priority chemical toxicants due to dilution in time and localization on the industrial site of the respective emission sources.

Compliance with the established regime for the use of the territory of the SPZ includes a set of measures: (1) preventing the placement of industrial and civil facilities that pose a threat of exceeding the normative values of health risks at the border of the SPZ; (2) eliminating existing and preventing the formation of potential unauthorised waste dumps; (3) improvement and landscaping of territories, etc. Long-term practice for a number of enterprises in this direction (for example, the implementation of a project to justify the sufficiency of the size of the established unified sanitary protection zone of the Southern Industrial Hub of Yaroslavl) in accordance with the principles of social responsibility of business confirms the effectiveness and efficiency of such measures.

Stage 4 – decommissioning. At this stage we did not consider standard actions within the framework of public health risk management due to the lack of a request for this type of research, although such a procedure is provided for by law. The decommissioning process depends on the intended purpose and is carried out in accordance with the established regulatory documentation, including the termination of the existence of the sanitary protection zone[19]. When meeting current regulatory requirements, risk values do not exceed acceptable levels.

3. Discussion

The results of the studies performed and the analysis of the practical experience of oil refineries in ensuring the environmental safety of the population living in the territories of their location not only substantiated the need and confirmed the real possibility of successful actions in this direction, but also made it possible to develop and test an appropriate decision-making algorithm. The operation of the algorithm is based on the implementation of the methodology for assessing the risk to public health due to air pollution. Its introduction into the practice of enterprise management makes it possible to ensure compliance with the standard indicator of residual health risk at the border of the SPZ. Based initially on the identification and analysis of various aspects of the occurrence of hazards to public health – geographical, technological and toxicological aspects, the actions within the algorithm are aimed at minimising the residual risk both in the process of designing new enterprises and during their operation, especially when planning and placing on industrial site of new construction facilities (stages when the level of health risks is most sensitive to the decisions made). Monitoring of current indicators of health risks with analysis of their dynamics in comparison with standard values is an indispensable and repetitive element throughout the entire life cycle of an enterprise[20].

[19] Paragraphs 9-11 of the Decree of the Government of the Russian Federation of March 3, 2018 No. 222 (as amended on March 3, 2022) “On Approval of the Rules for Establishing Sanitary Protection Zones and the Use of Land Plots Located Within the Boundaries of Sanitary Protection Zones”.

[20] It is carried out in accordance with the Methodology for express assessment of public health risk by chemical factor (https://risk.ntc-rik.ru/). This technique can be used for preliminary approximate calculations by employees of the environmental service of the enterprise using a specialized software package. LLC Scientific and Technical Center “Resources and Consulting” was registered, a certificate of registration of a computer programme dated April 16, 2019 No. 2019614934.

Health risk management is implemented using the following tools:

at the design stage:

– avoidance or minimisation of risk, as a result of (1) a reasonable choice of the option of locating new facilities on the industrial site of an existing enterprise, (2) reasonable adoption of planning decisions on the placement of environmentally hazardous production facilities on the industrial site of a new enterprise being designed;
– reducing the level of health risk by reducing potential damage and/or reducing the likelihood of risk arising as a result of the use of technologies whose environmental impacts correspond to the level of BAT, as well as environmental measures that are effective in terms of reducing health risks;

at the stage of operation:

– reduction of health risks by reducing the likelihood of a risk situation as a result of increasing the efficiency of production control systems and industrial environmental control (clarification of the location of measurement points, measurement schedule, list of controlled substances);
– reducing the level of health risk by reducing potential damage and/or reducing the likelihood of risk materialisation as a result of (1) changing the priority of the implementation of investment measures, including environmental purposes, taking into account the magnitude of reducing the level of health risks, (2) clarifying operational requirements to minimise the level and the likelihood of risky releases by minimising the duration of simultaneous operation of environmentally hazardous installations, diversifying repair and maintenance work by time and location on the industrial site, etc., (3) ensuring compliance with the established regime for using the SPZ territory, primarily preventing the placement of industrial and civil purposes, posing a threat of exceeding the normative values of health risks at the border of the SPZ.

The results of the practical application of the algorithm confirm the effectiveness of the decision-making mechanisms embedded in it both in terms of compliance with applicable legal requirements, and in the broader aspect of ensuring sustainable business development in accordance with ESG approaches.

The relevance of the algorithm is associated with the widespread short-sighted practice of developing planning decisions (the initial stage of design – decisions on the master plan), guided mainly by economic and technological considerations, while actually ignoring the environmental aspects of the functioning of future facilities (including health risks), which further increases the threat of violations of the environmental legislation with corresponding very significant financial, economic and reputational costs. One should also take into account the low environmental performance of environmental protection measures at the operation stage, which is limited even at the construction stage by the selected technologies and localisation of sources of emissions and discharges of pollutants [Fomenko, 2021].

The algorithm is universal. It can be used in relation to existing production facilities and new construction facilities as part of projects for the reconstruction and modernization of enterprises. It is also effective in the implementation of investment projects for the construction of new industrial enterprises. The scope of its application is not determined by industry specifics – it can be used in the management practice of any enterprise or industrial company, especially those that have environmentally hazardous production facilities on their balance sheet. And finally, the logic of the algorithm and the sequence of actions laid down are relevant not only in relation to chemical pollution of atmospheric air, but also in situations of health risks from acoustic and electromagnetic effects, from pollution of consumed water.

In general, it should be emphasised that, in accordance with the logic of risk-based management, the risks to the health of the population of adjacent territories from environmental impacts created by the enterprise should be integrated into the overall risk management system of the enterprise (along with risks of industrial safety, financial, operational, climatic, etc.). Obviously, within the framework of the risk management system, the created health risks can be identified as risks of non-compliance with the established legislative requirements in the field of ensuring the environmental safety of the population. Nevertheless, it is undoubted that indicators characterising the riskiness of an enterprise for the population should be included in the decision-making process in the field of risk management, strategic and financial planning, and current operational management.

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About the authors

Marina A. Fomenko

Candidate of geographical sciences, associate professor, EOQ auditor of the European Organization for Quality, first deputy director for scientific and consulting work, Scientific-Production Enterprise "Cadaster" Ltd. (Yaroslavl, Russia). SPIN-code: 3563-4926.

Research interests: integrated use and protection of natural resources, development and implementation of environmental programs and plans, environmental and economic indicators taking into account the socio-cultural factor; study of environmental risks and risks to public health in the context of sustainable development; improvement of indicators of sustainable development, environmental indicators and indicators of the green economy, the system of national accounts and natural and economic accounting, as well as methods of mapping them.

fomenkoma@rcs-cad.com

Georgy A. Fomenko

Doctor of geographical sciences, professor, scientific supervisor, Group of Companies Institute of Sustainable Innovations (Yaroslavl, Russia). SPIN-code: 8529-9836.

Research interests: problems of transition of the industrial economy to the stage of "green growth" with a focus on sustainable development; study of environmental and health risks in the context of sustainable development, as well as the development of a methodology for analyzing the resilience and vulnerability of anthropo-natural geosystems; research in the field of socio-cultural restrictions and regulation of management decisions in the environmental field, socio-cultural dimensions in the field of environmental management.

info@npo-kad.ru

Elena A. Skuratova

Head of the Risk Assessment Center, ANO Research and Design Institute "Cadaster" (Yaroslavl, Russia).

Research interests: research of environmental risks and public health risks in the context of sustainable development, development of medico-geographical approaches for territory typification and improvement of environmental management; elaboration and justification of engineering solutions to reduce environmental risks and public health risks, evaluation of the effectiveness of targeted programs to improve the environmental situation in cities and settlements.

skuratova@rcs-cad.com

作者信息

Marina A. Fomenko

地理学副博士，副教授，欧洲质量组织（EOQ）环境审计师，“卡达斯特尔”研究设计院科学和咨询工作第一副主任（俄罗斯雅罗斯拉夫尔）。SPIN 号码：3563-4926.

研究领域：自然资源综合利用和保护；保护环境方案和计划制定和实施；兼顾社会文化因素的环境和经济指标；可持续发展背景下的环境和健康风险研究；可持续发展、环境和绿色经济指标的改善；国民账户体系和自然和经济核算以及对它们进行映射的方法的改善。

fomenkoma@rcs-cad.com

Georgy A. Fomenko

地理学博士，教授，“可持续创新研究所”科学生产联合公司科学主任（（俄罗斯雅罗斯拉夫尔）。SPIN 号码：8529-9836.

研究领域：将工业经济推向以可持续发展为重点的绿色增长阶段的挑战；可持续发展背景下的环境和健康风险研究；人类和自然的地理系统的复原力和脆弱性分析方法论制定；社会文化制约因素和环境管理决策规范的研究；环境管理中的社会文化层面。

info@npo-kad.ru

Elena A. Skuratova

“卡达斯特尔”研究设计院风险评估中心主任（俄罗斯雅罗斯拉夫尔）。

研究领域：可持续发展背景下的环境和健康风险研究；开发用于地区类型化并改善环境管理发展的医学地理学方法；减少环境和公共健康风险工程解决方案制定和论证；改善城市和住区环境状况的目标方案的有效性评估。

skuratova@rcs-cad.com

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Implementation of infrastructure projects for the development of railway transport hubs: Empirical analysis

P.S. Kuzmin[1]
[1] "TENEX" JSC (Moscow, Russia)

Abstract

The key tool for economic growth and overcoming restrictions is the implementation of major infrastructure projects in the field of railway transport. Infrastructure projects aimed at organising passenger and freight rail traffic form a wide range of social effects, such as saving travel time, improving transportation safety, reducing emissions of harmful substances and noise levels, increasing physical activity, improving social integration and organising a barrier-free environment, agglomeration effects and an increase in subjective well-being.

At the same time, such projects are very capital-intensive and often cannot be implemented in full due to limited funding. Especially this factor plays a significant role in the current conditions of sanctions pressure. The combination of these factors leads to the need for comprehensive risk management when deciding on the implementation of an infrastructure project for the development of railway junctions.

Thus, the purpose of this study is to identify risks in the implementation of infrastructure projects, assess the identified risks and formulate recommendations for their reduction.

Keywords: infrastructure projects, transport hub, railway, risk analysis, railway network.

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铁路运输枢纽发展的基础设施项目的实施：实证分析

P.S. Kuzmin[1]
[1] TENEX 股份公司（俄罗斯莫斯科）

摘要

实施铁路运输方面的重大基础设施项目是经济增长和克服制约因素的关键工具。旨在组织客运和货运铁路交通的基础设施项目会产生广泛的社会效应，例如：旅行时间节省，运输安全改善，污染物排放和噪音水平减少，体育活动增加，社会包容性提高，无障碍环境创造，聚集效应和主观物质福利的提高。

然而，这类项目是高度资本密集型的，往往由于资金的限制而无法完全实施。在目前的制裁压力环境下，这一因素尤为重要。这些因素的结合导致了在决定发展铁路枢纽的基础设施项目时，需要进行全面的风险管理。

因此，本研究的目的是识别基础设施项目实施过程中的风险，评估所识别的风险，并制定减少风险的建议。

关键词：基础设施项目，运输枢纽，铁路，风险分析，铁路网。

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Introduction

The relevance of this study is primarily due to the fact that the key tool for economic growth and overcoming restrictions is the implementation of large infrastructure projects in the field of railway transport.

In a previous study [Kuzmin, 2020] the following areas for the implementation of infrastructure projects were identified:

- Modernisation of railway infrastructure in order to increase the speed of rolling stock. This direction of development is critical for increasing the average section speed of trains, which directly affects the speed of movement of goods or passengers [Tsypleva, 2017].
- Development of multimodal terminal and logistics centers. The development of these centers can improve the convenience of using the railway infrastructure for both passengers and consignors and consignees. In addition, the strengthening of the multimodal infrastructure will help to increase the degree of integration of rail transport into supply chains, reduce the travel distance and, in general, increase its attractiveness in relation to road and sea transport [Vinokurov et al., 2018b].
- Development of transport hubs. This direction in railway infrastructure development projects is one of the main ones for achieving positive agglomeration effects, such as increasing employment, wages, etc. [Assessment of large..., 2013].
- Modernisation of border crossing infrastructure. The movement of trains often slows down when passing borders. This is due to many factors, ranging from differences in the diameter of the railway track and electrification parameters of the railway network to the inefficiency of the customs document flow at the border crossing [Vardomsky, Turaeva, 2018].
- Implementation of digital platform solutions. The digitalisation of railway networks can not only increase the efficiency of the transport system, the throughput of nodes, but also have a beneficial effect on all market participants, as it will significantly increase the convenience of use for passengers and shippers and will make it possible to more effectively introduce rail transport into logistics chains.

Infrastructure projects aimed at organising freight traffic generate the following social effects:

– saving travel time;
– improving the safety of transportation;
– reduction of emissions of harmful substances and noise level (when choosing alternative options).

In turn, infrastructure projects aimed at organising passenger traffic form an even wider range of social effects:

– saving travel time;
– improving the safety of transportation;
– reduction of emissions of harmful substances and noise level (when choosing alternative options);
– beneficial effects of public transport due to increased physical activity;
– social integration and barrier-free environment;
– subjective wellbeing – the perception of the world around us, or the level of happiness [D'Acci, 2014; Value of rail.., 2017; Transport infrastructure.., 2019; Linder and Kuznetsova, 2020].

Making a decision on the implementation of major infrastructure projects requires a thorough analysis of the socio-economic effects that accompany the implementation of such projects, as well as the development of the most effective tools to improve the socio-economic level of development of territories through the implementation of infrastructure projects for the development of railway transport hubs.

At the same time, such projects are very capital-intensive and often cannot be implemented in full due to limited funding. This factor plays a particularly significant role in the current conditions of sanctions pressure. The combination of these factors leads to the need to evaluate not only potential socio-economic effects, but also to carry out comprehensive risk management when deciding on the implementation of an infrastructure project for the development of railway junctions.

Thus, the purpose of this study is to identify risks in the implementation of infrastructure projects, assess the identified risks and formulate recommendations for their reduction.

1. Research methodology

Any ongoing project, as well as the activities of organisations involved in the implementation of the project, is subject to risks caused by both internal and external factors and impacts that generate uncertainty as to whether the project objectives will be achieved, as well as the timing in which they will be achieved.

In a highly turbulent world economy, modern companies are exposed to various threats and risks that affect their development. This is largely due to the processes of competition, digitalisation, global changes in the political and economic situation [Kuznetsova, 2020]. Under the current conditions, modern companies are forced to form new methods and approaches to ensure the development of their risk management processes in a dynamically changing external and internal environment.

However, before proceeding to risk analysis, it is necessary to form a common understanding of the term "risk". The analysis of existing standards in the field

of risk management[1] and research [Ekaterinoslavsky et al., 2010; Green, 2016] allowed us to consider various formulations of the definition of risk and, based on the definitions presented, to conclude that the risk includes many aspects:

– the possibility of occurrence of an event;
– the probability of occurrence of an event;
– the event may affect the results of economic activity, the implementation of strategies;
– an event can be both a potential threat and an opportunity for development.

Based on the results of the analysis, the definition used in the work was formed: risk is the impact of uncertainty on the achievement of goals, where the influence of uncertainty means a deviation from the expected result or event (positive and / or negative).

To date, in the world practice of risk management, an approach to standardisation and unification of the area of risk management has been established. There are various risk management standards that involve managing the risks of industrial organisations according to certain algorithms. There are also a number of documents describing risk management in project implementation.

It should be noted that the goals can be different in content (in the field of the financial condition of the organization, reputation, ecology, etc.) and purpose (strategic, organisational, related to the development of the project, specific products and process)[2].

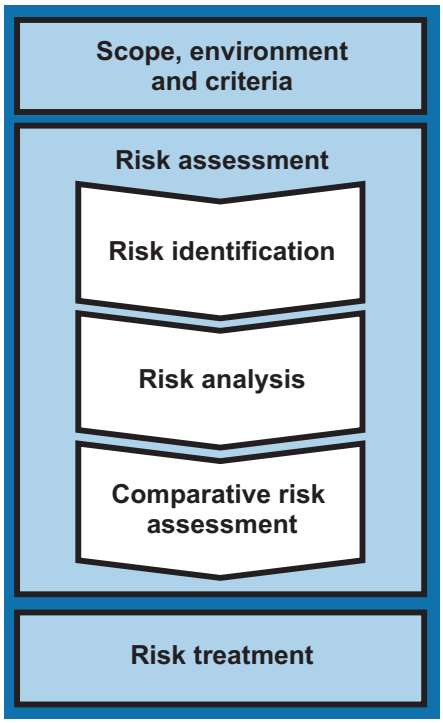
The ISO 31000:2018 Risk management – Principles and guidelines was taken as the basis for the risk management standard in this study. This standard forms a methodological basis for risk analysis[3].

Risk management involves risk management within the framework of the full process (cycle) of risk management, presented in Fig. 1.

Definition of the scope. For risk analysis, it is necessary to determine the specifics of the area of analysis. One of the most important aspects are the factors of the external and internal environment that affect the object under study. When analysing, it is important to understand in what external and internal conditions the subject operates, including:

– the external environment associated with doing business, social and environmental activities, legal and regulatory requirements, cultural factors, competition, financial situation and government policies at the international, national, regional or local levels;
– key trends and motivations that affect the achievement of the objectives of the organisation or project;

Fig. 1. Diagram of the risk management cycle



Source: Compiled by the author based on ISO 31000:2018.

– the significance of external stakeholders and their perception of risk.

It is equally important to determine the internal features:

– the organisation's capabilities in terms of resources and information in the area of risk;
– information flows and decision-making processes;
– internal stakeholders;
– the goals and objectives of the organisation, as well as the strategies needed to achieve them;
– the organisation's perception of the risk and its significance to the organisation;
– policies and processes of the organisation;
– standards and applied comparative models adopted by the organisation;
– organisational structures (eg management systems, distribution of functions and responsibilities).

The object of risk analysis in this work is the implementation of infrastructure projects for the development of railway transport hubs. As noted earlier, the main goal of implementing such projects is to increase the socio-economic

[1] Enterprise risk management – Integrated framework Committee of Sponsoring Organizations of the Treadway Commission (ERM-COSO) (w.y.). https://www.coso.org/Pages/default.aspx.
ISO 31000:2018. Risk management – Principles and guidelines. http://www.iso.org/iso/catalogue_detail%3Fcsnumber=43170.
Risk management standard – Federation of European Risk Management Association (RMS-FERMA). https://www.ferma.eu/.
GOST R 51897-2011. Risk management. Terms and Definitions. M.: Standartinform, 2011.
[2] http://www.iso.org/iso/catalogue_detail%3Fcsnumber=43170.
[3] Id.

level of development of territories, expressed in improving the level of services for consignors and consignees, increasing business activity in the project implementation region, increasing wages and living standards, reducing emissions of harmful substances and the level noise and other direct and indirect effects.

Thus, the external environment for the implementation of infrastructure railway projects is formed by a wide list of stakeholders. These are, for example, regional authorities that decide on the need to implement an infrastructure railway project, regulatory authorities, as well as business and business entities of the region, together with residents and workers whose well-being is directly affected by the implementation of the project.

The internal environment consists primarily of companies developing an infrastructure project and subsequent supervision of its implementation, employees implementing these projects, the equipment and software systems used that form the architecture of the railway network.

Risk identification. The purpose of risk identification is to find, recognise and describe risks that can help or hinder system participants from achieving their goals. When performing identification, the following factors and the relationships between them should be taken into account:

- material and non-material sources of risk;
- causes and events;
- threats and opportunities;
- vulnerabilities and abilities;
- changes in the external and internal environment;
- indicators of emerging risks;
- the nature and value of assets and resources;
- consequences and their impact on the objectives;
- limited knowledge and reliability of information;
- factors related to time;
- prejudices, assumptions and beliefs of the persons involved (stakeholders).

At the same time, in order to identify the risk, it is extremely important to correctly determine the external and internal environment of the organisation. The study of the organisation's external environment may include, but is not limited to:

- social, cultural, political, legal, regulatory, financial, technological, economic and environmental factors at the international, national, regional or local levels;
- the main factors and trends affecting the objectives of the organsation;
- relationships with external stakeholders (stakeholders), their perceptions, values, needs and expectations;
- contractual relations and obligations;
- the complexity of existing relationships and dependencies on external stakeholders.

The study of the organisation's internal environment may include, but is not limited to:

- vision, mission and values;
- management;
- management, organisational structure, roles and responsibilities;
- strategy, goals and policies;
- the culture of the organisation
- standards, directives and models adopted by the organisation;
- capabilities, available resources and accumulated knowledge (e.g. capital, time, people, intellectual property, processes, systems and technologies);
- data, information systems and information flows;
- relationships with internal stakeholders, taking into account their opinions and values;
- contractual relations and obligations;
- interdependencies and relationships.

Brainstorming, structured and semi-structured interviews, the Delphi method, scenario analysis, consequences and probability matrix, Ishikawa diagram, etc. can be used as risk identification methods.[4]

For the purposes of this work, the next section will review materials on the implementation of railway infrastructure projects in Russia and the world for the primary identification of risks, as well as in-depth interviews with experts for risk verification.

After verification and formation of the risk register, an assessment will be carried out on a sample of experts in order to determine the strength of the impact of risks and develop measures to reduce them.

2. Risk identification

For primary identification, the risks associated with the implementation of measures to develop the railway infrastructure were analysed based on analytical reviews of consulting companies [Overview of the freight transportation industry.., 2018; Transport infrastructure.., 2019; COVID-19.., 2020] and scientific research [Vardomsky, Turaeva, 2018; Vinokurov et al., 2018a, Kuzmin, 2020; Nalbandyan, Khovalova, 2020]. In order to further assess and develop recommendations to reduce the negative impact of possible risks, risks were identified that affect both the implementation of infrastructure railway projects and the achievement of socio-economic effects from implementation.

1. Risks from the demand side for rail freight and passenger transportation services. This type of risk is significant for the revenue side of infrastructure projects for the development of railway networks, as it has a direct impact on the revenue side and payback.

The risk of growth in the cost of transportation due to the growth of transport tariffs. At the moment, the tariff

[4] http://www.iso.org/iso/catalogue_detail%3Fcsnumber=43170.

system is relatively inflexible, and the tariffs are quite high (including in comparison with road transport). There is also a lack of adaptation of the tariff to demand.

In addition, there is a negative impact from increased fees for transportation in special containers, which repels a significant part of shippers from choosing rail transport. The above factors reduce the competitiveness and attractiveness of railway transport in comparison with other types.

The risk of reduced mobility of the population. One of the factors that significantly affected the transport and logistics industry in 2020 was the spread of a new coronavirus infection COVID-19. To slow the spread of the disease, restrictions on movement, stay in offices, and strict social distancing rules were introduced. In the transport and logistics industry, these restrictions have led to disruptions in a wide range of areas:

- Violation of operating modes of taxis, buses, metro, commuter trains and long-distance trains;
- complicating operational activities due to the transfer of part of the staff to a remote work mode, as well as ensuring social distancing measures;
- the emergence of barriers and restrictions in cargo transportation, a decrease in the volume of transported goods due to disruption of companies in global supply chains [COVID-19.., 2020].

In addition to reducing the mobility of the population at the time of the COVID-19 outbreak, the forced measures to organise remote work significantly accelerated the digitalisation of many sectors of the economy and made it possible to introduce the technologies necessary for remote work in a wide range of companies.

The result of surveys of the leaders of the largest companies showed that the impact of COVID-19 will have long-term consequences: 61% of experts believe that the digitalisation and automation stimulated by the pandemic will inevitably lead to a decrease in the number of employees in offices and, as a result, a decrease in the volume of commuting.

The trend towards a decrease in the mobility of the population has aggravated due to the complication of the external geopolitical situation and the introduction of restrictions on crossing borders.

Risk of insufficient level of cargo traceability. When sending cargo, there is currently no way to track it along the way, and even more so to track its condition, which negatively affects the safety of cargo transportation. The optionality of location tracking systems increases the risk of theft and breach of property.

The impact of this risk can be reduced through the implementation of satellite navigation, as well as industry 4.0 technologies, such as:

- Blockchain (facilitating transactions and increasing transparency of the supply chain);
- Internet of things (tracking the location of the shipment and its status);
- Big Data analysis [Overview of the industry.., 2018].

Similar traceability issues are seen with trucking companies. In the current regulatory legal framework of the Russian Federation, equipping road transport with navigation and tracking systems is necessary only for trucks carrying dangerous and special goods, bulky goods, as well as municipal solid waste.

The risk of increased resource intensity of transportation and transport costs. During the implementation of the measures provided for by the infrastructure project, a number of irrational decisions can lead to increased costs both during the implementation of the project and during subsequent operation. Also, an increase in the resource intensity of transportation and transport costs is possible in the event of a change in prices for the maintenance and operation of rolling stock, an increase in the cost of services of co-contractors for freight and passenger transportation, as well as changes in prices for the operation and repair of infrastructure facilities.

This risk is exacerbated by the unstable macroeconomic environment. To date, the most probable and severe risks are noted in the part of the high-tech equipment markets. Strengthening international competition in these markets, a shortage of some products (for example, silicon semiconductors), as well as sanctions restrictions can undermine procurement chains and lead to a number of serious consequences for the development of Russian industries, including shifting the implementation time of some projects “to the right”, reducing the profitability of these projects or even making it impossible to implement them.

The combination of the above listed factors can lead to a decrease in the level of competitiveness, a reduction in the volume of passenger and freight traffic and, as a result, a decrease in economic and social effects.

The risk of disproportion in the pace and scale of the development of road transport. Road transport plays a significant role in both passenger and freight traffic, and is one of the main drivers of socio-economic development in the regions along with rail transport.

The main number of movements occurs within the region, which is home for residents. The Central transport hub is characterised by the phenomenon of pendulum migration due to trips between Moscow and the cities of the Moscow region. Commuter travel is followed by trips to nearby regions [Linder, Litvin, 2020].

Pipeline and railway transport prevails in the volume of cargo turnover of the Russian Federation: cars occupy the 3rd place (4.6% of cargo turnover in 2018), significantly lagging behind the indicators of railway transport (46.1% of cargo turnover in 2018).

A study by the Center for Infrastructure Economics (hereinafter – CIE) notes that the motorisation trend can be described by an S-shaped logistic curve, where the level of saturation is determined by the characteristics of the regional infrastructure.

For 2018, the level of motorisation in the Moscow region was estimated at 300 cars per 1000 people, which is lower than the level of European countries, where motorisation reaches values of 500-550 cars. Thus, the saturation level has not yet been reached, and the level of motorisation will continue to grow. However, the work of the CIE revealed that the explosive growth rate has already been passed (and fell on the period from 2000 to 2017) and further average annual growth rates should be expected at the level of 2.2% [Transport infrastructure.., 2019].

Thus, despite the growth in motorisation and the use of cars for passenger and freight transport, the scale of this development will be relatively small.

The risk of increasing the competitiveness of air transportation and trucking. In addition to the previously mentioned inflexible and relatively high level of tariffs leading to the loss of part of the volumes on the short and medium leg, there is a threat of increased competition from air carriers and road carriers, including dumping by road carriers in the presence of the possibility of tax evasion and going into the shadow zone.

2. The risk of a shortage of qualified personnel. A low level of competencies, violations of discipline, etc. can seriously reduce not only the level of the development of an infrastructure project and its implementation, but also the quality of services provided and the level of maintenance of the railway infrastructure after the completion of the project. The innovative and technological development of the industry also requires an influx of highly qualified personnel [Trachuk, Sayapin, 2014].

3. Financial risks. These risks are caused by an underestimation of the required amount of financing, an increase in interest rates for replacement funds, a decrease in the availability of financing [Trachuk, Linder, 2016] and are inherent in infrastructure projects in themselves, however, they are increasing due to an unfavorable macroeconomic environment.

Risk of reduced or no private investment. The development of railway infrastructure can be carried out more efficiently through the organisation of public-private partnerships. However, the timing of the implementation of activities is relatively long, and the uncertainty is high. The combination of these factors can scare away private investors and lead to a reduction in funding to cover the costs of infrastructure development measures [Linder, Arsenova, 2016].

Risk of reduced public investment in railway infrastructure. However, in addition to the risk of not attracting private investment, there is a risk of reducing public investment.

4. Risk of infrastructure restrictions. The obsolescence of infrastructure facilities, the irrationality of their location, the inconvenience of use and the lack of multimodal opportunities can significantly reduce the socio-economic effects of the development of railway networks. An outdated and inefficient infrastructure leads to a decrease in the speed of cargo handling, an increase in the waiting time for shippers and consignees, a decrease in the speed of movement, reliability and safety of transportation, which will lead to customer dissatisfaction and a decrease in traffic volumes.

To verify the identified risks and form the Risk Register for the implementation of infrastructure projects for the development of railway transport hubs, preliminary telephone interviews were conducted with 15 experts implementing infrastructure solutions in the field of railway tracks and hubs, regional authorities, and consulting agencies.

In this case, the experts meet one of the following criteria:

1) the expert occupies a managerial position in a subdivision of an organisation engaged in the implementation of infrastructure projects for the development of railway transport hubs;
2) the expert is a competent consultant specialising in railway infrastructure projects;
3) the expert is a representative of the regional authorities responsible for the implementation of railway infrastructure projects.

Based on the results of the interview, a Register of Risks for the Implementation of Infrastructural Projects for the Development of Railway Transport Hubs was formed (Table 1).

Thus, a list of the main risks inherent in projects for the development of railway networks has been formed, and the factors leading to the realisation of these risks have been compiled. The next step in the study will be to assess the strength of the impact of these risks on the success of the implementation of infrastructure projects.

3. Assessment of the power of risk influence

To further assess the power of risk influence from the Register of Risks for the Implementation of Infrastructure Projects for the Development of Railway Transport Hubs, a quantitative analysis was carried out.

After verification of the model and the questionnaire, the questionnaires were sent to 195 experts selected according to the qualification criteria given in the previous section. 123 experts responded, the response to the questionnaires was 63%. Such a percentage of response and the size of the final sample can be considered a good result, sufficient to build a regression equation. The characteristics of the sample are presented in Table. 2.

Table 1
Register of risks for the implementation of infrastructure projects for the development of railway transport hubs

№	Name of risk	Risk factors
1. Demand-side risks for rail carrier services		
1.1	Risk of growth in transportation costs	High level of tariffs
1.2	The risk of reduced mobility of the population	Lack of dynamic pricing
1.3	Risk of insufficient level of cargo traceability	Increased fees for the transportation of certain goods
1.4	Risk of increased resource intensity of transportation and transport costs	Increasing the share of remote employees, reducing commuting
1.5	The risk of disproportion in the pace and scale of development of road transport	Reduced mobility as a result of the pandemic
1.6	The risk of increasing the competitiveness of air transportation and trucking	Reduced mobility due to external macroeconomic pressures
2. Risk of shortage of qualified personnel		
2.1	The risk of a shortage of qualified personnel in the implementation of the project	Lack of competencies for the development of an infrastructure project
2.2	Risk of shortage of qualified personnel during operation	Lack of competencies to oversee the implementation of an infrastructure project
3. Financial risks		
3.1	Risk of reduced or no private investment	Implementation timelines are relatively long and uncertainty is high, discouraging private investors
3.2	Risk of reduced public investment	Decrease in public investment due to potential reduction in funding for infrastructure projects
3.3	Other financial risks	Growth in interest rates on debt financing
4. Risk of infrastructure restrictions		
4.1	Risk of infrastructure facilities inefficiency	Irrational location of infrastructure facilities
4.2	Risks of lack of multimodal opportunities	Inconvenience of using infrastructure facilities

Table 2
Sample characteristic

Characteristics of the respondents	Number of respondents (persons)	Share of respondents (%)
Age of the company implementing infrastructure projects:		
less than 5 years	25	20
from 5 years to 10 years	37	30
over 10 years	27	22
Consulting companies	19	16
Regional authorities in the field of transport	15	12

Source: compiled by the author.

Respondents were asked to fill out questionnaires based on the Likert scale with steps from 1 to 5, where 1 - the risk did not have a significant impact on the effectiveness of the implementation of the infrastructure project, 7 - the risk had a critical impact on the implementation of the infrastructure project.

In order to perform a quantitative analysis and calculate the strength of the influence of the risks of implementing infrastructure projects for the development of railway transport hubs, a regression equation was formed:

$$Y=\beta_0+\beta_{1.1}\times Mark_1+\ldots+\beta_{1.6}\times Mark_6+\beta_{2.1}\times Comp_1+\beta_{2.2}\times Comp_2+ +\beta_{3.1}\times Fin_1+\ldots+\beta_{3.3}\times Fin_3+\beta_{4.1}\times Infr_1+\beta_{4.2}\times Infr_2+\varepsilon_i. \quad (1)$$

The list of variables described in the specification of the regression model is given in Table. 3.

Based on the results of the regression analysis, the forces of influence of risks from the Register of risks of the implementation of infrastructure projects for the development of railway transport hubs on the achievement of socio-economic effects from their implementation were assessed. The results of the quantitative stage of the study are given in Table. 4.

Thus, the analysis made it possible to assess the strength of the influence of the risks of implementing infrastructure projects for the development of railway transport hubs on the achievement of socio-economic effects from their implementation. The next step in the study is to analyse the obtained forces of influence and develop recommendations for reducing risks.

4. Risk Mitigation Recommendations

In the group of risks from the side of demand for railway freight and passenger transportation services, the risk of increasing the competitiveness of air transportation and road transportation has the greatest influence ($\beta_{1.6}$ = 0.423). OHowever, despite its high power of influence, the competent implementation of infrastructure railway projects can be the most effective measure to mitigate it. Based on this, the main ways to manage this risk can be: the introduction of a more flexible tariff system, increasing the attractiveness of railway

Table 3
List of regression model variables

Risk category	Variable	Characteristic of the variable
–	Y	The resulting indicator characterising the socio-economic effect from the implementation of infrastructure projects for the development of railway transport hubs
Demand-side risks for rail carrier services	$Mark_1$	Risk of growth in transportation costs
	$Mark_2$	The risk of reduced mobility of the population
	$Mark_3$	Risk of insufficient level of cargo traceability
	$Mark_4$	Risk of increased resource intensity of transportation and transport costs
	$Mark_5$	The risk of disproportion in the pace and scale of development of road transport
	$Mark_6$	The risk of increasing the competitiveness of air transportation and trucking
Risk of shortage of qualified personnel	$Comp_1$	The risk of a shortage of qualified personnel in the implementation of the project
	$Comp_2$	Risk of shortage of qualified personnel during operation
Financial risks	Fin_1	Risk of reduced or no private investment
	Fin_2	Risk of reduced public investment
	Fin_3	Other financial risks
Risk of infrastructure restrictions	$Infr_1$	Risk of infrastructure facilities inefficiency
	$Infr_2$	Risks of lack of multimodal opportunities

Source: compiled by the author.

Table 4
The strength of the impact of the risks of implementing infrastructure projects for the development of railway transport hubs

Independent indicators	Nonstandardised Coefficients	Standardised Coefficients
Constant (β_0)	0.201 (0.019)	
Demand-side risks for rail carrier services		
Freight cost risk $Mark_1$	0.356** (0.085)	0.382**
The risk of reduced mobility of the population $Mark_2$	0.302*** (0.078)	0.333*
Risk of insufficient level of cargo traceability $Mark_3$	0.258** (0.063)	0.264**
Risk of increased resource intensity of transportation and transport costs $Mark_4$	0.287** (0.056)	0.291**
The risk of disproportion in the pace and scale of development of road transport $Mark_5$	0.097** (0.015)	0.101**
The risk of increased competitiveness of air and road transport $Mark_6$	0.423* (0.116)	0.446**
Risk of shortage of qualified personnel		
The risk of a shortage of qualified personnel in the implementation of the project $Comp_1$	0.325** (0.082)	0.364***
Risk of shortage of qualified personnel in operation $Comp_2$	0.278** (0.063)	0.286***
Financial risks		
Risk of reduced or no private investment Fin_1	0.367** (0.094)	0.385**
Risk of reduced public investment Fin_2	0.452*** (0.103)	0.501***
Other financial risks Fin_3	0.621** (0.124)	0.639***
Risk of infrastructure restrictions		
Infrastructure risk $Infr_1$	0.434** (0.099)	0.457**
Risks of lack of multimodal opportunities $Infr_2$	0.359** (0.087)	0.380*
Adjusted R^2	0.735	
Number of observations	123	

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

transport in the eyes of the consumer through infrastructure modernisation, improving the quality of service and the speed of transportation.

The need to introduce a flexible system of tariffs is also confirmed by the high impact of the risk of growth in the cost of transportation due to the growth of transport tariffs ($\beta_{1.1} = 0.356$). This risk can be managed by timely interaction with the federal executive authorities in the field of tariff regulation, as well as by changing the tariff system to ensure greater flexibility and timely response to the market situation.

The risk of reduced mobility of the population has a moderate influence ($\beta_{1.2} = 0.302$). At the same time, it seems possible to reduce this risk only by increasing the attractiveness, reliability and convenience of using rail transportation relative to other transport.

Also, the risks of insufficient level of cargo traceability ($\beta_{1.3} = 0.258$) and the risk of increasing the resource intensity of transportation and transport costs ($\beta_{1.4} = 0.287$). have a moderate influence. Based on this, when implementing infrastructure projects for the development of the railway network, it is necessary to ensure the implementation

of tracking systems in railway networks. In addition to containing the risk of theft and damage to property, this measure will increase competitiveness in comparison with road carriers. Planning costs, taking into account possible changes in the cost of resources for the operation and repair of railway networks and rolling stock, can significantly reduce the risk of increasing the resource intensity of transportation and transport costs ($\beta_{1.5} = 0.097$). Since, despite the growth in motorisation and the use of cars for passenger and freight transportation, the scale of this development is relatively small, the development of rail transport, railway infrastructure, as well as improving the convenience and safety of using railway networks can reduce the risks from the spread of road transport.

In the group of risks of a shortage of qualified personnel, both risks have a moderate impact: $\beta_{2.1} = 0.325$ for the risk of a shortage of qualified personnel during project implementation and $\beta_{2.2} = 0.278$ for a shortage of qualified personnel during operation.

As measures to manage the last risk, the development of a personnel motivation system, increasing the comfort of working conditions, conducting career guidance, as well as increasing the level of employee discipline can act.

To minimise the first risk, it may be useful to strengthen interaction with representatives of consulting companies, since they have a wider expertise in designing railway junctions as parts of urban and agglomeration infrastructure, which allows choosing the most effective implementation paths when developing infrastructure solutions and leading to greater public satisfaction regions where these projects are being implemented.

In addition, the risk of staff shortage in the long term can be reduced through cooperation with flagship universities for the railway industry.

The group of financial risks has the greatest power of influence. Other financial risks received the highest rating ($\beta_{3.3} = 0.621$), due to the current macroeconomic situation. The risks of reducing private ($\beta_{3.1} = 0.367$) and state ($\beta_{3.2} = 0.452$) funding received comparatively lower estimates. A public-private partnership programme can become the most effective tool for reducing the risks of a funding gap, since it is this model that makes it possible to achieve a synthesis of the competencies of private investors and their experience with the ability of the state to provide subsidies, benefits, targeted financing or other assistance that allows to achieve maximum efficiency in the implementation of infrastructure projects.

Attracting private investors can be more successful if the state is involved as a guarantor and facilitator in the course of implementing the activities envisaged by the project. The state is able to create favorable conditions and support for investors in the form of access to infrastructure, easing the tax regime and providing bank guarantees.

It is also necessary to interact with the relevant federal executive authorities as part of the justification of the economic and social feasibility of the project being implemented.

The risks of infrastructure restrictions have a moderately high impact force: $\beta_{4.1} = 0.434$ – for the risk of inefficiency of infrastructure facilities and $\beta_{4.2} = 0.359$ – for the risk of lack of multimodal opportunities. These values emphasise how important it is for the implementation of infrastructure development projects to correctly introduce new transport hubs into the existing infrastructure, while simultaneously expanding the possibilities of multimodal interaction. It is also important to provide railway networks with digital binding, which will increase their convenience, efficiency and transparency for users.

Conclusion

Infrastructural projects for the development of railway transport hubs are among the most important for increasing the level of socio-economic development of the territories. At the same time, due to the high capital intensity and complexity of implementing such projects, including under conditions of external geopolitical pressure, they are associated with a wide range of risks. In this study, risks were identified in the implementation of infrastructure projects, the identified risks were assessed and recommendations were made to reduce them.

At the first stage, the risk management methodology was described, as well as the main stages of the study, their content and methodological background. Further, by analysing the literature and conducting in-depth semi-structured interviews, a list of risks inherent in infrastructure projects for the development of railway transport hubs was formed. 13 risks were identified, divided into four groups: risks from the demand side for services, risks of a shortage of qualified personnel, financial risks and risks of infrastructure inefficiency. Then a quantitative analysis was carried out through a survey of experts, which made it possible to determine the strength of the influence of the identified risks on the achievement of positive socio-economic effects.

At the end of the work, a list of recommendations aimed at reducing risks and facilitating the maximisation of positive socio-economic effects is presented.

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About the author

Pavel S. Kuzmin

Chief specialist of the Risk Management Department, "TENEX" JSC (Moscow, Russia). SPIN-code: 8042-4060; Author ID: 991705.

Research interests: digital transformation, company development strategy and management, company development strategy formation.

kuzminps.fa@yandex.ru

作者信息

Pavel S. Kuzmin

"TENEX" 股份公司风险管理部主任专家（俄罗斯莫斯科）。SPIN 号码：8042-4060；Scopus Author ID：991705。

研究领域：企业数字化转型，公司发展战略与管理，公司发展战略的形成。

kuzminps.fa@yandex.ru

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A single digital space for the efficient functioning of industry

Yu.S. Bogachev[1]
P.V. Trifonov[1]
[1] Financial University under the Government of the Russian Federation (Moscow, Russia)

Abstract

The article is devoted to the development of the concept of a single digital space for the effective functioning of the industry. A new model of industrial production organisation, the platform ecosystem are analysed. The analysis of the theoretical concepts of the world economy on its structure, the system of organisation of interaction between ecosystem participants, factors affecting its dynamic development is given. It is shown that digital technologies play an essential role in the organisation of the ecosystem. At the same time, digitalisation occurs in two directions: the creation of the digital space of the enterprise participating in the ecosystem and the creation of the digital space of the ecosystem of industrial production.

The analysis of the use of digital technologies in various industries is given. The rating of the use of digital technologies in industry is discussed. The analysis of the factors constraining the process of digitalisation of the industry of the Russian Federation is given. The concept of ecosystem, presented in the world literature, and its functional and organisational features are analysed.

The influence of institutional conditions on the functional characteristics of the ecosystem is discussed. The ecosystem management system affects the economic and technological efficiency of each ecosystem participant. The prospects for the development of ecosystems based on platforms are shown.

The ability of the Russian manufacturing industry to adapt digital technologies and the organisation of modern forms of production on their basis are analysed. It is demonstrated that the potential of modern production of complex multicomponent products is determined by the ability to scale based on industry 4.0 technologies. At the same time, most of the enterprises fulfill individual orders of consumers and do not participate in the production chains of such products.

The tasks necessary for the organisation of breakthrough development of manufacturing enterprises in Russia are formulated. For modern organisational forms of the manufacturing industry a non-departmental management body is proposed. Its structure and functions are discussed.

Keywords: digital technologies, Industry 4.0, digital platforms, digital space, industrial policy, industrial revolution, digitalisation levels, value chains, advanced technologies, industrial ecosystem.

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用于工业高效运作的的单一数字空间

Yu.S. Bogachev[1]
P.V. Trifonov[1]
[1] 俄罗斯联邦政府金融大学（俄罗斯莫斯科）

摘要

文章论述了为工业的有效运作发展单一数字空间的概念。分析了工业生产组织的新模式 —— 平台生态系统。作者分析了世界经济结构的理论洞察力，而且描述了组织生态系统参与者之间互动的系统以及影响其动态发展的因素。数字技术已被证明在生态系统的组织中发挥了重要作用。而数字化是在两个方面进行的：为参与生态系统的企业创建一个数字空间，以及为工业生产生态系统创造一个数字空间。

对数字技术在不同工业部门的应用进行了分析。讨论了数字技术在工业中的应用水平。对俄罗斯工业数字化的制约因素进行了分析。对世界文献中提出的生态系统的概念及其功能和组织特征进行了分析。

讨论了制度条件对生态系统的功能特征的影响。生态系统管理体制影响到其中每个参与者的经济、技术效率。

基于平台的生态系统的前景显示。作者分析了俄罗斯加工工业采用数字技术和在其基础上组织现代生产形式的能力。证明了，当今复杂的多部件生产的潜力是由基于工业4.0技术的扩展能力决定的，同时企业主体部分完成客户的个别订单，不参与此类产品的生产链。

制定了俄罗斯加工工业突破性发展的挑战。作者建议为加工工业建立一个非部门管理机构，并讨论其结构和功能。

关键词：数字技术、工业4.0、数字平台、数字空间、工业政策，工业革命、数字化水平、价值链、尖端技术，工业生态系统。

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Introduction

In the countries – digital leaders, there is an intensive process of digitalisation of the economy, including industry. Digitalisation processes in them are determined, among other things, by the reaction to crisis processes in the socio-economic space.

More than 20 years ago, in order to optimise costs, developed countries began to transfer manufacturing enterprises to developing countries, in which the level of wages and costs of organising production were at a rather low level (relative to their own indicators). Currently, geopolitical tensions have contributed to the generation of the sanctions regime in foreign economic activity. This led to a break in supply chains and contributed to the emergence of structural problems in the national economies of developed countries. Significant progress in production technologies, means of communication and data processing has created conditions for the reshoring of the manufacturing industry in these countries, so the problem of digitalisation of industry is relevant.

The technological level determines the potential for the development of the digital space at enterprises where production processes, business processes in the enterprise management system, logistics, jobs, their organisation and distribution, interaction with financial institutions, etc.[1] are significantly changing.

The theory of digital space makes it possible to optimise the costs of ordinary labour productivity, the efficient use of financial and human resources, quickly respond to external influences, and expand the clientele of product sales.

This is facilitated by the introduction of intelligent control systems for measuring instruments at various operating sections of the production line, cyber-physical systems, computerisation of workplaces, the creation of a unified system for the fleet of equipment and workplaces, and the development of information and analytical data processing systems.

1. Theoretical review

Digital technologies in modern conditions are the main tool that determines the functioning of the value chain. Currently, production networks unite independent economic market entities, taking into account the high level of coordination of interests and interdependence of participants based on the common goal of production [Digital transformation in Russia, 2020]. Within the

[1] The Decree of the Government of the Russian Federation of July 28, 2017 No. 1632 Program “Digital Economy of the Russian Federation”. http://static.government.ru/media/files/9gFM4FHj4PsB79I5v7yLVuPgu4bvR7M0.pdf.

network, a decentralised production model is being created, including management systems of independent companies.

According to K. Schwab, President of the World Economic Forum, industrial enterprises involved in digitalisation are on the verge of large-scale changes, in which production and business process models are a system of interaction with business partners and customers and with the environment as a whole [Schwab , 2017]. In the world literature, research is being actively carried out on the nature of the organisation of this system.

It should be noted that the following sections of economic theory were taken into account when forming the concept of ecosystems: organisational ecology, neoinstitutional theory, and the theory of dynamic abilities of ecosystems [Moore, 1993].

At the initial stage, the concept of ecosystems used the provisions of the theory of organisational ecology. However, subsequently, on the basis of these provisions, an independent section of the ecosystem concept was developed. The new institutional economic theory had a significant impact on the development of the theory of ecosystems. Indeed, in various studies of the model of interaction between participants in ecosystems, contracting models used in business, models of transaction costs are used. The theory of dynamic abilities stimulated researchers to substantiate the concept of ecosystems based on platforms. From the point of view of this theory, the organisational development of an ecosystem is considered through the dynamics of the development of a set of ecosystem organisations. This set of organisations, combining their competencies in the production process, has the goal of creating a multicomponent product. Summarising the results of these studies, it can be noted that this system is based on the modular organisation of the use of resources and competencies [Baldwin, 2008].

Modern industrial production is an ecosystem in which autonomous organisations complement the competencies necessary for the production of complex multicomponent products [Seiger et al., 2014]. For this reason, the architecture of the ecosystem is modular in nature, within each module a certain type of coordination is carried out [Roundy et al., 2018]:

– engineering, forming a single model of production at all its stages;
– informational, within the framework of which the interface of various elements of the technology implementation is carried out;
– resource, carrying out the exchange of resources between participants in the production chain.

To control the technological interaction, the leaders of the ecosystem set the structure, basic parameters, rules and methods of interaction of various modules. In each module, taking into account its functional features, mechanisms for interaction with partners are formed.

A characteristic feature of the ecosystem is the fact that the formation of the final product is carried out on the basis of technological coordination of intermediate products (components) of a complex product (multicomponent).

An important circumstance is the institutional conditions that determine the effectiveness of the ecosystem [Chepurenko et al., 2019]. From this point of view, it should be noted that in the theory of dynamic capabilities, the competitiveness of an enterprise is ensured by its ability to adapt its competencies to changes in the external environment [Winter, 2003]. In ecosystem theory, it represents the environment in which its participants must respond to changes. From this point of view, the theory of dynamic abilities introduces the concept of “platform-based ecosystems” [Teece, 2017]. Within its framework, the formation of the architecture of a multicomponent product based on technological competencies is carried out. In the process of formation, the opportunities of the process participants for the integration of competencies are highlighted. This creates an impulse for self-development.

A number of studies are devoted to modeling the process of absorption by corporations of small innovative enterprises during the formation of an ecosystem. However, conditions are possible (regulation of competition, tax regime, subsidies) under which exponential growth of both types of organisations (small and corporations) occurs.

The working hypothesis of the study is the possibility of organising an industrial production platform in Russia on the basis of a single digital space, taking into account the characteristics of the technological, production, economic, and financial potentials of the enterprise.

2. Methodology and results of the study

In this paper to substantiate the direction of development of the potential for digitalisation of industrial production in the Russian Federation, the following research methods are used:

1) a comparison method to obtain information about the directions and ways of digitalisation of industry in different countries;
2) a functional method for determining the tasks of digitalisation, taking into account the functional profile of the object’s activity;
3) methods of analysis and synthesis to determine the ways of interaction based on digital methods of various functional systems of the enterprise;
4) modeling methods for developing the concept of a single digital space of an industrial enterprise or groups of enterprises;
5) statistical methods that allow to obtain an objective description of the state of industry digitalisation in the world and in Russia.

Table 1
Information about the use of digital technologies and related goods and services in production
(% of the number of respondents surveyed)

Industry	Digital platforms	Big Data	AI technologies	Cloud services	IoT	Digital twin	Industrial robots / automated lines	Additive technologies
Mining	13.2	21.8	2.5	19.0	14.6	2.1	4.2	1.5
Manufacturing industries	16.0	26.5	3.6	27.1	15.8	3.3	17.2	5.2
Supply of energy, gas and steam, air conditioning	16.6	23.7	3.3	19.4	15.9	1.2	2.0	1.1
Collective classification grouping by types of economic activity "Industry" (based on OKVED2)	15.4	24.8	3.3	23.9	15.3	2.5	11.3	3.6

Note. Information on the use of digital technologies and the production of related goods and services units of measurement are given as a percentage of the number of respondents (representatives of industrial enterprises).

Source: Russian Statistical Yearbook (2021): stat. Sat. Moscow: Rosstat.

Statistical data show the distribution of digital technologies used by industry (Table 1).

Thus, digitalisation goes in two directions:

1) creation of the digital space of the enterprise;

2) creation of an ecosystem of industrial production.

In Russia, the leading companies in the digitalisation of industry are KAMAZ PJSC, Kalashnikov PJSC, RusAl OJSC, Petrozavodskmash JSC. At KAMAZ, the Digital Transformation Center has created: logistics planning systems, a system for monitoring and operational management of production (MRP-2), a cloud platform system, a system for interacting with customers, and robotisation. Currently, the number of systems accounts for 900. As a result of digital transformation, the company's sales volume increased by 21% [Digital technologies in logistics.., 2020].

The process of digitalisation is actively going on in high-tech companies such as PJSC Russian Helicopters and JSC UAC.

The introduction of digital technologies makes it possible to effectively solve the problem of industrial safety based on preventive technologies (Table 2).

Table 2
Rating of digital technologies in the industry in 2020

№	Technology	Significance Index
1	Industrial robots	1
2	Artificial intelligence	0.86
3	Machine learning	0.68
4	Digital Prototyping	0.56
5	Sensorics	0.42
6	Wireless connection	0.30
7	Blockchain	0.21
8	Big Data	0.20
9	Virtual and augmented reality	0.12
10	Product as a service	0.09
11	Computer vision	0.03
12	Smart contracts	0.03
13	Industrial Internet of Things	0.03
14	Digital Twin (BIM)	0.02
15	Smart factories	0.01

Source: Digitalisation: history, prospects, digital economies of Russia and the world. Manufacturing control. https://up-pro.ru/library/strategi/tendencii/cyfrovizaciya-trend/.

Digital technologies make it possible, in particular, to monitor the entire production process and timely register violations of safety rules.

It should be noted the factors hindering the development of digitalisation of Russian industry:

1) low-tech level of the production process;
2) lack of automatic control;
3) low level of production required for the digitalisation of equipment (processors, sensors, routers, etc.);
4) low level of production standardisation;
5) many processes at the state level are not structured;
6) lack of qualified specialists in the use of IT technologies;
7) insufficient level of training of IT-specialists in Russia;
8) the specific mentality of entrepreneurs – many strive for a quick income (while in developed countries a significant proportion of businessmen are engaged in projects with a payback period of 30 years).

Now, in accordance with the data [Korovin, 2019], in Western countries the share of the digital economy in the structure of GDP is 16-35%, while in Russia it is 5%, and even then in the service sector.

PwC conducted a survey of 1,155 manufacturing executives from various industries in 26 countries[2]. Four categories of companies were identified: digital newbies, digital followers, digital innovators, and digital champions. Only 10% of industrial companies are digital champions, of which 2/3 are in the early stages. Digital champions are companies that have implemented four ecosystems: operational, technology, human resources and customer. Overall, across all industries, Asian companies are leading (19% of surveyed companies have reached digital champion maturity), while in the automotive and electronics industries, 20% of respondents have reached this level of maturity. These companies are significantly behind enterprises from the sphere of production of consumer and industrial goods, as well as the processing industry. In the US, the least digitised are the traditional industries – oil, mining, chemicals, and pharmaceuticals.

In Russia, based on the analysis of big data in the 100 largest companies representing the metallurgical, oil and gas, banking industries, as well as the financial sector, it turned out that 68% of companies have begun to form tools for the digital economy. The main direction is the robotisation of business processes (Robotic process automation, RPA) and predictive analytics.

Unfortunately, domestic companies that have begun to digitalize their activities carry it out spontaneously, without an integrated plan. Only 35% of Russian companies have a ready-made digitalisation strategy, while the rest are only going to develop it [Gudkova, 2021].

Digitalisation means a transition to a fundamentally new technological level – not only the replacement of obsolete and obsolete equipment with the latest, but also the digitalisation of this equipment.

Russian companies, with the support of leading foreign companies, have begun training their employees in digital skills. However, at present, under the current conditions, it is necessary to mobilise efforts in leading universities that train specialists in information technology and programming, with the development of a set of training programmes for domestic IT companies. The low level of digitalisation is also facilitated by the weak development of high-tech industries.

A promising object of industrial digitalisation is value-added production chains [Russia in a new era .., 2020]. The theoretical foundations for organising production chains were formulated by D. Hopkins [Digitalisation of the manufacturing industry.., 2021]. Production chains are a system of independent enterprises that produce elements of multicomponent complex products.

Researchers believe that the essential difference between an ecosystem and a traditional market is the degree of cooperation and competition between participants in ecosystem relations.

3. Discussion of results

It should be noted that the ideas about the ecosystem have been developed in developed countries, in which a significant number of industrial enterprises have a high technological level of production organisation. These enterprises have a high potential for the formation of ecosystem associations based on digital technologies.

In Russia, even the leading branches of the manufacturing industry, such as mechanical engineering, have a low technological level of production. This feature limits the ability of enterprises to produce products in a wide range of products. As a result, enterprises have a low potential for organising large-scale production of multicomponent products. Thus, in the engineering industry, out of 40,000 enterprises, only 2,000 are able to organise large-scale production.

At present, the main sectors of the manufacturing industry in the Russian Federation (machine building and the chemical industry) are largely dependent on imported technologies and equipment. The needs of the Russian economy in industrial goods (engineering) were satisfied by 60% by foreign purchases. In sectors such as civil engineering, communication equipment, electronic devices,

[2] Connected and autonomous supply chain ecosystems 2025. https://www.pwc.com/sg/en/services/reimagine-digital/business-transformation/digital-supply-chain/connected-and-autonomous-supply-chain-ecosystems-2025.html.

the share of imports is approaching 90-100%[3]. It should also be noted that more than a quarter of machine-building enterprises are economically inefficient[4].

The analysis performed shows that Russian manufacturing enterprises have a low potential for organising modern production of complex products, especially in high-tech industries. Two tasks need to be solved:

1. To form the potential for breakthrough development of manufacturing enterprises.
2. To combine enterprises with breakthrough development potential into ecosystems.

4. Conclusions and suggestions for further research

Thus, in order to ensure the economic sovereignty of the country, it is necessary to develop a fundamentally new model of industrial production in the context of digital transformation. To do this, it is necessary to solve the following tasks:

1. To identify the main groups of goods that are a priority for the Russian economy.
2. To reveal the existence of enterprises with competencies in the production of these goods.
3. To monitor the technological state of the production of these products.
4. Based on the information received to engineer the possibility of creating a production chain, identifying and eliminating bottlenecks through interaction with friendly countries (China, India).
5. To monitor the personnel potential of the industry.
6. To coordinate with enterprises the needs of customers in the range of products, the scale of supplies, quality characteristics on a long-term basis.
7. To form stable logistics links between enterprises and consumers of industrial products.
8. To develop an after-sales service system.
9. Science and technology platforms define short-, medium- and long-term plans for the technological development of value chains. The implementation of these plans creates the conditions for solving the problem of technological sovereignty of the Russian industry. When organising scientific and technological platforms, the following circumstances must be taken into account: no company in the world has the full scope of competencies to create sustainable scientific and technological development. In this regard, conditions for coordination of leading scientists, engineers, and designers, regardless of their departmental affiliation, should be created on this platform.
10. To create a system of value chains, provide them with a modern system of interaction, which will allow, regardless of ownership, to increase labour productivity due to a high level of technological security, optimal use of resources and the scale of production. As a result, an industrial hub will be created, within which a wide range of complex multi-component products will be produced.
11. When creating an industrial hub, it is necessary to take into account the limitations of digital management models of individual enterprises.
12. In the value chain, production technology and management system should be digitally synchronised.

To implement the concept of an industrial hub, it is necessary to create a special development institution based on a public-private partnership with the participation of engineers and leading designers, representatives of the state in the format of a self-governing organisation. The development institution created by the state will manage the entire hub, and a branch of the organisation, empowered by the development institution, will manage a separate chain. The coordinating body will be the strategic development committee, which will include six state representatives. An advisory vote will be given to specialists - heads of the largest enterprises, leading scientists and experts in relevant subject areas.

[3] Digitalisation of industry. Overview of TAdviser. https://www.tadviser.ru/index.php/%D0%A1%D1%82%D0%B0%D1%82%D1%8C%D1%8F:%D0%A6%D0%B8%D1%84%D1%80%D0%BE%D0%B2%D0%B8%D0%B7%D0%B0%D1%86%D0%B8%D1%8F_%D0%BF%D1%80%D0%BE%D0%BC%D1%8B%D1%88%D0%BB%D0%B5%D0%BD%D0%BD%D0%BE%D1%81%D1%82%D0%B8._%D0%9E%D0%B1%D0%B7%D0%BE%D1%80_TAdviser.

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About the authors

Yurii S. Bogachev

Doctor of physical and mathematical sciences, chief researcher of the Institute of Financial and Industrial Policy, Financial University under the Government of the Russian Federation (Moscow, Russia). ORCID: 0000-0002-8595-7674; SPIN-code: 4904-1754; Author ID: 134869.

Research interests: industrial policy, industrial development institutions, innovations of high-tech industrial sectors.

bogachev43@mail.ru

Pavel V. Trifonov

Candidate of economic sciences, associate professor, Department of Management and Innovation, leading researcher at the Institute of Financial and Industrial Policy, Financial University under the Government of the Russian Federation (Moscow, Russia). RSCI: 8842-5179; ORCID: 0000-0003-2228-5441; Scopus ID: 1540947; Researcher ID: E-2266-2019.

Research interests: development of industrial enterprises, production potential of enterprises, business process management.

PVTrifonov@fa.ru

作者信息

Yurii S. Bogachev
物理学数学博士、俄罗斯联邦政府金融大学金融和工业政策研究所首席科学家（俄罗斯莫斯科）。 ORCID： 0000-0002-8595-7674； SPIN： 4904-1754； Scopus Author ID： 134869。
研究领域：工业政策、工业发展机构、高科技产业部门的创新。
bogachev43@mail.ru

Pavel V. Trifonov
经济学副博士，俄罗斯联邦政府金融大学高等管理学院管理与创新系副教授，金融和工业政策研究所主任研究员（俄罗斯莫斯科）。 RSCI： 8842-5179； ORCID： 0000-0003-2228-5441; Scopus ID： 1540947; Researcher ID： E-2266-2019。
研究领域：工业发展、企业的生产潜力、业务流程管理。
PVTrifonov@fa.ru

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Transformation of business models of Russian industrial companies under the influence of digital technologies

A.S. Karikova[1]

[1] Financial University under the Government of the Russian Federation (Moscow, Russia)

Abstract

The article presents the results of the influence of digital technologies on the transformation of industrial companies' business models and its analysis. The author has conducted a survey of industrial companies, at which point the most used advanced technologies are identified, the amount of investments and the investment pattern in digital transformation are analysed, as well as the purchase of foreign and domestic technologies, equipment and software by enterprises. The criteria for classifying digital business models used by production companies are formulated and two clusters are specified: platform-based business models and business models of "Factories of the future". For the first time business models of digital transformation of companies in the Russian industry are specified: digital ecosystems, platforms for joint value co-creation, the introduction of a customising product, smart factory, remanufacturing and digital engineering. Digital transformation strategies used by industrial companies are specified for each cluster. The characteristics of digital transformation strategies are determined and the distribution of the strategies over manufacturing sectors are carried out.

Keywords: digital transformation, business model, industrial company, strategy, digital technologies.

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俄罗斯工业企业在数字技术影响下的商业模式转型

A.S. Karikova[1]

[1]俄罗斯联邦政府金融大学（俄罗斯莫斯科）

摘要

本文章介绍了数字技术对工业企业商业模式转型影响的分析结果。作者对工业企业进行了一项调查，突出强调了最经常使用的先进技术。分析了数字化转型的投资数量和方向，以及企业购买国外和国内技术、设备和软件的情况。制定了工业企业使用的数字商业模式的分类标准，突出了两个集群——平台商业模式和"未来工厂"的商业模式。俄罗斯工业企业数字化转型的商业模式首次得到强调：数字生态系统，共享创造价值的平台，实施定制的产品，智能工厂，工厂升级和数字工程。对于每一个集群，都强调了工业企业使用的数字化转型战略。数字化转型战略的特点已经被确定，所使用的战略也分布在各个行业。

关键词：数字化转型，商业模式，工业企业，战略，数字技术。

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Introduction

Digital transformation has become the most significant trend in recent years and has been included in the strategies of most enterprises in Russia, including production ones. Today digital transformation is an essential prerequisite for the sustainable development of the organisation, it allows companies to hold a competitive advantage in conditions of constant process acceleration and dynamic changes. At the same time, the digital transformation can be interpreted as a strategically controlled process of transforming the business model of an organisation with the use of digital technologies, the purpose of which is to create an updated business model that can work effectively and develop steadily within the conditions of the modern digital economy. Among digital technologies for production companies advanced manufacturing technologies claim attention.

The most essential advanced manufacturing technologies, with regard to the digitalisation of the product life cycle, are computer and supercomputer modelling technologies, digital twins of products and their subsequent virtual testing and optimisation. The basis for the implementation of the aforementioned advanced manufacturing technologies are product design software and computing engineering based on mathematical and simulation modelling (CAD, CAM, CAE and others), as well as product life-cycle management (PLM). Besides, the concepts of "Smart manufacturing", "Digital engineering", "Customising product" imply a high degree of automation and robotisation of business processes, real-time control with consideration to constantly changing conditions.

The implementation of the concepts of "Smart manufacturing", "Digital engineering", "Customising product" is impossible without the combination of IoT technologies, big data analysis and management information systems for production and business processes, robots, additive 3D and 4D printing technologies, industrial avatars with control via brain-computer interface. To implement the concept of a "Customising product", it is necessary to switch to the service business model "Product as a service" and predictive maintenance with the use of the technology of IoT devices installed on the product.

According to the study of the consulting PwC company, among European countries the leaders of digital transformation in industry are Germany, Denmark, France, the United Kingdom, among Asian countries – China, Japan, South Korea, as well as the United States and Canada. At the same time, the most used technologies by industrial companies in European countries are cloud services, industrial robots, automated lines, the Internet of Things and artificial intelligence [PwC, 2020].

In modern conditions the execution of digital transformation programmes by industrial companies may be disrupted due to limited access to digital technologies. In this regard, we conducted a survey among 205 production enterprises of manufacturing industries with the number of employees fewer than 250 people (small companies), more than 250 people (medium-sized companies) and more than 500 people (large companies).

The production companies included in the sample are divided into three sectors: low-; medium-; and high-tech business, according to the division of manufacturing industries by Federal State Statistics Service (Rosstat)[1]. Companies that were difficult to answer the questions concerning the impact of digital technologies on the transformation of business models were excluded from the sample. The final sample included 196 companies.

The characteristics of the production companies included in the sample are presented in Table 1.

The study was conducted through an online survey from April to September 2022. The respondents were selected taking into account their greatest awareness of the processes of digital transformation and the execution of the digital transformation strategy in companies. The study design implied the participation of one respondent from one company. To analyse the level of implementation of digital technologies the information of the following advanced manufacturing technologies was used:

- industry robots /automated lines;
- additive technologies;
- cloud services;
- IoT;
- radio frequency identification technologies (RFID tags);
- software for creating digital twins;
- software for design and modeling (CAD; CAE; CAM; CAO);
- software for automated production management;
- software for big data analysis;
- artificial intelligence;
- digital platforms;
- ERP systems;
- software for product lifecycle management (PLM systems).

Besides, companies were suggested to provide a form of statistical observation No 3 for 2020–2021, as it reflects the necessary information on the application of the specified technological solutions by industrial companies. Also, the analysis of the data presented in the reports of industrial companies made it possible to conduct an econometric analysis of the impact of advanced manufacturing technologies on the efficiency of industrial manufacturing, to analyse the spread of advanced manufacturing technologies and its speed and compare industrial sectors with each other and with foreign countries.

The first poll question concerns studying the popularity of the implementation of end-to-end digital technologies by industrial companies. The respondents' answers are shown in Fig. 1.

As expected, companies in the high level high-tech and medium-tech sector implement advanced manufacturing technologies more often than companies in the low level low-tech and medium-tech sector. The implementation of advanced manufacturing technologies is influenced by the size of the

[1] The division was made according to the recommendations of Federal State Statistics Service (Rosstat). High-tech industries include: the production of pharmaceutical products, the production of office equipment and computer machines, electronic components and equipment for radio, television and communications, medical products, aircraft, including space vehicles. Medium-tech industries include: chemical production, production of machinery and equipment, production of electrical machinery and equipment, production of automobiles, oil products, rubber and plastic products, metallurgical production, production of finished metal products. Low-tech industries include: the production of food products, tobacco products, textile production, clothing production, wood processing and production of wood products, pulp, paper, cardboard production, publishing and printing activities, processing of secondary raw materials.

Table 1
Descriptive statistics of the companies' distribution under study

Sector	Investments to R&D (% of companies)	Export marketing activities (% of companies)	Share of proceeds of sale, aimed at the purchase of new technologies (weighted average value)	Standard deviation	Profit on the sale aimed at the implementation of digital transformation projects (weighted average value)	Standard deviation
Up to 250 people (28 companies)						
High-tech sector	25	18	0.04	0.0037	0.09	0.003
High-level medium-tech sector	21	13	0.08	0.0024	0.11	0.0014
Low-level medium-tech sector	12	9	0.04	0.0018	0.06	0.0068
Low-tech sector	7.7	4	0.01	0.0043	0.02	0.0023
250–499 people (88 companies)						
High-tech sector	41	17	0.1	0.0019	0.12	0.0024
High-level medium-tech sector	31	15	0.07	0.0028	0.1	0.0019
Low-level medium-tech sector	26	10	0.04	0.0021	0.08	0.0043
Low-tech sector	14	7	0.01	0.0014	0.04	0.0053
500 and more people (80 companies)						
High-tech sector	52	26	0.15	0.0029	0.2	0.0034
High-level medium-tech sector	20	19	0.1	0.0042	0.15	0.0032
Low-level medium-tech sector	23	13	0.03	0.0045	0.06	0.0058
Low-tech sector	15	7	0.02	0.003	0.02	0.0013

Source: compiled by the author.

company: larger companies invest more in the purchase of new technologies and implement more diverse technologies. Industry robots are most often implemented among high-level high-tech and medium-tech companies (43 and 32% respectively); cloud technologies (37 and 31% respectively); software for design and modeling (29 and 25% respectively).

Such technologies as radio-frequency identification technologies (27 and 21% respectively); technologies for automated production management (19 and 21% respectively); digital platforms (22 and 20% respectively) are also implemented frequently enough. The least popular are the implementation of digital twins (7 and 4% respectively); artificial intelligence (4 and 2% respectively); software for product lifecycle management (6 and 5% respectively). Among low-level low-tech and medium-tech companies the most popular technologies are: cloud services (19 and 24% respectively); industry robots (23 and 17% respectively); ERP systems (22 and 21% respectively); digital platforms (13 and 17% respectively) and radio-frequency identification technologies (15 and 16% respectively).

The least popular are artificial intelligence technologies (1 and 2% respectively); software for product lifecycle management (1 and 2% respectively); software for creating digital twins (2% each); the Internet of Things (3 and 5% respectively).

The following poll questions concern the amount of investments and the investment pattern in digital transformation. The answers to the question about the amount of investments in digital transformation from the total gross revenues are shown in Fig. 2.

According to the survey, the costs of implementing digital transformation programmes differ significantly depending on the industry sector.

In high-tech industries investments reach about 10–12%, in medium and low-tech industries they are significantly lower – on average 2–7% of the total proceeds of the company's sales. At the same time, the costs of digital transformation from the total amount of the company's investment are slightly higher.

The companies' response to the types of digital transformation expenditures is presented in Fig. 3.

All sectors of the manufacturing industry are characterised by higher expenditures for the purchase of technologies and equipment than by the expenditures for the investments in software. Other costs relate to the organisation of electronic document flow, numerical tagging of goods, etc.

The next question related to the correlation between the purchase of foreign and domestic technologies, equipment and software. The respondents' answers are shown in Fig. 4.

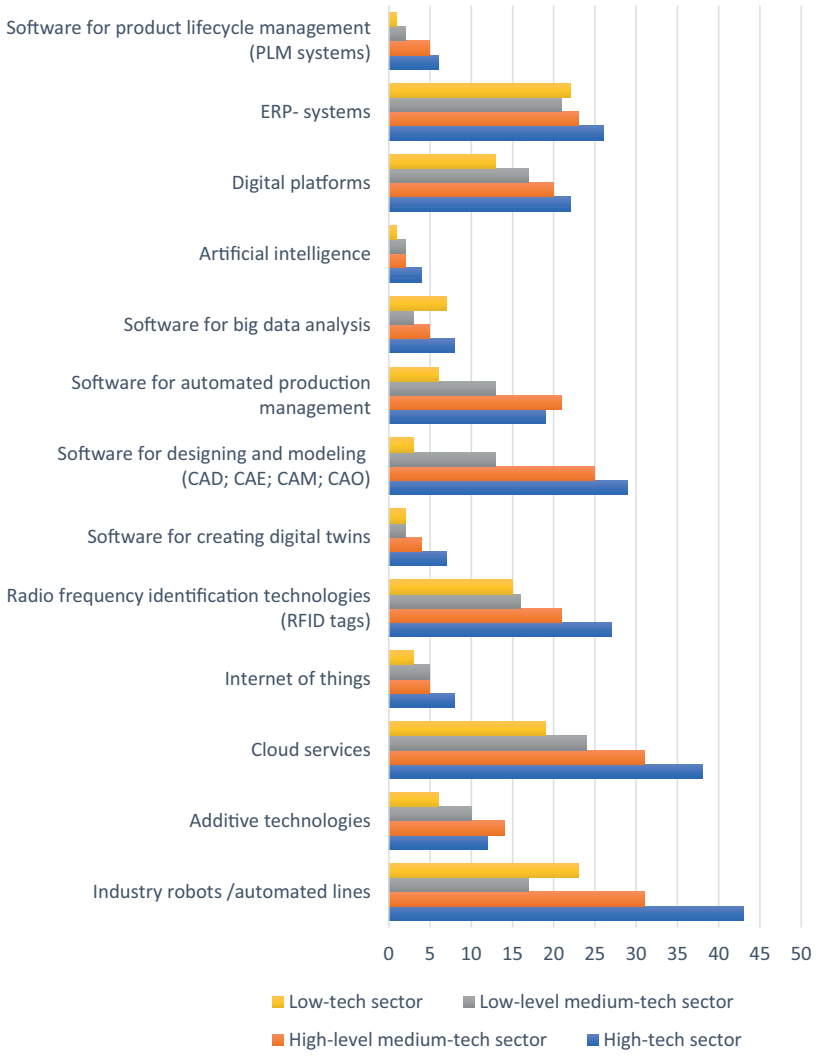
As shown in the figure, both high-tech and low-tech companies mainly use foreign equipment, technologies and software customised to Russian companies.

The main problem of transition to domestic software and technologies is that the technologies and software used are incompatible with Russian ones, i.e. during the transition, many software packages and technologies will have to be replaced simultaneously, as well as integrated with all systems in the enterprise. The majority of respondents admit that such expenses, especially in the current conditions, are impossible for them.

Another problem of the transition to domestic technologies and software is their narrow range of choice and incomplete correspondence to all the needs of the company.

The next question concerned the realisation of the projects "Smart manufacturing", "Digital engineering", "Customising product" by manufacturing companies.

Fig. 1. The results of the survey of production companies on the most frequently implemented advanced manufacturing technologies



Source: compiled by the author.

According to the Strategy of Digital Transformation of Manufacturing Industries, the Smart Manufacturing project performs tasks aimed at improving the efficient use of fixed assets, raw product, materials, the development and implementation of Russian software and increasing the share of enterprises using predictive analytical technologies and the industrial Internet of Things.

The Digital Engineering project is aimed at accelerating the development and sales of products, increasing the number of companies working with universal marketplaces, reducing the time of the introduction of products to the market, as well as the share of enterprises using digital twins and virtual testing technologies.

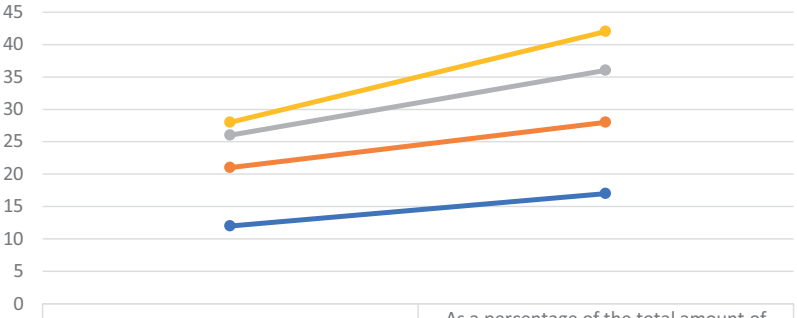
The project "Products of the future" has the main purpose of introducing a service model of product realisation and providing wide access to new technologies and also implies the transition to a flexible assembly line production model, the customisation of the product to customer requirements and an increase in the share of enterprises using predictive analytical technologies.

The respondents' answers about the implementation of these projects in their companies are shown in Fig. 5.

The group of companies of high-level high-tech and medium-tech industries implement digital transformation projects, which cover almost the entire life cycle of products from design to production and maintenance.

Besides, such companies use a wide variety of technologies necessary for the implementation of these projects – digital twins, virtual tests, Internet of things, digital platforms, etc.

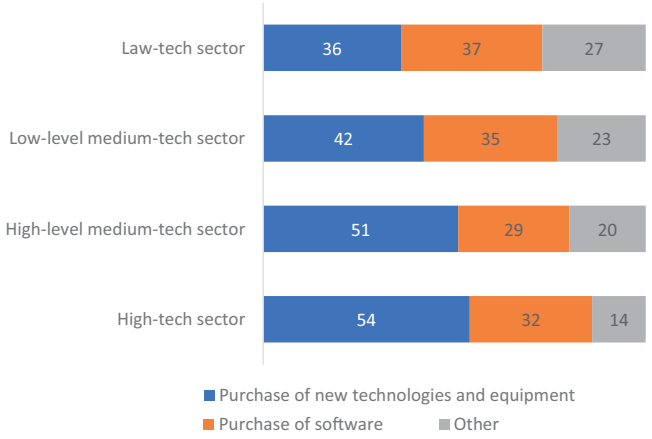
Fig. 2. The expenditures of industrial companies on the implementation of digital transformation programmes (the survey results)



	As a percentage of gross revenue	As a percentage of the total amount of investments
Law-tech sector	2	6
Low-level medium-tech sector	5	8
High-level medium-tech sector	9	11
High-tech sector	12	17

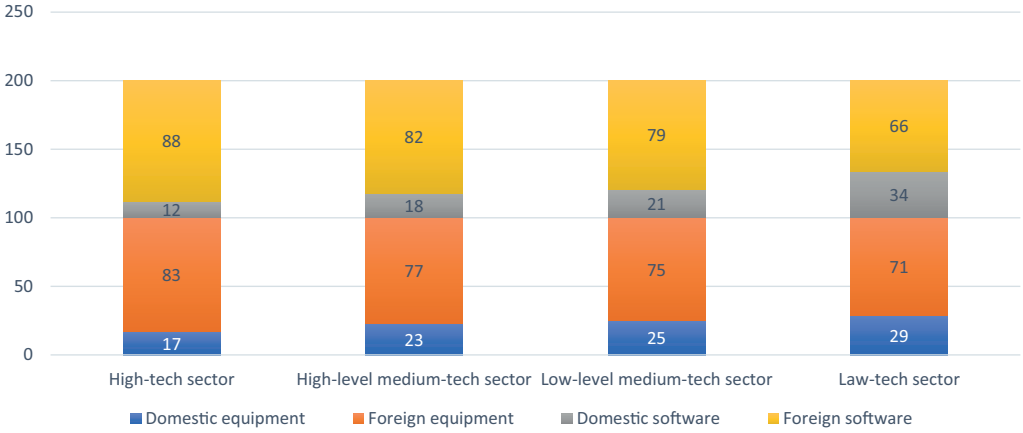
Source: compiled by the author.

Fig. 3. Expenditures of manufacturing companies for digital transformation according to type (the survey results)



Source: compiled by the author.

Fig. 4. The ratio of domestic and foreign technologies and software used by manufacturing companies (the survey results)



Source: compiled by the author.

Among the enterprises of low-level low-tech and medium-tech sectors the projects of "Products of the future" and "Smart manufacturing" enjoy the greatest popularity, but they put more emphasis on the introduction of domestic software rather than companies in high-tech industries.

At the same time, there are rather low numbers of the implementation of the specified priority projects in all sectors. It should also be noted that the implementation of these priority projects is carried out only by large companies, while small and medium-sized businesses are undergoing a phase of transformation of separate production and business processes, without creating production ecosystems on the basis of digital platforms (which is a condition for the implementation of all priority projects).

Thus, the improvement of support measures of digital transformation should consist in supporting the implementation of digital technologies, software and priority projects "Smart manufacturing", "Digital engineering", "Customising product" in companies of small and medium-sized industries.

The next question was to analyse the risks for the implementation of the digital transformation strategy under the sanctions imposed in the spring of 2022.

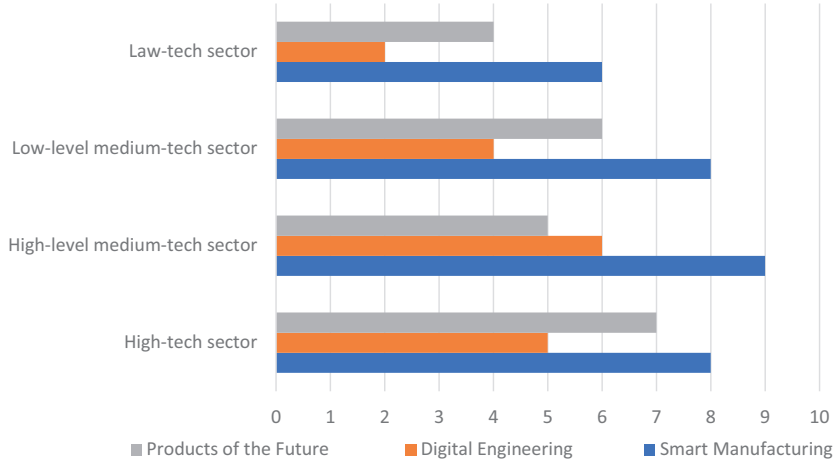
The majority of respondents admitted that the suspension of sales and updates of foreign software, the ban on the supply of components, the rise in loan interest rates, the increase in the cost of equipment will have a negative impact in the medium-term horizon (2–3 years) on the implementation of the digital transformation strategy. More than half of the respondents admitted that the sanctions pressure stimulates reverse engineering of equipment and software, and the speed of development of domestic technologies and software will determine the implementation of the digital transformation strategy in the medium-term horizon. Since all the technologies used for the implementation of priority projects are closely interconnected, companies will have to completely switch to domestic equipment and software, which will lead to high financial expenditures, and that seems unrealistic for respondents in the medium-term horizon. Besides, respondents noted a lack of human assets to create basic technologies and software. In this regard, as for us, the most effective measures to support the implementation of the digital transformation strategy among manufacturing companies will be: the creation of reverse engineering centers, including centres on the basis of universities; the creation of centers for the development of domestic software and equipment; reduced-rate lending for the purchase of domestic software and equipment; the creation of a favorable investment and business environment, including granting tax exemptions.

The purpose of this article is to analyse the influence of digital technologies on the transformation of business models of industrial companies.

1. Theoretical literature review

Research in the field of digital transformation can be divided into several major directions, which were set by the book that became fundamental for the digital transformation processes: "Guide to digitalisation: How to turn technology into digital transformation" [Westerman et al., 2014]. The authors define digital transformation as "the transformation of three key areas of an enterprise: customer experience, operational processes and business models" [Westerman et al., 2014, p. 13]. All further research in one way or other relates to one of these areas. Digital transformation has generated considerable interest among both scientists and practitioners,

Fig. 5. Implementation of priority projects by industrial companies (the survey results)



Source: compiled by the author.

considering its huge potential impact on products, services, innovation processes and business models [Andal Ancion et al., 2003; Lyytinen et al., 2016; Nambisan, 2017]. Digital transformation reduces the time required to develop and launch the process of innovations, reduces the lifecycle of new products and services on the market and requires companies to share knowledge related to technologies they are not familiar with. The boundaries between industries and product categories are erasing, and competition is increasingly determined by multilateral platforms and related ecosystems. A successful response to these challenges requires flexibility, as well as dynamic capabilities in the development of products and services [Kock, Gemünden, 2016], which, in their turn, require bold changes in the ways of managing the innovation process, organising and managing innovation activities, as well as the competencies and relationships of those who involved in innovation processes.

The emergence of the economic category "business model" is associated with the work [Teece, 2010] and focused on searching for the answers to three key questions: Why should a customer buy anything from a company? How can a company gain by selling its product? What are the key actions that will allow a company to implement its plan?

The most famous among the studies on the structure of the business model is the work [Osterwalder et al., 2010] in which the authors distinguish nine elements: consumer segments, value proposition, channels of distribution, relationships with customers, income streams, key resources, key activities, key partnerships and expenditure pattern. In the work [Chesbrough, Rosenbloom, 2002] the main components are the value proposition, market segment, value chain structure, expenditure and profit structure, a position within the value chain, competitive strategy. D. Teece distinguishes such elements as technologies and product features, consumer advantage when using the product, target market segments, income streams, mechanisms for obtaining value.

Since the nature of value added has changed, today companies have to adapt their business infrastructure to the new digital era, namely, to rebuild the entire value chain to new digital technologies [Porter, Heppelmann, 2014]. The use of new technologies should be incorporated into new business models that will form competitive advantages [Bharadwaj et al., 2013; Hess et al., 2016; Becker et al., 2018]. Companies will be able to take full advantage of their value creation potential in case they have a well-defined strategic orientation that will help to implement digital business models.

Digital transformation may require a significant change in the business model to maximise benefits and reduce costs. The implementation of digital technologies calls into question the traditional way of business dealing, and therefore companies should reconsider the elements used to create and maintain their competitive advantage [Correani et al., 2020].

Digitalisation allows to realise cost advantages, fulfil additional sales potential and increase productivity. A strategy that considers the use of digital technologies is crucial for the future business success of companies of any size and industry [Hess et al., 2016].

2. Research design

The clustering method was applied to identify digital transformation strategies in manufacturing industry with a use of a two-step procedure. This procedure was applied in the research works [Gokhberg et al., 2010; Trachuk, Linder, 2015; Miles et al., 2017; Linder, 2020]. First, using the principal component analysis the factors that distinguished the enterprises from each other and the factors that were common to the group of enterprises were determined. Then, considering the presence of certain factors, enterprises were assigned to different groups, so that each group of enterprises (cluster) consisted of enterprises with a particular set of characteristics and at the same time each cluster differed from each other.

The key factor in the division of industrial companies was the factor "the participant composition of digital services and business processes based on the principles of mutually beneficial relationships." To analyse it respondents were asked two questions:

- Are external participants involved in the business processes of the organisation? (technology SSO or single sign-on technology) (if yes – 1, otherwise – 0);
- Are digital services unified by a common brand? (if yes – 1, otherwise – 0);
- Do digital services allow to increase the user base and generate profit from non – traditional businesses? (if yes – 1, otherwise – 0).

In terms of the factor "Implemented digital technologies", respondents were asked the following questions:

- Is the full range of Industry 4.0 technologies implemented throughout the value chain being applied? (if yes – 1, otherwise – 0);
- Are modular production lines that can be quickly delivered, assembled and connected being implemented? (if yes – 1, otherwise – 0);

– Are intelligent services ensuring the appearing of a "seamless user experience" being implemented? (if yes – 1, otherwise – 0).

In terms of the "Reach of transactions" factor (this factor stands for the breadth, complexity and consistency of the value proposition, how many goods and services are included in the value proposition, how interconnected they are and whether they can lead to repeat purchases). To analyse it, respondents were asked the following questions:

– Do the digital technologies implemented in the company allow to form a value proposition that has breadth, complexity and consistency? (if yes – 1, otherwise – 0);
– Does the implemented business model allow to develop digitised channels? (if yes – 1, otherwise – 0);
– Are goods and services, within the value proposition, interconnected and lead to repeated purchases? (if yes – 1, otherwise – 0);
– Do the digital technologies implemented in the company allow to customise the value proposition for clients? (if yes – 1, otherwise – 0).

In terms of the "Cost optimisation" factor, respondents were asked to estimate the direction of digital technology influence: reduction in expenditure on quality assurance (if yes – 1, otherwise – 0), cost reduction (if yes – 1, otherwise – 0), acceleration of bringing a product to market (if yes – 1, otherwise – 0), acceleration of the manufacturing cycle (if yes – 1, otherwise – 0), reduction of time for prototyping (if yes – 1, otherwise – 0), reduction of time spent for logistics (if yes – 1, otherwise – 0), reduction in expenditure on customer capture and increase in the the user base (if yes – 1, otherwise – 0).

Descriptive statistic is presented in Table 2.

To determine the companies' clusters the hierarchical cluster analysis method was used, according to which the distances between arbitrary pairs of clusters are determined and then the Hamming distance can be used as a means of the homogeneity, reflected in Formula (1), calculated as the ratio of the number of matching values to the number of all variate values:

$$d_{ij} = \sum_{k=1}^{m} |x_{ik} - x_{jk}|, \quad (1)$$

where d_{ij} – is a distance between x_{ik} and x_{jk}, x_{ik} – is a value k-th property of x_i, x_{jk} – is a value k-th property of x_j.

Using this methodology, the strategies of digital transformation in the Russian industry will be further distinguished.

3. Business models of digital transformation: The research results

Table 3 presents the results of a factorial analysis, in which four factors with eigenvalues greater than 1 were analysed, in summation explaining 68.27% of the dispersion.

Indicators on risk management and cybersecurity, as well as control over resource allocation, were not included in the results of the factor analysis, as they are approximately equal for all respondents and make it difficult to identify strategies for digital transformation of enterprises.

The first factor is "The participant composition of digital services and business processes based on the principles of mutually beneficial relationships". The availability of external participants implies the company's desire to transform the business by creating platforms or an ecosystem. In the absence of external participants, the company considers closed business models of "Smart factories" and "Digital production" to be a successful solution. It should also be noted that if a company has large volumes of its own incoming traffic, with a significant number of leads, companies strive to create their own ecosystems, optimise business processes and engage partners to provide related services to customers. A limited flow of applications determines the formation of companies' own

Table 2
Descriptive statistic of variables the study variables

Variables	The number of enterprises	Average value (1 - answer "yes," 0 - answer "no")	Standard deviation
The company invests in digital technologies	196	0.341	0.671
The company invests in quality assurance and creation of a new product	196	0.231	0.462
The company invests in value creation together with the consumer	196	0.649	0.671
The company transforms its business model	196	0.44	0.473
The company transforms managerial decision-making	196	0.33	0.55
The company has the opportunity to implement digital innovations independently	196	0.473	0.528
The company creates a digital ecosystem	196	0.616	0.627
The company manage risks and provides cybersecurity	196	0.264	0.583
The company controls the resource allocation	196	0.33	0.561
The company rationalises production and improves business processes	196	0.396	0.594
The company digitalises commercial processes and supply chain management	196	0.638	0.495
The company is receptive to new technologies, transfer of technology	196	0.319	0.528
The company performs maintenance of equipment according to the condition	196	0.209	0.517
The company manages the effectiveness with the use of digital technologies	196	0.143	0.572

Source: compiled by the author.

marketplaces or integration into global marketplaces with their goods or services.

The factor "Implemented digital technologies" shows which focus areas and business processes are digitised by the company most particularly: business processes aimed at developing "smart production", improving existing technological processes, ensuring the rationalisation of production considering its type (mass, serial, one-off or single-item) or the implementation of new technologies contributes to increasing in user base, reducing the expenditures on customer capture, the success of the brand.

The "Reach of transactions" factor is focused on understanding the formation of a value proposition for customers by companies, supplementing the value proposition with services and increasing the level of its customisation. Most commonly platform-based business models tend to increase the reach of transactions and ecosystem business models simultaneously combine the reach of transactions with an increase in the level of customisation. Meanwhile, business models aimed at improving the production process are accompanied by a small expansion of the reach of transactions do not imply the formation of digitised channels for promoting value proposition and adapting to customer needs.

The "Cost optimisation" factor allows to determine the key effects of the implementation of the target digital business model. If the key effects are focused on reducing the expenditure on quality assurance, reducing the prime cost, accelerating the introduction of products to the market, productivity gain and accelerating the production cycle, mostly common such companies build business models of "smart production". If the expectation effects are connected with a reduction of expenditures on searching for new customers, with more accurate identification and satisfaction of their needs, with forecasting demand fluctuations with maximum precision, the company strives to build digital platforms or ecosystems.

To identify clusters of industrial companies implementing certain digital business models, the methodology described in the article [Trachuk, Linder, 2015] was used. According to this methodology, the maximum local distance equation is used to determine the distances between clusters. The calculation results are presented in Table 4.

As was shown above, 196 companies were surveyed, 82 of which use platform business models. As a result of the calculations, we can see two spikes, highlighted in italics in the table: the first split occurred at step 105, the second one at step 166, which means that the selected set according to the factor "the participant composition of digital services and business processes based on the principles of mutually beneficial relationships" can be divided into 2 clusters.

Table 3
The analysis of factors to identify digital transformation strategies

Indicators	Factors			
	The participant composition of digital services and business processes based on the principles of mutually beneficial relationships	Implemented digital technologies	Reach of transactions	Cost optimisation
Investments in digital technologies	0.35	0.35	0.35	0.35
Investments in quality assurance and creation of a new product	0.17	0.17	0.17	0.17
Investments in value creation together with the consumer	-0.1	-0.1	-0.1	-0.1
Transformation of business models	0.78	0.78	0.78	0.78
Transformation of managerial decision-making	0.14	0.14	0.14	0.14
The company has the opportunity to implement digital innovations independently	0.12	0.12	0.12	0.12
The company creates a digital ecosystem	0.1	0.1	0.1	0.1
The company rationalises production and improves business processes	0.25	0.25	0.25	0.25
The company digitalises commercial processes and supply chain management	0.65	0.65	0.65	0.65
The company is receptive to new technologies, transfer of technology	0.28	0.28	0.28	0.28
The company performs maintenance of equipment according to the condition	0.21	0.21	0.21	0.21
The company manages the effectiveness with the use of digital technologies	0.13	0.13	0.13	0.13
Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.646		
	Approximate square value	592.697		
	Number of freedom degrees	20.9		
	Significance	0.000		

Source: compiled by the author.

Table 4
Results of Hamming distance calculation

Step	Coefficient (d_{ij})	Step	Coefficient (d_{ij})
103	0.213	…	…
104	0.215	163	1.532
105	0.236	164	1.565
106	0.527	165	1.576
107	0.554	166	2.512

Source: compiled by the author.

According to the methodology applied within these two large groups, we also distinguished clusters of enterprises with common characteristics according to the indicators highlighted in Table 3. We used the *k*-means method presented in Formula (2) to group clusters:

$$V = \sum_{i=1}^{k} \sum_{X \epsilon S} (x_j - \mu_i)^2, \quad (2)$$

where k – is a number of clusters, s – specified clusters, x_i – individual characteristics of the analyzed factor, μ_i – mean characteristic of the analysed factor in the group, i – number of iterations from 1 to k.

Based on the calculations in each of the two large clusters other groups of enterprises with common characteristics according to the factors were distinguished with reference to the factors as presented in Table 3.

Thus, Cluster I and Cluster II differ only in the participant composition of digital services and business processes based on the principles of mutually beneficial relationships, and Clusters 1, 2, 3, 4, 5 differ in the following factors: the availability of an ecosystem, consumer involvement in joint value co-creation, the ability to implement a customising product, building a model of "smart factories", the ability to implement remanufacturing and digital engineering. It means that distinguished clusters are digital business models implemented by industrial companies.

The division into Clusters I and II is due to the possibility of building platform business models. The companies of each distinguished Cluster 1, 2, 3, 4, 5 have similar characteristics of business models of digital transformation.

The distinguished Clusters are shown in Fig. 6.

Cluster I – enterprises building platform business models – companies included in this cluster are distinct in the fact that they unite a large number of participants on the principles of mutually beneficial relationships, services and business processes, both around one company and with many players. Platform business models contribute to:

- ensuring higher competitiveness of all participants due to the synergetic effect, which is absent if companies work alone;
- generation of profits from the concentration of a variety of services (own or partner ones) and additional types of business;
- the increase in user base and reduction in the expenditures on customer capture, including by means of collecting big data and customising the value proposition;
- increasing the success of the brand by means of high-quality integration of all services and ensuring a high level of platforms innovativeness.

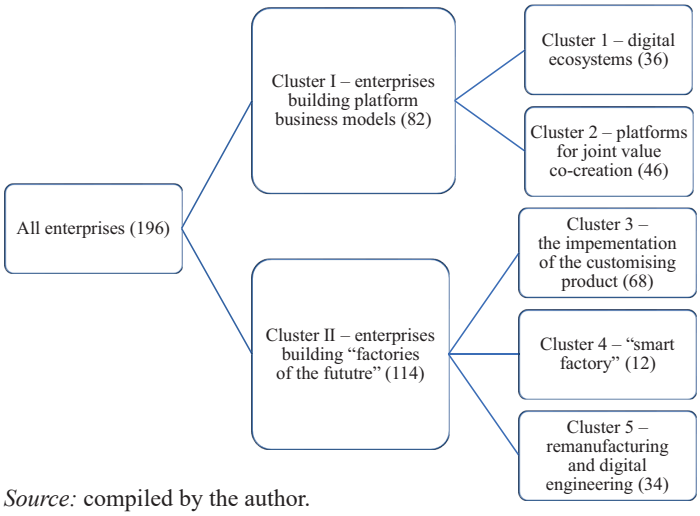
As a result of the analysis, the following business models can be distinguished in Cluster I: *Cluster 1 – Digital ecosystems* that are characterised by access to all services through a single account (single sign-on technology) and the unification of services under a common brand. Digital ecosystems are characterised by the emergence of a "seamless user experience" that allows the client to seamlessly switch between various services included in the ecosystem. At this time, the services in the ecosystem can be own, acquired or partner ones. The main purpose of the additional inclusion of the service in the ecosystem is to ensure synergy between businesses. Table 5 presents the strategies used by companies when implementing digital ecosystems.

Cluster 2 is a platform for joint value co-creation – these business models are aimed at the interaction of two or more companies, which somehow need each other. Platforms create value by driving down the cost of searching, distributing, and conducting transactions with each other. Industrial companies use platforms as part of the exchange of materials and resources, joint logistics, ensuring the sharing of knowledge and skills or creating mutual value with consumers. The specifics of creating digital business models for industrial companies are that the "winner takes all" principle does not work, and combining a large amount of data and digital platform participants leads to greater potential to stimulate innovation and increase productivity. Table 6 presents the strategies used by companies, which implement a joint value co-creation model.

Cluster II – combines business models aimed at enhancement of operational activities, changing production processes and technologies used, gaining competitive advantages by means of significantly reducing production expenses, reducing the time to bring new products to market, releasing high-tech products, increasing flexibility of production (and the ability to manufacture one-of-a-kind items industrially). In Cluster II three key business models used by industrial companies can be distinguished as follows:

Cluster 3 – implementation of a customising product. Companies implementing such business models strive to adapt their products to the preferences of individual customers, most

Fig. 6. Clusters of production companies by type of digital transformation strategy



Source: compiled by the author.

Table 5
Digitalisation strategies of enterprises using the "Digital ecosystems" business model

Strategies	The number of enterprises using the strategy
Customisation and personalisation strategy	12
Strategy of a new revenue stream with a low cost-price	—
Digital promotion channels strategy	5
Strategy of digitalisation of goods and services	3
Cost optimisation strategy	8
The strategy of creating a completely automated mass production of goods at low prices	—
Strategy of rapid response to changes in customer preferences	4
Strategies of a personalised offer creation	4
Total	36

commonly as part of the promotion and product sales. At the same time, companies can use both extensive customisation and adapt products to the requirements of various customers, and narrow customisation to adapt products to the requirements of individual customers. At this time, narrow customisation creates more value for the client, but is characterised by higher expenditures. As a general matter, companies using these business models prefer to create more value for customers, but at the same time, the increased diversity significantly increases the product cost. Companies implementing this business model most commonly use such technologies as 3D printing (allows to create products with an unlimited number of projects), digital models and twins (allow to accurately reflect and use the specification of individual customers), 3D scanning and modelling, big analytics algorithms that allow to collect a large amount of data about customers, artificial intelligence that allows to use flexible, dynamic pricing. Organisational methods and customisation tools include modular production, product lifecycle management, lean production, and co-design, which implies deep involvement of customers in product development processes. Table 7 presents the strategies used by companies implementing a customising product.

This business model is most often found among the industries of construction materials, food, machine engineering, textile and clothing.

Cluster 4 – a "smart factory". The feature of this business model is the intelligent control and optimisation of business, digital and production processes throughout the value chain in real-time mode. The implementation of the "Smart factory" business model implies achieving a level that makes it possible to have functions of self-organisation in production and in all processes related to production. This business model assumes minimal interference in the production process, optimised electric power consumption, improved product quality, reduced idle time and increased flawless operation of equipment. "Smart factory" involves end-to-end digitisation of the production process: product design, production, distribution and sale. The use of this business model implies the implementation of a whole range of digital technologies, such as virtual modeling, cloud storage of data, the internet of things, cloud computing, artificial intelligence, robot engineering, predictive analytics, additive manufacturing. Table 8 presents the strategies used by companies implementing the "Smart factory" model.

Cluster 5 – remanufacturing and digital engineering. Companies implementing this business model are aimed at upgrading old devices or introducing new modules into old devices. Recycling of products is also a part of this business model and companies implementing non-waste production and recycling can get additional profit by optimising resources or

Table 6
Digitalisation strategies of enterprises using the platforms for joint value co-creation model

Strategies	The number of enterprises using the strategy
Customisation and personalisation strategy	12
Strategy of a new revenue stream with a low cost-price	—
Digital promotion channels strategy	2
Strategy of digitalisation of goods and services	4
Cost optimisation strategy	10
The strategy of creating a completely automated mass production of goods at low prices	—
Strategy of rapid response to changes in customer preferences	8
Strategies of creation of a personalised offer	10
Total	46

Table 7
Digitalisation strategies of enterprises using the "Implementation of a customising product" business model

Strategies	The number of enterprises using the strategy
Customisation and personalisation strategy	16
Strategy of a new revenue stream with a low cost-price	—
Digital promotion channels strategy	9
Strategy of digitalisation of goods and services	5
Cost optimisation strategy	13
The strategy of creating a completely automated mass production of goods at low prices	—
Strategy of rapid response to changes in customer preferences	11
Strategies of creation of a personalised offer	14
Total	68

Table 8
Digitalisation strategies of enterprises using the "Smart factory" business model

Strategies	The number of enterprises using the strategy
Customisation and personalisation strategy	—
Strategy of a new revenue stream with a low cost-price	3
Digital promotion channels strategy	2
Strategy of digitalisation of goods and services	—
Cost optimisation strategy	5
The strategy of creating a completely automated mass production of goods at low prices	2
Strategy of rapid response to changes in customer preferences	—
Strategies of creation of a personalised offer	—
Total	12

Table 9
Digitalisation strategies of enterprises using the "Remanufacturing and digital engineering" business model

Strategies	The number of enterprises using the strategy
Customisation and personalisation strategy	6
Strategy of a new revenue stream with a low cost-price	—
Digital promotion channels strategy	—
Strategy of digitalisation of goods and services	2
Cost optimisation strategy	12
The strategy of creating a completely automated mass production of goods at low prices	—
Strategy of rapid response to changes in customer preferences	10
Strategies of creation of a personalised offer	4
Total	34

Table 10
Characteristics of Digital business models in industry

Characteristics	Digital ecosystems	Platforms for joint value co-creation	The implementation of a customising product	"Smart factory"	Remanufacturing and digital engineering
Availability of external users	+	—	—	—	—
Types of implemented digital technologies			3D printing, digital models and twins, 3D scanning and modelling, big data analysis, artificial intelligence		
Personalisation of the output	+	+	+	+/-	+/-
Cost optimisation	To attract customers and partners	To attract customers and partners	By means of improving the understanding of the customer and reducing the cost of their retention	By means of the implementation of technologies throughout the value chain	By means of resource optimisation and reusing materials
Increase of efficiency of innovation activities	By means of creating a platform for the production of research and experiments	The use of digital platforms for joint research, discussion of new ideas	By means of "short" communication with the customer, faster testing of new products	Artificial intelligence and computer-assisted teaching stimulate innovation in all functioning areas of industrial manufacturing	By means of creating virtual models by combining dynamic sounding and visualisation data on a real time basis
The resulting effects	Creating more value with the use of a number of additional services	Increasing customer and partner loyalty by means of value added activity based on personal specifications, accompanied by repeat purchases, and the increase in the number of recommendations	The increase of customer lifetime value	The improvement in the quality of production which leads to the willingness of customers to pay a higher a price	Improving competitive positions by optimising resources, cost improvement and reusing materials
Financial results	The increase by means of reduction of stocks and more accurate identification of need satisfaction	By means of accelerating the introduction of products to the market	By means of reducing the expenditures on quality assurance, reducing the production lot size, more accurate identification of need satisfaction	By means of increasing the product output, acceleration of the production cycle, increasing the overall effectiveness of equipment and reducing the product cost in general	By means of reducing the time to develop prototypes, reducing the expenditure on re-release of defect products and reducing the expenditure on the quality assurance

Source: compiled by the author.

reusing materials. The technologies used in the implementation of this business model are: robot engineering, 3D modelling of products, including simulation modelling, simulation, debugging and control, 3D scanning or 3D laser scanning and the creation of digital twins. Table 9 presents the strategies used by companies implementing the Remanufacturing and digital engineering model.

The characteristics of the distinguished digital business models in industry are presented in Table 10.

4. Conclusions and the future research trends

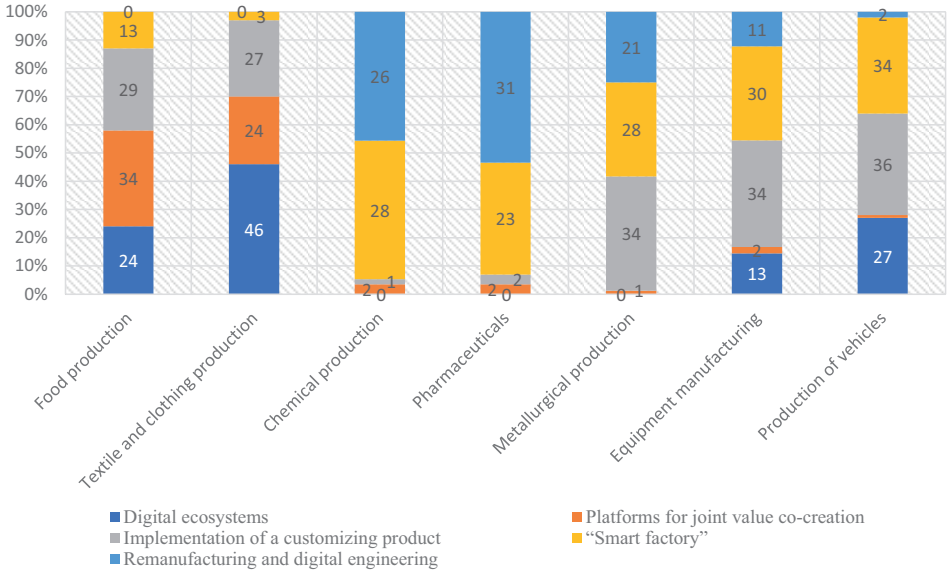
Due to the development of digital technologies, growing competition, constantly increasing customer requirements, the emergence of new solutions for the optimisation of business processes, the transformation of business models has become an integral part of the functioning of industrial companies.

In the survey conducted among production enterprises of manufacturing industries the most frequently implemented technologies were identified, among which: industry robots and automated lines, cloud services, the industrial Internet of Things and FRID technologies. The effects of the implementation of digital technologies were determined: cost reduction, improvement of product quality, increased flexibility of production, reducing the time for the introduction of new products to the market. It was found out that all sectors of the manufacturing industry are characterised by higher expenditures on the purchase of technologies and equipment than investments in software. The key problem of the transition to domestic software and technologies was identified, which lies in the fact that the technologies and software used are incompatible with Russian ones, i.e. during the transition, many software packages and technologies will have to be replaced simultaneously, as well as integrated with all systems of the enterprise.

The cluster analysis method was used to identify digital transformation strategies in industry. The key factor in the division of industrial companies was the factor of "the participant composition of digital services and business processes based on the principles of mutually beneficial relationships." The factors "Implemented digital technologies", "Reach of transactions" and "Cost optimisation" were also distinguished. As it follows from the analysis, two large clusters were identified – enterprises building Platform business models (I) and enterprises building "Factories of the future" (II), which differ from each other in the participant composition of digital services and business processes based on the principles of mutually beneficial relationships. These clusters, in their turn, were reanalysed in terms of the implemented digital business models, at which point five other clusters were distinguished that differed from each other in terms of the availability of the ecosystem (1), consumer involvement in joint value co-creation (2), the ability to implement a customising product (3), building of a "smart factories" model (4), the ability to implement remanufacturing and digital engineering (5). Thus, the division into Clusters I and II is due to the possibility of building platform business models, and the companies of each distinguished Cluster 1, 2, 3, 4, 5 have similar characteristics of business models of digital transformation. Within each cluster digitalisation strategies of enterprises using a particular business model were selected, and the digital business models used by industrial companies were also characterised.

In further research we plan to analyse how the implemented business model affects the financial results and the efficiency of industrial companies. Also, in further studies, it would be possible to expand the survey sample and include not only industrial manufacturing, but also other industries. In addition, it seems advisable to analyse how the implemented business model affects the financial results and efficiency of industrial companies.

Fig. 7. Presents the availability of certain Digital business models among Russian manufacturing sectors



Source: compiled by the author.

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About the author

Anastasiia S. Karikova

Assistant of the Department of Management and Innovations, deputy dean of the Faculty "Higher School of Management" of Financial University under the Government of the Russian Federation (Moscow, Russia).

Research interests: digital transformation, innovation, entrepreneurship and modern business models, strategy and development management companies, digital transformation of business models.

ASKarikova@fa.ru

作者信息

Anastasiia S. Karikova

俄罗斯联邦政府金融大学高等管理学院副主任，管理与创新系助教（俄罗斯莫斯科）。

研究领域：数字化转型，创新，创业和现代商业模式，公司发展的战略和管理，商业模式的数字化转型。

ASKarikova@fa.ru

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