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Innovation managers for the country's technological sovereignty

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Abstract

The article substantiates the authors' position, supported by empirical data, on the sharp increase in the intellectual intensity of managerial activities and on the transformation of the managerial profession into one of the most complex, gaining particular importance in the organisation of the innovation process for technological sovereignty. The increasing role of management science in understanding the ongoing turbulent changes, developing methodologies for proactive management and identifying competencies in demand in the economy is highlighted. The need for the introduction of advanced learning in these conditions is demostrated; the authors' experience in its development and implementation in terms of specific organisational models, content and teaching methods is presented. Within the framework of the proposed concept of further education, it is necessary to introduce a management specialisation focused on specific industries into the existing system of higher education. It will provide enhanced fundamental and applied training, a significant increase in the volume of practice and will enable students to master the engineering-economic and engineering-managerial knowledge necessary for taking into account interdisciplinary relationships between high technology, economics and finance when making management decisions.

Keywords: technological sovereignty, management education, interdisciplinarity, proactive management, systems engineering, advanced training, fundamental training, specialty.

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创新管理者于国家技术主权

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摘要

该文章通过经验数据证实了作者的观点，即当今管理活动的智力密集度急剧上升。管理已成为最繁难的专业之一，这一点在组织技术主权的创新进程时尤为重要。管理科学在理解正在发生的动荡变化、制定积极管理方法和确定经济所需的专长方面发挥着越来越重要的作用。作者证明，在这些条件下有必要引入超前教育方法，而且从具体的组织模式、内容和教学方法等方面介绍了设计和实施该课程的经验。有必要在现有高等教育体系中引入管理专业，该专业将面向特定行业。这种教育包括加强基础培训和应用培训，大量增加实践经验。这将为学生提供在做出管理决策时考虑知识密集型技术、经济和金融的跨学科相互关系所需的工程-经济和工程-管理知识。

关键词： 技术主权、管理教育、跨学科、积极管理、系统工程、超前教育、基础培训、专家学位。

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Introduction

The task of ensuring Russia's technological sovereignty is strategic and is enshrined in the Concept of the country's technological development until 2030[1]. According to it, the share of domestic high-tech products should reach 75% and lead to the country's independence from imports in the context of increasing geopolitical risks and the threat of unfair market behaviour by foreign producers. Technological sovereignty implies the ability of a country to independently generate the latest scientific knowledge and create breakthrough innovations that determine the long-term sustainable development of the state [Crespi et al., 2021; Edler et al., 2023]. Its achievement depends on solving two interrelated problems: the development of effective production methods and subsequent replication of innovative technical solutions, business models, products and services that are critical for the economy; the implementation of new technologies and products in foreign markets to achieve global competitiveness[2]. Thus, technological sovereignty does not imply complete autonomy of the state from external actors. On the contrary, its presence gives it a strong negotiating position with economic partners in the exchange of know-how, access to which in turn further strengthens the state's technological leadership and economic security[3].

On the way to technological sovereignty, Russia is already facing the most acute problem of a shortage of qualified personnel. This problem is being raised quite actively in the professional community, but it has not yet been widely and meaningfully discussed.

The extent of this problem, which is already hampering the country's innovative development, is underestimated. Basically, the discussion boils down to the shortage of workers and engineers, IT specialists and the need to reformat the relevant educational programmes (abandoning the Bologna system and moving towards specialisation). This study raises an equally important aspect of the problem, namely the total lack of professional, competent managers to organise the innovation process - innovation managers - and the need for a radical modernisation of management education in this respect.

Today, revolutionary changes in the management of companies are literally taking place in front of our eyes. Proactive management is really coming to the fore - a set of technical, organisational, resource and economic measures carried out at all levels of an industry, a specific company and aimed at preventing the negative impact of internal and external factors that threaten sustainability, functionality, competitiveness, economic and environmental efficiency [Gitelman et al., 2017].

Proactive management aims to address the challenges and threats posed by general instability, as well as to identify emerging opportunities as a result of monitoring scientific and technological trends. The goal of proactive management is largely achieved through the inextricably linked advance preparation of the company for unexpected changes and planned innovations (5-10-15 years ahead), including R&D, building intellectual capital, introducing flexible organisational structures and creating a creative business environment.

Unfortunately, Russian science pays practically no attention to the issues of proactive management. In the Russian database of scientific publications eLibrary for the last ten years, it is possible to find a small number of serious publications on economics and management (for example, [Vaino et al., 2011; Zarochintsev, 2021]), which contain this concept in keywords. Considering that more than 10 thousand articles were published in economics and management during this period, the share of publications on proactive management is essentially negligible - less than 0.1%.

The inattention to this issue in academia is reflected in the current state of management education. It is still based on an outdated paradigm that corresponds to the ideas, principles and management practices of advanced countries thirty years ago. As a result, the gap between the tasks of technological sovereignty and the competencies of management personnel is widening and increasingly becoming a serious obstacle to the country's development.

The purpose of this article is to present and discuss the results of the authors' many years of research, which demonstrate:

(1) the rapid increase in the complexity of management tasks due to scientific and technological progress and the growth of the knowledge intensity of production;

(2) the urgent need for advanced management education that anticipates changes in the content of managers' activities;

(3) the need for a deep restructuring of the educational process, with a pronounced emphasis on promising industry technologies and best practices, which determines the relevance of the new learning paradigm and the replacement of bachelor's degrees with specialist degrees.

1. Research methodology

The study is based on a systematic approach in which the issues of achieving technological sovereignty, managing scientific and technological projects, modernising the national economy and industry are considered in a comprehensive manner, primarily in terms of the emergence of new types of activities that determine changes in the content of the tasks solved by managers. This methodological principle

[1] Decree of the Government of the Russian Federation dated 20 May 2023 ¹ 1315-r 'On Approval of the Concept of Technological Development for the Period up to 2030'. http://static.government.ru/media/files/KlJ6A00A1K5t8Aw93NfRG6P8OIbBp18F.pdf.
Decree of the Government of the Russian Federation dated 15 April 2023 ¹ 603 603 'On approval of Priority areas of projects of technological sovereignty and projects of structural adjustment of the economy of the Russian Federation and Regulations on conditions for classifying projects as projects of technological sovereignty and projects of structural adjustment of the economy of the Russian Federation, on providing information on projects of technological sovereignty and projects of structural adjustment of the economy of the Russian Federation and keeping a register of these projects, as well as requirements to organisations authorized to submit conclusions on compliance of projects with requirements for projects of technological sovereignty and projects of structural adjustment of the economy of the Russian Federation'. http://publication.pravo.gov.ru/Document/View/0001202304170025.
[2] Evtukhov V. (2023). Technological sovereignty is a story not only about critical, but also about advanced technologies. Kommersant, 11 July.https://www.kommersant.ru/doc/6081958.
[3] Peskov D. (2022). Why is technological sovereignty important for Russia? RBC, 9 June. https://www.rbc.ru/newspaper/2022/06/10/62a0e95b9a79472d8b713207.

determines the logic of the study, which involves the passage through several interrelated stages:

1) empirical justification for the radical increase in the complexity of management activities and the demand for proactive management;
2) formulation of requirements for advanced learning - an integral element of proactive management in conditions of dynamic change and uncertainty;
3) determination of organisational models to train management personnel for innovative activities and technological breakthroughs and their implementation in the shortest possible time.

The information base was formed by surveys of experts - managers and specialists of electric and thermal power engineering enterprises, telecommunications enterprises of the Russian Federation, professors and university teachers (more than 100 respondents in total); 150 students and graduates of management programmes were also recruited. The results of the expert assessments, combined with an analysis of the content of the curricula of management training programmes, allowed the authors to identify the characteristics of management activities that determine the reference structure of programmes and the composition of educational content. In addition, an analysis of more than 50 relevant scientific publications was carried out.

2. Management is becoming an extremely complex profession

The factors determining the rapid growth of the intellectual intensity of the management profession are the following.

1. The ongoing technological revolution is generating an avalanche of scientific and technological achievements, the significance of many of which for business, the economy and society has yet to be grasped. New knowledge is required to introduce advanced technologies into production and management and to define the principles of their integration with technologies of previous and future generations, which means that science is moving to the forefront of innovation.

The manager becomes a researcher of problems, trends and contextual changes and a developer of fundamentally new production and technological systems [Senge, 2011]. He must analyse the organisation as a meta-system and the external and internal trends and forces acting on it, anticipate changes in a wide range of areas of activity and begin to prepare for them immediately.

2. Disruptive technologies are rapidly penetrating even traditionally conservative industries, radically changing the production landscape, business models and economics of companies. The very concept of 'industry' is expanding - its boundaries are changing and expanding significantly, new sectors are emerging, and competition is moving to the inter-industry level [Porter, Heppelmann, 2014; Bessonova, Gonchar, 2019]. The main competitive advantage is no longer the products themselves, but the innovative systems and technological platforms that connect them [Pereira et al., 2018; Trachuk, Linder, 2023].

As a result, the systems in which the manager works become much more complex. To manage the functioning and development of such systems, a manager needs a deep understanding of their structure and interrelated characteristics - engineering, technical, financial, economic, environmental, social. It requires knowledge of the latest methods for creating resilient and flexible systems that are resistant to unexpected external influences and disruptive factors. This is particularly true for critical infrastructure - life-sustaining and strategically important industries such as energy, aerospace, nuclear and electronics, oil and gas, telecommunications, fintech, heavy engineering.

3. In the context of technological sovereignty, it is necessary to solve a wide range of complex problems in the shortest possible time: import substitution, modernisation of existing and creation of new production facilities, formation of optimal supply chains, forecasting demand and development of new markets, advanced training of personnel, ensuring energy and information security. A deep understanding of the relationships between 'technology - engineering - ecology - economy and finance – management' is the imperative of a modern leader, and his activities acquire a pronounced interdisciplinary character [Rolstone, 2022; Gutiérrez-Iñiguez et al., 2023][4].

4. A manager's main 'product', a management decision, is made under conditions of relatively high uncertainty and often information chaos [Bledow et al., 2011]. There are virtually no ready-made algorithms for most decisions, and the cost of an error from a wrong choice increases many times over [Zhang, Parker, 2019]. Big data processing, predictive analytics, artificial intelligence, multi-factor scenario design methods, risk management tools and the latest systems engineering methods make it possible to set up control systems that are highly sensitive to weak signals and reduce the overall uncertainty of the future. Therefore, making strategic decisions with long-term consequences requires powerful analytical tools and expensive IT infrastructure, including cyber protection of critical data [Makarov, Makarov, 2021; Karikova, 2023].

5. The development of specific management thinking among managers, characterised by a fundamentally larger scale, is significantly updated: it includes systemic, cost, entrepreneurial, technical and conceptual thinking [Harju et al., 2021; Gratton, Gratton, 2022]. For different levels of management, these types of thinking are needed in different proportions: while for middle managers, systemic, entrepreneurial and technical thinking may be most important, for top managers, conceptual, systemic and cost thinking is a priority, shaping their visionary qualities [Kearney et al., 2019].

[4] Also refer to: Rolstone G. (2022). Why middle management is one of the most difficult jobs. Delphinium, 14 February. https://delphiniumcc.co.uk/why-middle-management-is-one-of-the-most-difficult-jobs/.

6. The shortage of highly qualified personnel, which some experts describe as catastrophic [Bondarenko, 2022][5], requires taking into account the factor of generational change, the values of young people, whose main motivators are not only career and money, but also intangible factors: trust and recognition in the team, interesting creative tasks, working in a team. Therefore, even in conservative industries, the importance of innovation, creativity, distributed leadership, self-development and learning opportunities is increasing.

In the empirical assessment of the complexity of the managerial profession, the authors used criteria formulated on the basis of the results of their own research [Professionals in Competition..., 2021; Gitelman et al., 2022a], generalisations of scientific publications [Sacramento et al., 2013; Shin et al., 2020; Bai et al., 2021][6], special rating techniques[7] and communication with experts. These criteria include:

- intellectual intensity: the need for versatile knowledge, systems thinking, the ability to use experience in the relevant field of activity; intensity of the work process and the number of decisions made in a given period of time;
- proactive decision making;
- the high social cost of errors: the damage caused by the consequences of the decisions taken for the company and the subjects of the external environment;
- lack of ready-made algorithms and uncertainty of conditions for solving problems, the need to search for non-standard approaches when making decisions;
- innovative activity: mastering advanced scientific and technical achievements, generating new ideas and knowledge for their implementation;
- professional working conditions: high physical and emotional stress (responsibility, frequent stressful situations);
- the need to work with large amounts of data;
- diversity of communication: the need to interact, use a common conceptual language and achieve mutual understanding with people from different professions, positions, viewpoints and experiences;
- multitasking: the need to deal with a large number of different issues simultaneously, requiring constant switching from one to another;
- adaptability to change: continuous restructuring of actions, tactics and behavioural strategies in response to changes in objectives, technologies and operating conditions.

Let us comment on some of the survey results. For example, management activities are already characterised by increasing complexity at the middle level (Fig. 1). Moreover, according to a number of criteria, the transition between the lower and middle levels of management is not linear but exponential in terms of complexity (Fig. 2).

At the same time, a survey of undergraduate and graduate students, future leaders, showed that most of the characteristics of activity, in which complexity increases most dynamically, are extremely poorly reflected in the corresponding educational programmes. Particularly negative is the low rating of students for the compliance of programmes with the criterion of innovative activity - a key factor in solving the problems of modernisation and achieving technological sovereignty - only 5.7 points out of 10. This situation correlates with the opinion of practising managers about the areas of activity in which there is the greatest deficit of relevant knowledge and skills (Fig. 3).

3. Management science will need to understand the changes that are taking place

In an environment where science does not provide answers to many of the questions that modern managers face, they have to search for answers and make decisions themselves, almost always with the risk of a high cost of error. In this context, the demands on managers' professional skills are increasing radically.

The reliance on experience in management decisions increases rather than reduces the risk of error, because its accumulation was linked to situations whose development was more predictable. Today, we have to rely on intuition, but it naturally involves considerable risks, since the concentrated experience of previous decisions in situations that are irrelevant today plays a significant role in its mechanisms [Myers, 2010].

According to the authors, managers need fundamentally different skills and tools to act successfully.

1. Organising and carrying out applied research on specific situations, highlighting current factors and relevant contexts. They are necessary because tasks for which there is insufficient existing knowledge (not found in reference books or even among experts) become critical.

2. Using the current structure of basic knowledge (anticipatory management methodology, scientific foundations of production and technologies of the future, vision of changes in professional activities) to analyse the nature of new processes, trends and identify the reasons for their emergence [Gitelman et al., 2022c].

3. Multidimensional flexible management thinking, including the ability to use, switch and integrate such types of thinking as strategic, systemic, critical, cost, conceptual and project, allowing to find hidden resources for effective solutions.

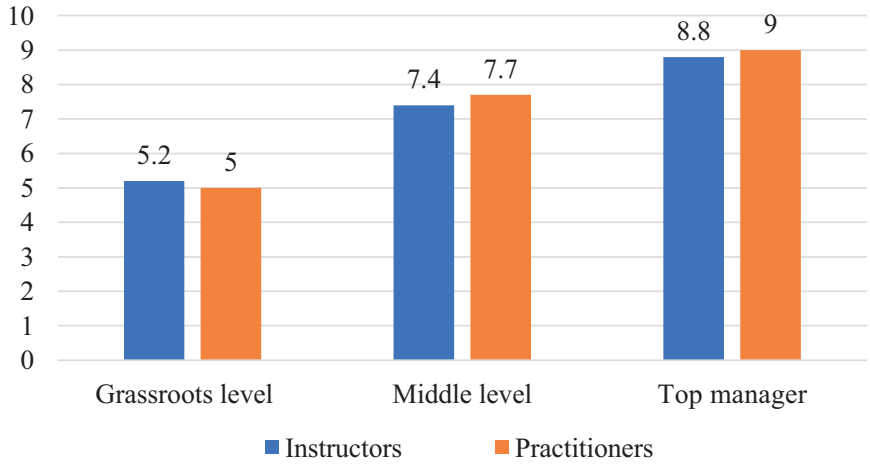
4. Using in-depth analysis of changing situations to carry out a calculative justification of the most appropriate alternative and make the right, least risky choice.

[5] Also refer to: Kozlov A., Grinkevich D. (2023). Personnel shortage and local unemployment: what awaits the labour market in 2023. Vedomosti, 18 January. https://www.vedomosti.ru/economics/articles/2023/01/18/959434-kadrovii-golod-i-lokalnaya-bezrabotitsa.

[6] Also refer to: Chin C. (2023). Why is management so difficult? Management for Startups. https://managementforstartups.com/articles/why-management-is-difficult/.

[7] Davis C. (2023). Hardest jobs in the world. ValiantCEO, 17 August. https://valiantceo.com/hardest-jobs-in-the-world/.
Zambas J. The 40 hardest jobs in the world (and what they pay) (2023). Careeraddict, 21 July. https://www.careeraddict.com/5-most-difficult-jobs-in-the-world.

Fig. 1. Results of expert assessment of management complexity
(on a 10-point scale)



5. Using the resource of interdisciplinarity and teamwork to solve the most complex and time-consuming problems.

6. Knowing the principles, methods and tools of proactive management, not only to anticipate threats in the early stages of their emergence, but also to realise emerging opportunities for production development.

Each of these skills increases the effectiveness of management action in contingency situations, but none of them is universal, so they often need to be used in combination to solve management problems successfully.

Of particular importance today is the ability of managers to formulate multifactorial business development scenarios and to reduce uncertainty about the future, which can no longer be predicted simply by extrapolating from the past. In this respect, there are areas and methodologies that aim to solve this problem and are actively developed in the scientific community (Fig. 4). It should be noted that most of these areas of future research are interdisciplinary in nature and have emerged in the last two to three decades, reflecting well the exponential growth in the complexity of economic development problems and related activities, primarily management, on which their successful solution depends. Therefore, the new generation of managers must be able to navigate in new areas of knowledge and find in them

Fig. 2. Dynamics of the complexity level of activities according to specific criteria
(average assessment by practitioners and professors)

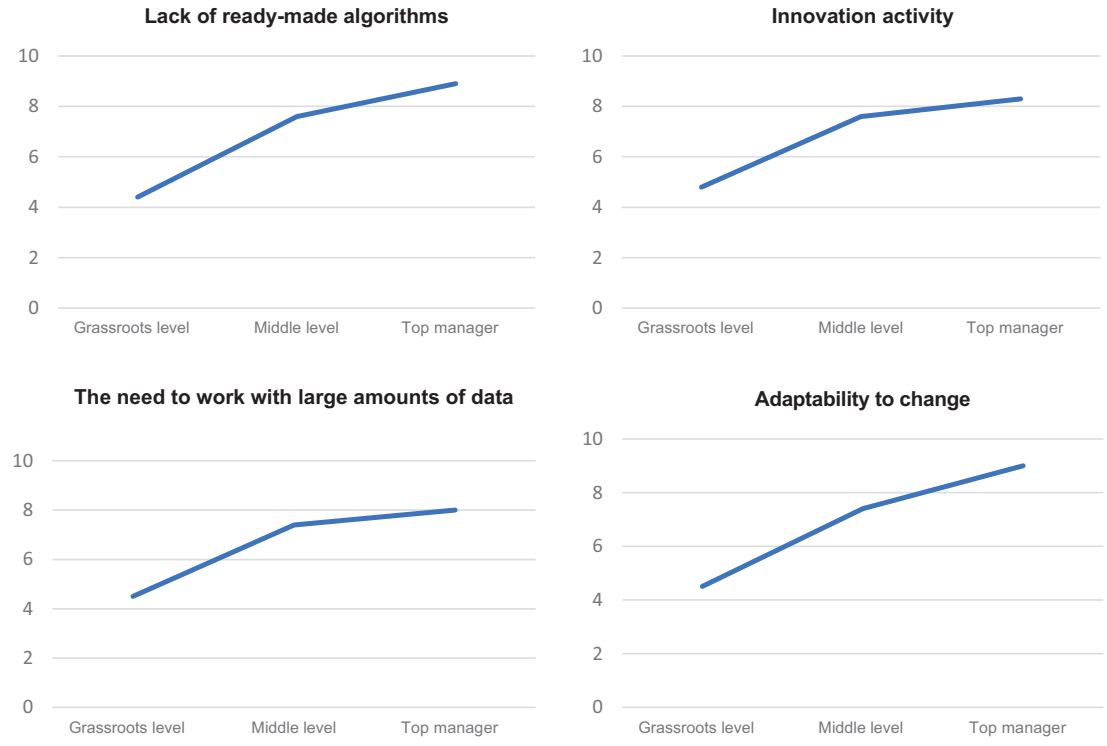
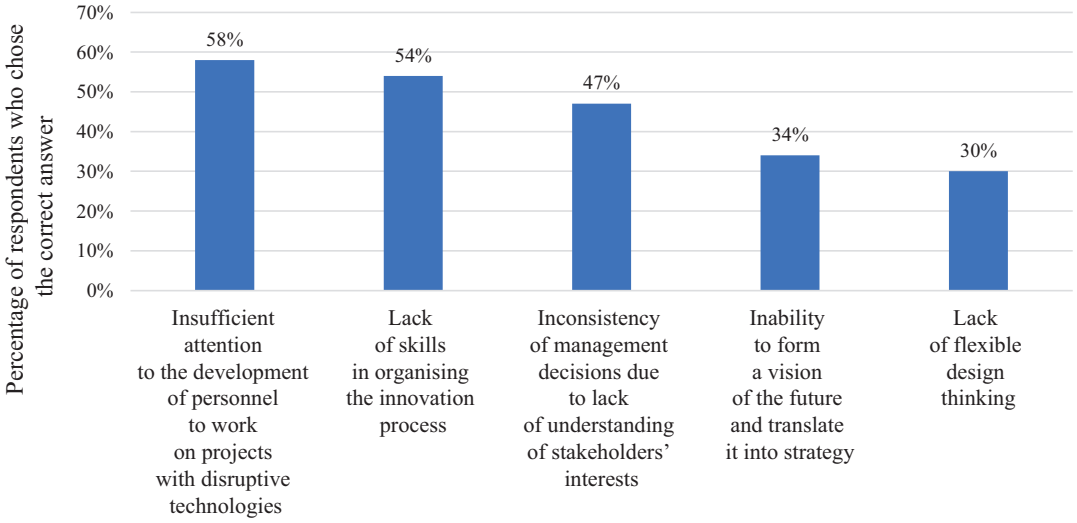


Fig. 3. Main disadvantages of high-tech business leaders

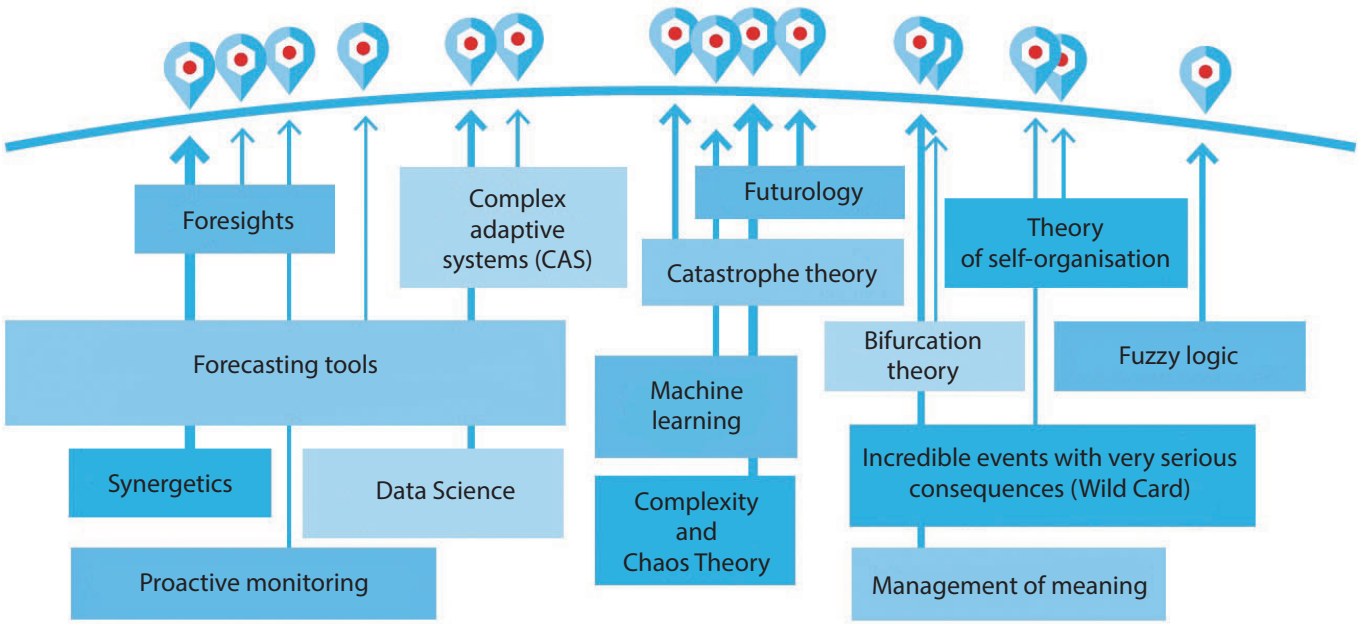


guidelines for solutions that are adequate to the content of the tasks and the conditions of current practice.

The ability to cope with increasing complexity will largely determine the success of innovation, which poses many multidimensional problems. In this context, research into the practical application of the systems approach - systems engineering - is of great interest [Bar-Yam, 2005]. The methods and tools developed on its basis are successfully used in practice for a wide class of objects, including socio-technical systems and systems of systems.

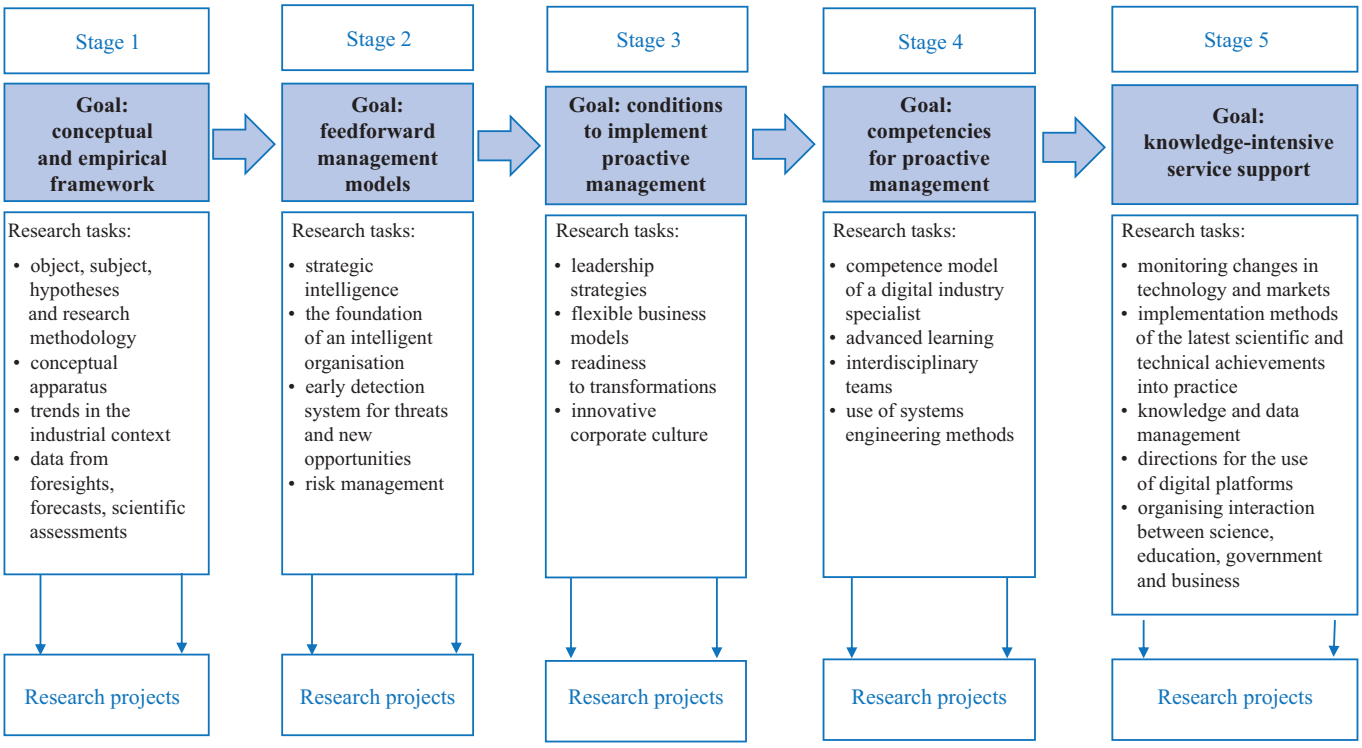
Analysis tools use fuzzy logic, neural networks, Markov chains and social network analysis methods. Diagnostic tools are based on Monte Carlo methods, algorithmic complexity, fractal dimensions and graph theory. Modelling tools include game theory, cellular automata, system dynamics and multi-scale models. Architectural frameworks, genetic algorithms, multi-agent systems and adaptive networks are used to synthesise solutions [Shalizi, 2006]. It is worth pointing out that these areas are not adequately represented in the corresponding areas of mathematics studied at universities, a science that is of high value to management as a fundamental basis for professional training (as confirmed by the experience of some of the world's top universities [LeSage et al., 2021][8]).

Fig. 4. Relevant future research areas



[8] Also refer to: Why do managers need advanced mathematics? (2022). St. Petersburg State University, 25 May. https://english.spbu.ru/news-events/news/why-do-managers-need-advanced-mathematics.

Fig. 5. Creation of topics in the scientific field of 'Proactive management in actively developing industries and sectors of the economy'



Systems engineering is by nature interdisciplinary. Interdisciplinarity implies the synthesis of knowledge from different fields of science and practice, the identification of new relationships between them, allowing us to obtain qualitatively new solutions to complex problems.

Research aims to solve management problems, not engineering problems [Calvo-Amodio, 2019]. Particular attention is paid to the problem of increasing the flexibility and adaptability of systems - giving them properties that protect them from the adverse effects of unpredictable factors and increase the stability of their functioning. Thus, the methodology of elasticity (resilience) is being actively developed in various fields (ecology, sociology, psychology, organisation and engineering) [Stevenson et al., 2015].

System resilience is defined as the ability to cope with adverse conditions and events through preparation (planning), resistance to disruption, recovery from failure and successful adaptation to change and disruptive influence[9]. Elasticity implies the ability of a system to:

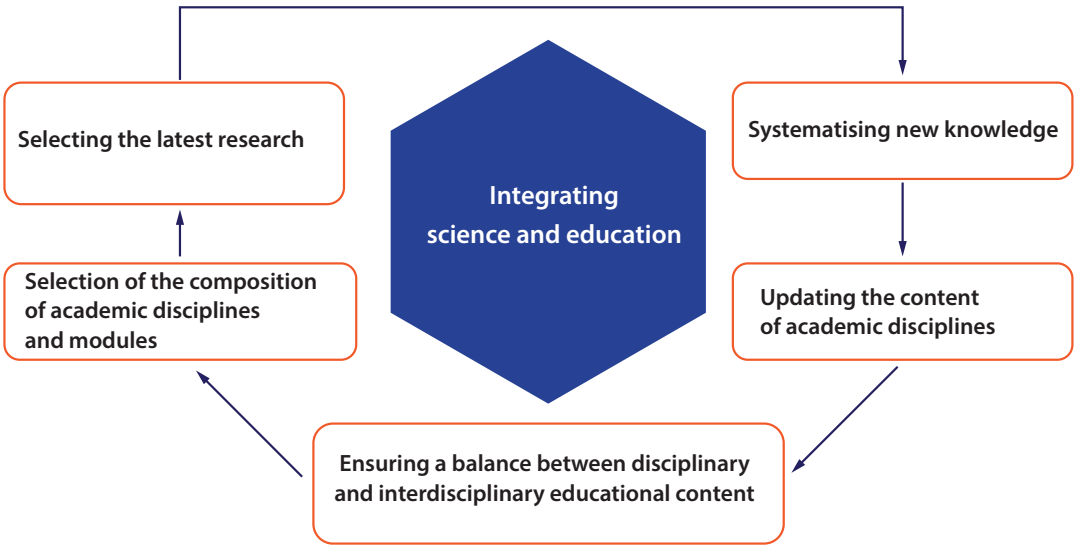
- anticipation - anticipating impending dangers in order to start adapting earlier and reduce the risk of decompensation;
- synchronisation - managing the coordination of activities at different levels to respond to rapidly changing events and reduce the risk of conflicting objectives;
- responsiveness - developing the ability to respond to future 'surprises' and reducing the risk of unreliability;
- proactive learning - learning to understand the signs, causes and sources of unreliability and improving the ability to withstand them (resilient performance) before a large-scale breakdown occurs by learning from the experience of monitoring and resolving unexpected situations [Hollnagel, Woods, 2006].

Another actively developing area of systems engineering is methodologies aimed at ensuring the flexibility of complex systems designed to operate under conditions of high instability and to perform critical functions where failure is unacceptable or very costly (agile methodologies). Such systems require a special approach to design and development. The techniques and tools developed by agile systems engineering for the design and development of such systems are described by the authors in [Gitelman et al., 2020].

The FuSE Agility project [Willett, 2021], which is one of the research projects initiated by the Future of Systems Engineering working group, is currently underway. The project considers four aspects of the Agile methodology.

[9] National research council. Disaster resilience: A national imperative (2012). Washington, The National Academies Press.

Fig. 6. Structure of the block for rapid updating of educational content



1. Agile systems engineering (processes): the application of agile tactics, technologies and procedures throughout the system lifecycle.

2. Agile systems engineering (technology): ensuring the adaptability of the system to both predictable and unpredictable change.

3. Operational flexibility (external environment): providing the ability to configure (flexibly configure) work processes to maintain efficiency in adverse conditions.

4. Flexibility in Performance (People): High adaptability to change, skills, knowledge and personal effectiveness.

In general, it can be said that the scientific issues of technological breakthroughs are increasingly moving into the realm of interdisciplinarity, taking into account engineering, technical and organisational-economic relationships as drivers of management development. This should, of course, be taken into account in the professional training of managers when developing their ability to quickly navigate a changing environment and find non-standard solutions to emerging problems [Pan, Sun, 2018; Anderson et al., 2023].

As a result of the conclusion on the special role of science in solving the problem of technological sovereignty, attention is drawn to the fact that the passport of the Higher Attestation Commission for the scientific speciality 5.2.6 'Management' does not sufficiently reflect the problems that have been relevant for the last decade. Among them are digital transformation, use of artificial intelligence in decision-making, big data management, knowledge management, proactive management). Therefore, we must admit that this document, which defines the main vector of development of all management science in the country, does not fully reflect the dynamics of modern trends and requires adjustments.

4. Proactive learning becomes imperative

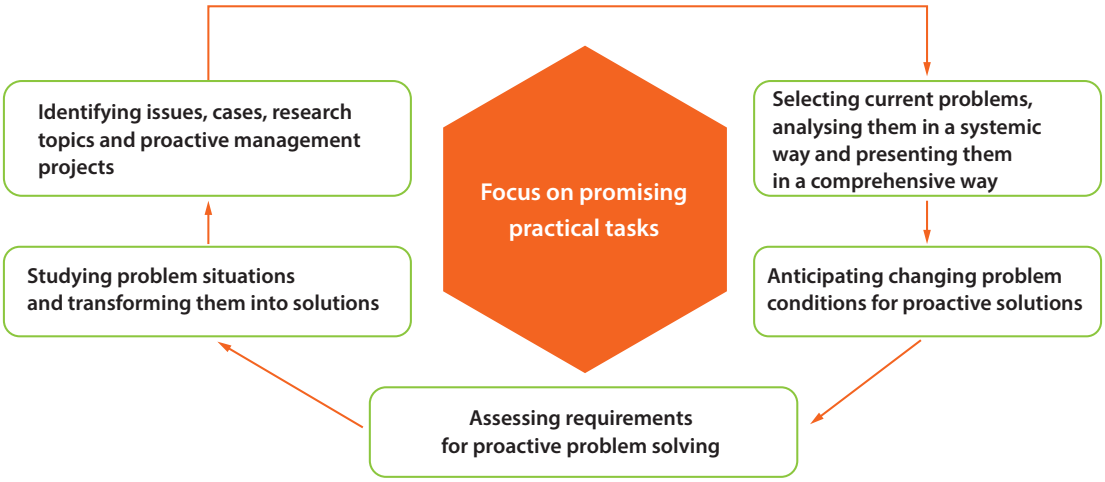
Thus, the need for significant changes in the training of managers for the tasks of technological breakthrough and technological sovereignty is obvious. It is proposed to conduct such training within the framework of the concept of advanced learning with a strong emphasis on design and research work [Gitelman et al., 2022b]. In this regard, the authors have formulated and are implementing a groundbreaking scientific direction 'Proactive management in actively developing industries and sectors of the economy', in which they have been working for more than ten years [Professionals in Competition.., 2021]. The logic of its application in current research projects is shown in Fig. 5.

It should be emphasised that feedforward learning generates knowledge for feedforward management; these two concepts are inextricably linked and define a new model for managing the evolution of any complex system [Gitelman et al., 2022b]. Examples of other features of feedforward learning are:

- interdisciplinary links with emerging trends and scientific and technological advances. The result is the development of skills to anticipate change, neutralise threats, exploit new opportunities and develop anti-crisis measures;
- intensive research and design work according to the real agenda of the company (region, territory), its strategy and development priorities;
- formation of constructive management thinking to implement breakthrough transformations, create innovative business models, leadership management systems.

The authors have created a self-developing educational system of advanced learning, which includes a number of blocks that perform certain functions and are in a state of

Fig. 7. Structure of the problem-focused block of the educational programme



active interaction with each other to ensure the flexibility of the educational process. It includes problem-orientation of the educational programme; rapid updating of educational content; systematisation and integration of learning outcomes; types and methods of educational activities; support for self-study services.

Let us comment on the blocks that directly perform the functions of developing competencies in students for proactive action.

The block for rapid updating of educational content is the key to advanced learning (Fig. 6). It creates conditions for the flexibility of educational modules: (1) their composition makes it possible to create different learning pathways according to students' objectives and priorities; (2) the composition of educational modules and disciplines is regularly updated with developments corresponding to the emergence of new knowledge and technologies; (3) the content of modules is updated on the basis of research and the prompt transfer of its results into educational content.

The block of problem-oriented focus of the educational programme (Fig. 7) is intended to determine the practical component of advanced learning in the form of current problems, the solutions to which should become the object of independent analytical, research and project activities of students.

The block of types and methods of educational activities characterises the methodological complex for the formation of universal and professional competences and shows the variety of cognitive and practical activity of students (Fig. 8). Together they form in students a holistic perception of the organisational and managerial context, an understanding of the possibility of analysing problems and tasks from different angles, as well as the ability to find relations between different processes and events.

Fig. 8. Structure of the block of types and methods of educational activities

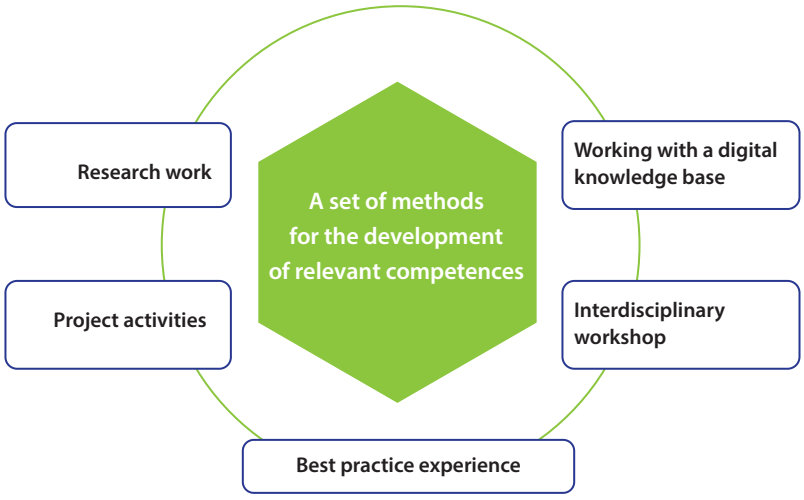
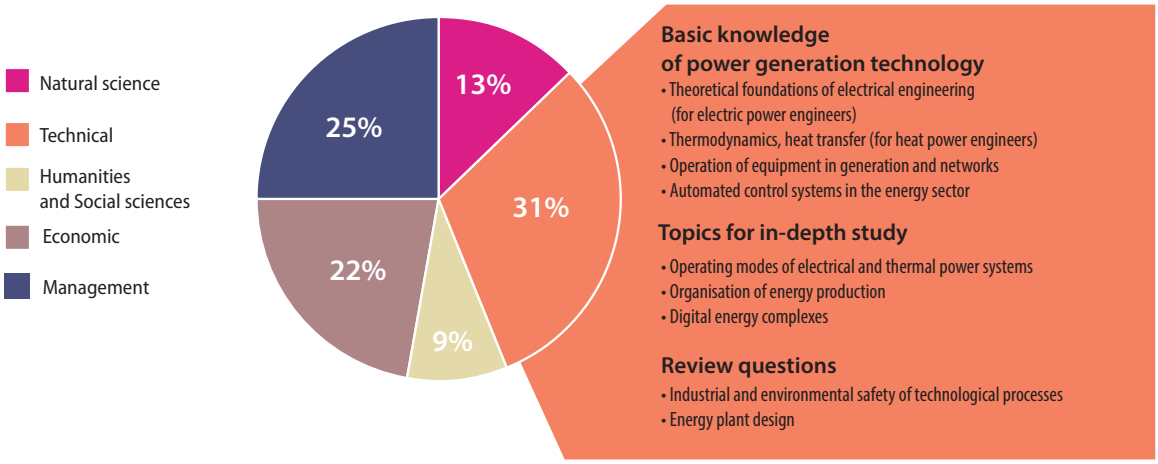


Fig. 9. Reference structure of the educational programme for energy managers (%)

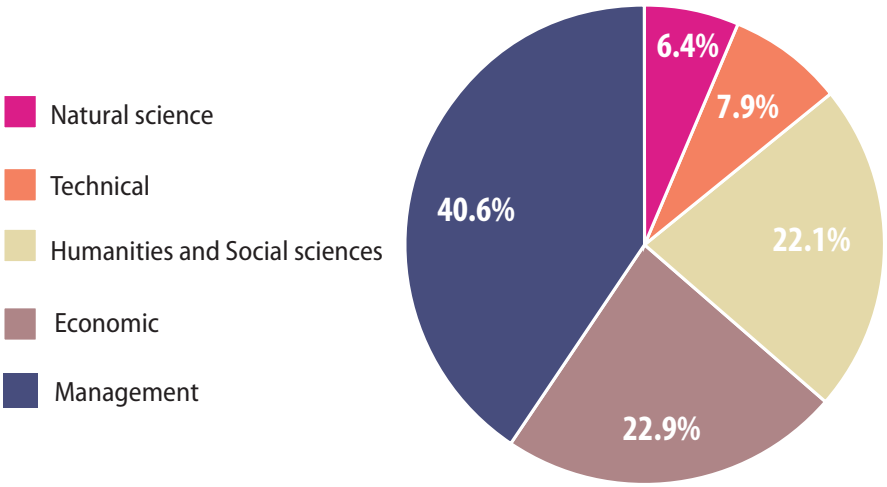


Thus, the main function of interdisciplinary education programmes of advanced learning is to form a holistic vision of the interrelations of processes and action algorithms from different scientific fields and academic disciplines.

In order to implement and develop the concept of advanced training, a new methodology for the training of managers is being created, using the best practices of traditional training and developing new organisational and methodological tools, which are clearly still insufficient. In this direction, the authors have developed a number of technologies used in the training of managers and breakthrough teams in large energy and industrial companies and universities. Among them are:

- electronic education and training complex for advanced learning is a system that integrates for the users educational content, methods, information and service support for advanced learning. It focuses on the study of development problems and the anticipation of management decisions for non-standard situations of the future; a promoter of continuous competence building, which implements the idea of lifelong learning in compliance with the continuity of different levels of education, ensured on the basis of re-evaluation of the material completed at previous levels. At the same time, personal professional and company interests, the student's planned position are taken into account, and the content and formats of the training can be changed flexibly according to the specifics of the tasks to be solved. The technology is the basis for the design of educational programmes that involve the mastering of several educational levels in a short period of time (Bachelor + Master, Master + MBA, Master + Postgraduate), which corresponds to the practice of the world's leading universities;

Fig. 10. Relevant structure of educational programmes in management (%)



- 'module within a module' is a technology that represents the integration within a block of academic disciplines of different activities, the proportions of which vary directly during the training according to the preferences of the students;
- digital knowledge base, including more than 50 textbooks, teaching aids, monographs and 300 articles written by the faculty of the Department of Energy and Industrial Management Systems of Ural Federal University;
- project repertoir 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 are: organising a strategic process in a digital environment; strategic intelligence of the organisation; readiness for systemic change based on designing the future; asset management under conditions of uncertainty; environment and competencies for a breakthrough in the markets of the future; breakthrough teams and systems for growing talents and leaders.

5. An interdisciplinary approach requires an understanding of the technological underpinnings of production

Technology has a decisive impact on business performance. Therefore, the engineering and economic competences and the engineering and management competences of managers come to the fore, ensuring the functioning and development of the company, its technical, technological and economic systems as a whole, from the point of view of increasing reliability, safety, environmental and economic efficiency. These competences are required to justify and make management decisions in almost all areas of activity (logistics, finance, marketing, strategic management, etc.) [Gitelman et al., 2022a].

For example, in the power industry, in the process of fuel supply to power plants, it is necessary to understand that the boiler runs on fuel of a certain quality, with strictly defined suppliers and prices. In financial activities, when planning the budget of an energy company, it is necessary to know the relationship between the efficiency of power units and business results. Energy marketing presupposes the rational behaviour of an active consumer on the energy and power market - a customer who orders the necessary services from the energy system. It is not without reason that a survey of experts conducted by the authors revealed the particular importance of engineering and technical disciplines in the training of energy managers. According to the respondents, it is precisely these disciplines, which are organically linked to the economic and management disciplines, that should come to the fore in training and should account for more than 30% of the teaching load (Fig. 9).

At the same time, the analysis of the curricula of undergraduate management programmes carried out in various universities of the Russian Federation shows that engineering and technical education is given extremely little attention. Thus, in the standard structure of 'management' education shown in Fig. 10, which the authors created based on the analysis of the curricula of domestic universities from various regions (MSU, HSE, NSU, TSU, St Petersburg State Polytechnic University, Plekhanov Russian University of Economics, Gubkin Russian State University, Far Eastern Federal University, etc.), the predominance of humanities and social sciences over natural sciences and engineering is clearly reflected.

A completely different principle and, of course, a different set of disciplines can be seen in management training programmes for knowledge-intensive industries at the best foreign universities. An example of one of these is given in Table. 1.

The practice of individual Russian universities focused on complex high-tech industries (e.g. MEPhI, MSTU named after N.E. Bauman, ITMO and a number of others) indicates an increased interest in engineering, management and business education. At the same time, programmes in so-called general management, which are in no way linked to the specifics of production, continue to be the most popular in domestic universities. As a result, the content and methods of management training at most universities are not much different for a trading company, a clothing factory, an energy company or a metallurgical plant. However, outside of specific technologies, business processes and the specifics of industrial markets, it is impossible to use teaching methods aimed at studying the latest scientific and technical achievements, their impact on competitiveness, introducing digital solutions and analysing the best practices in organising innovative activities. Moreover, the question of a strong increase in the role of science in the educational process loses its practical meaning.

6. Discussion

The professional training of the new generation of managers requires fundamental organisational decisions to change existing training practices. The most important of these is a change in the format of training - a move towards specialisation, implemented in long-cycle programmes (5 years).

In contrast to a bachelor's degree, a specialisation offers the possibility of organising a more comprehensive education, both in terms of theory and practical skills. The structure of the specialisation is based on pre-established criteria for the complexity of management activities, includes basic and applied training, specialised industry practice and develops students' readiness for innovative activities.

Let us take the example of designing a specialised programme to train managers in the electricity industry.

1. 1. The programme provides a thorough grounding in understanding the patterns of economic, scientific and technological development, mastering the skills of systems thinking and forming a holistic view of modern management activities, taking into account industry specifics.

Table 1
Master Programme 'Management and Engineering in the Electric Power Industry' of the University of Aachen (Germany) in cooperation with the Maastricht Business School (The Netherlands)

Term	University	Key disciplines
1	Aachen	Electrical Machines (part 1); Testing and Diagnostics in the Engineering of Complex Systems; Theory and Analysis of Energy Transformations; Electricity Storage and Accumulation Systems; Entrepreneurial Strategy; Technology Development Strategy
2	Aachen	Electrical Machines (Part 2); High Voltage Equipment in Main and Distribution Electrical Networks; Automation in Complex Power Systems; Accidents and Stability of Power Systems; Energy Economics; Architecture of Energy Markets; Finance and Accounting; Power Storage and Accumulation Systems - Laboratory Practice
3	Maastricht School of Management	Global Trends and Sustainable Business Competitiveness; Organisational Development and Transformation; Managing International Network Projects; Business Economics; Supply Chain Management; Human Capital Management
4	Aachen / Maastricht School of Management	Preparation of a Master's thesis

2. Already in the first third of the education cycle, the emphasis is on technical and economic training, which solves two problems:

- - to give an idea of energy technologies and production complexes as highly complex and responsible management objects;
- to teach students to analyse the interdisciplinary relationships between engineering - technology - ecology - economics - management in order to make informed decisions about the development of the energy industry and to improve individual business processes and areas of activity of energy companies.

3. An increased number of internships are planned in companies and events that introduce students to energy production and involve them in solving operational and innovative problems.

4. YThe curriculum is based on the idea of having one or two key disciplines in each semester - majors and short minors that enrich and thematically complement the majors. In this way the problem of redundancy of disciplines in the curriculum is solved and it becomes more focused on specialised knowledge and skills.

5. A teaching method in which the design and research work of the students comes to the fore becomes fundamentally important. Its volume may be small in junior courses, while in senior years it may reach 70-80% of academic work. It is also important to instil in students a culture of self-development, self-learning and creative exploration. As our analysis has shown, these components largely determine not only the complexity of management activities, but also, in principle, the effectiveness of a manager's work in conditions of unpredictable change and increased risk.

An example of the content of the specialist's degree programme is given in Table. 2.

We emphasise that the proposed model of specialisation does not contradict the requirements of the federal state educational standards, which establish obligatory modules on the ideological foundations of professional activity, the foundations of Russian statehood and military training. The authors' proposals concern the part of the specialist's degree programme directly related to the profession.

Let us look at some important conditions for the implementation of this model.

First, it is necessary to overcome the 'identification' of management and business education. In terms of content, these types of professional training no longer coincide, although a significant part of the educational programmes have common content. Today, the understanding of business management has a different emphasis - it is no longer only about solving economic problems (with an understanding of their importance), but also about environmental and climate agendas, social responsibility, working conditions and personal self-realisation, which are becoming increasingly important. The high dynamics of change in production technologies, the digitalisation of all aspects of business, the activation of geopolitical factors, the general unpredictability of the external environment and market conditions require managers to have systemic knowledge of the interrelationships between engineering, computer science, geopolitics and psychology as much as knowledge of new economic approaches.

The development of economic and management science and practical activity is going in very different directions. For managers, the multidimensionality of tasks is increasing sharply and the possibility of their algorithmisation is decreasing; economists, on the contrary, have more opportunities to use intellectual means of calculation and analytical work by transferring a part of routine operations to machines. In general, the content of real practical problems solved by managers changes every year and the share of economic knowledge in it decreases. All this leads to an increasing differentiation of management and economic professions. This issue is discussed in more detail by the authors in [Gitelman et al., 2020].

Fundamental changes are needed in the organisation and content of student placements. It is much more difficult for a management student to choose a placement in a company than in any other field. 70-80% of management activity consists of interaction and communication with other people: subordinates, colleagues, managers, experts, employees in various fields of activity. At the same time, the content of these interactions is predominantly interdisciplinary. In addition, it varies considerably depending on the area of activity, even within the same management level. For this reason, functional units are preferable for those involved in organising student placements - future managers. They have less communication, fewer decision-making procedures and less organisation of their implementation, but more analysis with well-known algorithms for preparing decisions.

It is much more difficult to organise a management practice in the production sector. The activity of a line manager is not only to make operational decisions and communicate with other people, but often to direct the implementation of the decisions made, to prepare orders and instructions for carrying out the necessary actions. It is difficult, if not impossible, to organise this kind of practice by the manager delegating some of his functions to the trainee. Here another form of practice is needed, for example in the form of the trainee's participation in the work of a manager. Even in this form of production practice there are many limitations to the acquisition of the necessary experience in management activities.

The problem of a radical increase in the volume of practice for students of management specialities requires an urgent response. Today, graduates of Management major are actually deprived of the opportunity to fully acquaint themselves with real production - the volume of hours allocated to them for practice is less than 4% of the curriculum [Gitelman, Kozhevnikov, 2023], and should be at least three to four times more, as shown in the proposed design of the management specialist programme.

In this regard, it is appropriate to cite the experience of foreign universities, where practice is usually organised in two forms: an internship in a company, which can last a whole semester, or, which is more often implemented, an intensive project literally from the first year. Moreover, the last year of study can be entirely devoted to students carrying out projects under the guidance of mentors from the university and the company [Matzembacher et al., 2019]. This approach is used, for example, at Stanford University (USA), Dalhousie Research University (Canada), University College London (UK) [Gitelman et al., 2022a]. Student placements account for at least 20-25% of the curriculum, and the more innovative the student's future field of work, the more placements are included in the curriculum.

They should also pay attention to the general problems that impede the implementation of advanced learning and the viability of the proposed design of the specialised programme.

For example, it is no secret that in the last decade many universities have actively adopted the so-called mass education approach to the implementation of their educational programmes. Its characteristic features are:

- a significant increase in the general theoretical block of disciplines in the total volume of the educational programme, with a simultaneous decrease in its professional block;
- large-scale 'clustering' of students in classrooms, even for specialised courses (often 200-300 people each), to minimise programme costs;
- a sharp decrease in the threshold of points obtained by applicants in the Unified State Examination, which is necessary for admission to management programmes (to enter, it is enough to pass exams with weak C grades) - even in the leading universities of the Russian Federation, priority is given to the number of students over the quality of their input knowledge;
- the design of curricula based on the principle of throwing dozens of disciplines into a 'single pot', unrelated or duplicating each other, in order to preserve the teaching load of the teams to which it was 'historically' assigned.

In terms of management training, Russian universities today tend to favour the training of general managers, the content and methods of which are little different for the service, trade and high-tech sectors. Such training promotes the importance of 'soft skills' and ignores the importance

Table 2
Design of the management degree programme for the electric power industry

	Learning cycle				
	1st year	**2nd year**	**3rd year**	**4th year**	**5th year**
Key academic disciplines	Introduction to specialty Patterns of scientific and technological development General Mathematics Economics and Market Architecture	Organisation of energy production Modern Information and Digital Technologies Advanced Mathematics and Statistics	Industry Economics Industrial Economics (Energy Markets) Financial Mathematics Investment and Risk	Management system for energy companies Strategic management under uncertainty Investment Project Management Human Resource and Team Development Methods	Research and Business Analysis in Management Business Process Engineering
Basic active learning methods	Intellectual business games Innovative company tours Professional quests	Public pre-defence of diploma projects in energy companies	Public pre-defence of diploma projects in energy companies Расчетно-аналитические кейсы	Public pre-defence of diploma projects in energy companies Management cases	Internships in companies Public proposal defense of diploma projects in energy companies
Scope of design and research work	20%	40%	60%	60%	80%
Type and duration of internship	Academic internship at the department (2 weeks)	Technological practical training in the workplace (2 weeks)	Business practical training in a specialised division of an energy company (4 weeks)	Internship with the management of an energy company (8 weeks)	Pre-diploma placement combined with on-the-job training (16 weeks)

of knowledge of the latest advances in engineering and technology. The training process in these programmes does not usually involve the use of specialised laboratory equipment or experimental production sites, so the profitability of training 'generalist' managers is much higher than that of training engineers or scientists. And for many applicants with a very average level of preparation, management education is an attractive option: it is easy to enrol in programmes, especially contract programmes, it is prestigious, and studying does not require much effort. This 'system' of selecting applicants for management programmes leads to a situation where less than 20% of students have expressed professionally important qualities for management activities [Isaev, 2010; Professionals in competition.., 2021].

Students themselves often believe that they will work as sales or purchasing managers when they graduate, which shows the discrediting of the management profession and a complete lack of understanding of its complexity and responsibility.

What makes the problems identified particularly acute in the context of this article is the fact that in many universities the departments of sectoral economics and management have essentially been liquidated (or placed in conditions that impede normal work and development): mechanical engineering, energy, metallurgy, petrochemistry, construction - unique and highly sought-after centres of competence. This is done in order to meet the requirements of the so-called managerialisation of training and cost reduction.

However, this insignificant saving leads to a significant loss in the quality of trained managers for the real sector of the economy and creates a serious shortage of them in high-tech industries. There is also an acute shortage of teachers in engineering-economics and engineering-management programmes. According to the authors, it will take at least 5-10 years to eliminate this shortage.

Conclusion

The achievement of the country's technological sovereignty, together with the development of scientific and technological breakthroughs, the introduction of the latest production, digital and organisational solutions into the economy, is determined by the ability to organise the innovation process at all stages of its life cycle (from R&D to the operation of new equipment) and to manage the creation and development of complex integrated systems. Success is largely achieved through management. After all, it is innovative managers who implement transformations and must effectively solve problems of the highest intellectual intensity. The job of a manager is thus becoming more responsible, more knowledge-intensive, more interdisciplinary and filled with fundamentally new content.

At the same time, management science, and therefore the management education system, is seriously lagging behind the understanding of established realities and continues to propagate paradigms that were relevant decades ago. Moreover, neither science nor education has fully grasped the challenges facing management. This problem essentially blocks the implementation of a technological breakthrough, and its solution is therefore of great national importance.

Today, proactive management and the inextricably linked anticipatory learning are coming to the fore in management - concepts that involve an early response to future events and the creation of flexible management systems that take advantage of new opportunities. In practice, these concepts are embodied in a certain logic, according to which first a broad research agenda is established, generating the latest knowledge, and then an accelerated transfer of this knowledge into educational content is carried out. An important role will be played by a knowledge-intensive service infrastructure, including tools for monitoring changes in markets, platforms for knowledge management and communication, technologies for the continuous updating of educational products based on the results of the latest research.

The reform of management training in the country should be implemented immediately and include a number of priority organisational measures:

- transition to specialist's degree programmes for training innovative managers in high-tech industries;
- adaptation of the regulatory framework (mainly federal educational standards) in terms of greater attention to fundamentals, interdisciplinarity, actively developing scientific fields (anticipatory management methodology, systems engineering, data science, artificial intelligence, etc.), as well as work placement internship;
- creation of a system for accelerated training of university teachers with engineering, business and engineering and management skills to revitalise relevant industrial departments as centres of unique competence.

References

Bondarenko A. (2022). Problems of staffing in the fuel and energy sector. *Energy Policy.* November 14. https://energypolicy.ru/problemy-kadrovogo-obespecheniya-otraslej-tek/neft/2022/15/14/. (In Russ.)

Vayno A.E., Kobyakov A.A., Saraev V.N. (2011). Proactive management of complex systems. *Economic Integration Bulletin,* 11(1): 7-21. (In Russ.)

Gitelman L.D., Isaev A.P., Kozhevnikov M.V. (2022). *Advanced management education for the industry of the future.* Ekaterinburg, Ural University Press. (In Russ.)

Gitelman L.D., Isaev A.P., Kozhevnikov M.V., Gavrilova T.B. (2022a). Interdisciplinary competencies of managers for technological breakthrough. *Strategic Decisions and Risk Management,* 13(3): 182-198. DOI: 10.17747/2618-947X-2022-3-182-198. (In Russ.)

Gitelman L.D., Isaev A.P., Kozhevnikov M.V., Gavrilova T.B. (2022b). Advanced management education for technological breakthrough. *Strategic Decisions and Risk Management,* 13(4): 290-303. DOI: 10.17747/2618-947X-2022-4-290-303. (In Russ.)

Gitelman L.D., Isaev A.P., Kozhevnikov M.V., Gavrilova T.B. (2022c). Fundamental knowledge and flexibility of thinking - priorities of management education for a technological breakthrough. *Strategic Decisions and Risk Management,* 13(2): 92-107. (In Russ.)

Gitelman L.D., Kozhevnikov M.V. (2023). Radical changes are needed in the training of managers and engineers. *Energy Specialist,* 10. (In Russ.)

Zarochintsev S.V. (2021). Proactive governance and national security risk assessment. *Issues of State and Municipal Administration,* 3: 200-218. (In Russ.)

Isaev A.P. (2010). *Fundamentals of management of professionalization of managers of industrial enterprises.* Ekaterinburg, Ural University Press. (In Russ.)

Karikova A.S. (2023). Overcoming the barriers to the digital transformation of industrial enterprises through the business model selection mechanism. *Strategic Decisions and Risk Management,* 14(1): 74-85. DOI: 10.17747/2618-947X-2023-1-74-85. (In Russ.)

Mayers D. (2010). *IIntuition. Opportunities and dangers.* St. Petersburg, Piter. (In Russ.)

Makarov A.Yu., Makarov A.A. (2021). *Digital economy. Technologies that change management.* Moscow, SOLON-Press. (In Russ.)

Professionals in competition for the future. Advanced training for leadership in the digital industry (2021). Moscow, SOLON-Press. (In Russ.)

Senge P.M. (2011). *The fifth discipline.* Moscow, OLIMP-Business. (In Russ.)

Trachuk A.V., Linder N.V. (2023). Introduction of digital platforms by industrial companies as a source of competitive advantages. *Strategic Decisions and Risk Management,* 14(1): 18-32. DOI: 10.17747/2618-947X-2023-1-18-32. (In Russ.)

Andersone N., Nardelli G., Ipsen C., Edwards K. (2023). Exploring managerial job demands and resources in transition to distance management: A qualitative Danish case study. *International Journal of Environmental Research and Public Health,* 20: 69. DOI: 10.3390/ijerph20010069.

Bai J.Y., Tian Q., Liu X. (2021). Examining job complexity on job crafting within conservation of resources theory: A dual-path mediation model. *Frontiers in Psychology,* 12: 737108. DOI: 10.3389/fpsyg.2021.737108.

Bar-Yam Y. (2005). *Making things work: Solving complex problems in a complex world.* New England, Knowledge Press.

Bessonova E., Gonchar K. (2019). How the innovation-competition link is shaped by technology distance in a high-barrier catch-up economy. *Technovation,* 86-87: 15-32. DOI: 10.1016/j.technovation.2019.01.002.

Bledow R., Schmitt A., Frese M., Kühnel J. (2011). The affective shift model of work engagement. *Journal of Applied Psychology,* 96: 1246-1257. DOI: 10.1037/a0024532.

Calvo-Amodio J. (2019). Using principles as activity drivers in human activity systems. *Systems Research and Behavioral Science,* 36(5): 678-686. DOI: 10.1002/sres.2625.

Crespi F., Caravella S., Menghini M., Salvatori C. (2021). European Technological Sovereignty: An Emerging Framework for Policy Strategy. *Intereconomics,* 56(6): 348-354. DOI: 10.1007/s10272-021-1013-6.

Edler J., Blind K., Kroll H., Schubert T. (2023). Technology sovereignty as an emerging frame for innovation policy. Defining rationales, ends and means. *Research Policy,* 52(6): 104765. DOI: 10.1016/j.respol.2023.104765.

Gitelman L.D., Gavrilova T.B., Gitelman L.M., Kozhevnikov M.V. (2017). Proactive management in the power industry: Tool support. *International Journal of Sustainable Development and Planning,* 12: 1359-1369. DOI: 10.2495/SDP-V12-N8-1359-1369.

Gitelman L.D., Gavrilova T.B., Kozhevnikov M.V. (2020). Methodologies for managing complex systems under uncertainty. *WIT Transactions on Ecology and the Environment,* 241: 91-103. DOI: 10.2495/SDP200081.

Gratton G., Gratton L. (2022). Managers can't do it all. *Harvard Business Review,* March-April. https://hbr.org/2022/03/managers-cant-do-it-all.

Gutiérrez-Iñiguez Á., Collado-Agudo J., Rialp-Criado J. (2023). The role of managers in corporate change management: A bibliometric review. *Sustainability,* 15: 10811. DOI: 10.3390/su151410811.

Harju L.K., Kaltiainen J., Hakanen J.J. (2021). The double-edged sword of job crafting: The effects of job crafting on changes in job demands and employee well-being. *Human Resource Management,* 60(6): 953-968. DOI: 10.1002/hrm.22054.

Hollnagel E., Woods D.D. (2006). Epilogue: Resilience engineering precepts. In: Hollnagel E., Woods D.D., Leveson N. (eds.) *Resilience engineering: Concepts and precepts.* Aldershot, UK, Ashgate, 21-34.

Kearney E., Shemla M., van Knippenberg D., Scholz F.A. (2019). A paradox perspective on the interactive effects of visionary and empowering leadership. *Organizational Behavior and Human Decision Processes,* 155: 20-30. DOI: 10.1016/j.obhdp.2019.01.001.

LeSage A., Friedlan J., Tepylo D., Kay R. (2021). Supporting at-Risk University Business Mathematics Students: Shifting the Focus to Pedagogy. *International Electronic Journal of Mathematics Education,* 16(2): em0635. DOI: 10.29333/iejme/10893.

Matzembacher D.E., Gonzales R.L., Nascimento L.F.M. (2019). From informing to practicing: Students' engagement through practice-based learning methodology and community services. *The International Journal of Management Education,* 17(2): 191-200. DOI: 10.1016/J.IJME.2019.03.002.

Pan W., Sun L.-Y. (2018). A self-regulation model of Zhong Yong thinking and employee adaptive performance. *Management and Organization Review,* 14: 135-159. DOI: 10.1017/mor.2017.33.

Pereira G.I., Specht J.M., Silva P.P., Madlener R. (2018). Technology, business model, and market design adaptation toward smart electricity distribution: Insights for policy making. *Energy Policy,* 121: 426-440. DOI: 10.1016/j.enpol.2018.06.018.

Porter M.E., Heppelmann J.E. (2014). How smart, connected products are transforming competition. *Harvard Business Review,* November. https://hbr.org/2014/11/how-smart-connected-products-are-transforming-competition.

Sacramento C.A., Fay D., West M.A. (2013). Workplace duties or opportunities? Challenge stressors, regulatory focus, and creativity. *Organizational Behavior and Human Decision Processes,* 121: 141-157. DOI: 10.1016/j.obhdp.2013.01.008.

Shalizi C.R. (2006). Methods and techniques of complex systems science: An overview. In: *Complex Systems Science in Biomedicine.* New York, Springer, 33-114.

Shin Y., Hur W.-M., Park K., Hwang H. (2020). How managers' job crafting reduces turnover intention: The mediating roles of role ambiguity and emotional exhaustion. *International Journal of Environmental Research and Public Health,* 17: 3972. DOI: 10.3390/ijerph17113972.

Stevenson J.R., Kwok A., Skurak H.H., Davies A., Hatton T., Sajoudi M., Codling M., Bowie C. (2015). Multi-capital resilience annotated bibliography. *National Sciences Challenges,* 6. https://resorgs.org.nz/wp-content/uploads/2017/07/rnc_annotated_resilience_benchmarking.pdf.

Willett K.D., Dove R., Chudnow A., Eckman R., Rosser L., Stevens J.S., Yeman R., Yokell M. (2021). Agility in the future of systems engineering (FuSE) - A roadmap of foundational concepts. *Proceedings International Symposium.* International Council on Systems Engineering, Honolulu, HI, July 17-22. DOI: 10.1002/j.2334-5837.2021.00831.

Zhang F., Parker S.K. (2019). Reorienting job crafting research: A hierarchical structure of job crafting concepts and integrative review. *Journal of Organizational Behavior,* 40: 126-146. DOI: 10.1002/job.2332.

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Strategic management of the economic sustainability of a company in the paradigm of fuzzy logic

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Abstract

The theory of economic resilience is actively developing in Russian and foreign scientific studies. Most of them lack a comprehensive approach to the issue of resilience, the ability to assess the behaviour of economic systems under conditions of uncertainty and to offer optimal solutions to ensure the resilience of economic systems (enterprises, industries) in difficult conditions. It is necessary to develop optimal algorithms for managing economic systems under adverse effects (AE) of a natural, technological, or military nature. The article describes the method of managing economic resilience in three-dimensional spaces: 'stability – efficiency', 'risk – efficiency', and 'chance – efficiency'. The results of three approaches to resilience management are compared.

It can be tentatively assumed that the stability of an individual company is ensured if the economic stability index RI exceeds the level of 0.6 and the return on equity is at least 20% per annum. More generally, in the 'resilience – efficiency' space, the domain of stable states of the enterprise is described by a fuzzy parabolic R lens. In the 'risk – efficiency' and 'chance – efficiency' domains, the space of optimal solutions is represented by a set of non-dominated Pareto alternatives, united by a fuzzy parabolic efficient bound of the solution portfolio set. The organisation can control its level of economic resilience within multiple representations and act according to a predetermined plan in the event of a temporary loss of resilience. The research is original, using the methods of fuzzy set theory and soft computing. A technology has been proposed to ensure the economic resilience of systems operating in difficult conditions (e.g. in new regions of the Russian Federation where large-scale military actions are taking place). This makes the study highly relevant and practical.

Keywords: resilience index, return on equity, adverse effects, favorable external influences, risk, chance, R lens, matrix aggregate calculator.

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模糊逻辑范式内企业经济可持续性的战略管理

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摘要
俄罗斯和外国的科学研究都在积极发展经济可持续性理论。然而，这些研究大多缺乏处理可持续性问题的综合方法、在不确定条件下评估经济系统行为的能力以及提供最佳解决方案，确保经济系统（企业、行业）在复杂条件下的可持续发展。有必要开发最佳算法，以便在自然、人为或军事性质的不利外部影响下管理经济系统的可持续性。本文章描述了三个坐标空间中经济可持续性管理的顺序："可持续性——效率"、"风险——效率"和"机会——效率"。而且对已确定的三种可持续性管理方法的结果进行比较。
可以初步认为，如果经济可持续发展 RI 指数超过 0.6，且股本回报率每年至少达到 20%，则单个企业的可持续发展能力就得到了保证。从更广泛的角度看，在"可持续性——效率"空间中，企业的稳定状态区域可以用模糊抛物线 R 镜头来描述。
在"风险——效率"和"机会——效率"空间中，最优解的领域是在帕累托效率意义上非优势的备选方案集合，它们由投资组合解集的模糊抛物线有效边界联合起来。企业可从以下几个方面监测其经济可持续性水平并在暂时失去稳定的情况下按照已知计划行事。
本研究具有独创性，应用了模糊集理论和软计算方法。作者提出了以确保复杂工作条件下系统的经济可持续性技术（例如，在俄罗斯联邦正在开展全面军事行动的新地区）。这决定了所开展研究的极端相关性和实际意义。
关键词： 经济可持续性索引、股本回报率、不利影响、有利影响、风险、机会、R 镜头、矩阵计算器。

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Introduction

In order to clearly formulate the research problem of this article, it is first necessary to define the terms. Here and in the following, the efficiency of the economic system of a company is understood as the ability of a company to organise the production of a target product in such a way that the resulting relationships between the company and all the important stakeholders are mutually satisfactory. The stakeholders of the firm are understood as consumers of the target product, suppliers, banks, employees, investors (shareholders) and the state, represented by its federal and regional institutions. This definition of efficiency does not focus on the target product, but on the exchange of value that takes place in the business environment that accompanies the preparation, release and delivery of the product to the consumer.

This immediately raises the question of the efficiency measure. Traditionally, in the works of the fuzzy economics school [Malyukov et al., 2023a; Nedosekin et al., 2020], as a basic measure of efficiency we consider the return on equity (ROE) as a percentage per annum. The main explanation for our choice is as follows. There are two chains: the chain of adding value to the target product and the chain of distributing the benefits associated with the sale of the product, which in a sense mirrors the first chain. If the entrepreneur is at the beginning of the value chain (initiates the business, invests capital), he is at the end of the benefit distribution chain. This can be easily observed in the example of a report on the financial position of an organisation. The first in the chain of distribution of goods is, of course, the consumer, whose benefit is concentrated in the target product. By paying for a product, the consumer creates the basis for the distribution of benefits further down the chain. The second link in the chain is the supplier of raw materials and inputs, followed by the employees and their wages. The state tirelessly collects tribute from the company in the form of various taxes; the banks do not lag behind the state with their interest rents. The net profit from the results of all the business activities of the enterprise goes to the owner as a reward for a successfully organised business - in the last place, at the last moment. As a risk premium, the owner naturally demands a higher return on invested capital, i.e. ROE at the level of at least three deposit rates in a reliable bank. In today's conditions (2023), this becomes a business covenant at the level of 20% per annum in roubles.

A rate of return on equity in excess of 20% per annum is formulated by the owner under normal operating conditions.

When the situation has changed and conditions have become abnormal, the owner finds himself at a crossroads:

- in extreme operating conditions, when the economic system of companies and industries is affected by adverse external influences of a military, natural or man-made nature, the owner thinks about preserving the business and the efficiency criterion recedes into the background. It turns out that it is sufficient to ensure the break-even point of the enterprise, i.e. to require the return on equity above 0. The task of ensuring economic sustainability, understood in the sense of resilience, comes to the fore [Nedosekin et al., 2020; Malyukov et al., 2023a; 2023c;], i.e. the ability of the enterprise to continue functioning in the conditions of adverse external influences, even with reduced efficiency;
- in the paradigm of public-private partnership mobilisation, the enterprise is included in the chain of implementation of state orders (for example, defence). In this case, the entrepreneur has the right to return to the requirement of ROE above 20% per annum at the cost of a partial loss of his economic independence (payment for maintaining economic stability under state patronage). We will explain this idea in more detail outside the scope of this article;
- if a company opens up a new market niche and has the chance to enter it with a new product (blue ocean paradigm [Kim, Mauborgne, 2015]), then this should be considered as an opportunity (opportunity in the sense of the SWOT matrix), i.e. as a kind of favourable impact on the economic system of the company. Of course, when an entrepreneur decides to develop and implement an innovation, there is a risk that the firm will lose its level of sustainability (at least temporarily), and this is an additional risk. As a premium for this risk, the owner expects a return on the capital invested in innovation, which is already at a triple-digit level. The ROE covenant of more than 100% per annum is not extreme for innovation. Moreover, in a number of cases, such a level of ROE is achieved in relation to the company's total equity. For example, in 2020, according to the Finance.Yahoo resource, international companies with the tickers EVR.L, CROX and LMT exceeded the ROE level of over 100% per annum. The issue of economic sustainability in the sense of resilience is discussed in more detail in [Holling, 1973; Holling, 1996; Gunderson and Pritchard, 2002; Perrings, 2006; Walker et al., 2006; Hill et al., 2008; Martin, 2011; Martin, Sunley, 2013; Muller et al., 2013; Hosseini et al., 2016; Buheji, 2018; Sabatino, 2019; De Graaf et al., 2000; Nedosekin et al., 2020].

As a measure of sustainability, Fuzzy Economics scientific school uses the sustainability index (RI), which takes values from 0.1 (very low level of sustainability) to 0.9 (very high level of sustainability). The assessment of RI for companies can be carried out using an express method with the help of the Matrix Aggregate Calculator (MAC, [1]) technology, as well as according to a detailed scheme - with the help of the 4x6 strategic matrix technology [Malyukov et al., 2023c]. The corresponding analysis can be carried out both for individual enterprises and for groups of enterprises (sectors, industries).

Now let's determine the risks and opportunities. In monographs [Kozlovsky et al., 2016; Abdulaeva, Nedosekin, 2017], an independent methodology for analysing the risks and opportunities of economic systems was proposed, based on a number of key definitions:

- threat - a situation associated with an unfavourable effect on the system;
- opportunity - a situation associated with a favourable effect on the system;
- weakness - deficiency, lack of effectiveness, target for threat;
- strength - excess, competitive advantage, target for opportunity;
- negative - a state of the system associated with a violation of normative levels 'down';
- positive - a state of the system associated with a violation of the normative levels 'up'.

Then the definition of risks and opportunities might look like this:

$$Risk = Poss\ \{Negative \mid Threat \oplus Weakness\},$$
$$Chance = Poss\ \{Positive \mid Oportunity \oplus Strength\}, \quad (1)$$

where *Poss* is the 'opportunity' sign, | - the 'provided' sign, ⊕ - the overstrike, superposition sign.

In a 4x6 matrix, risks and opportunities have their own separate places. At the highest level of the matrix's strategic presentation (the 'Impact' row), the integral risks and opportunities for the company/industry are presented.

Thus, when managing the sustainability of his company, the entrepreneur or his delegate (CEO) must simultaneously keep all four key indicators (efficiency, sustainability, risk, opportunity) in mind and look for target (desirable) points for positioning on a number of the most representative coordinate planes. The article presents the results of research in three of these planes: RI - ROE, Risk - ROE and Chance - ROE. Each of these planes provides the decision maker with a wealth of material for understanding.

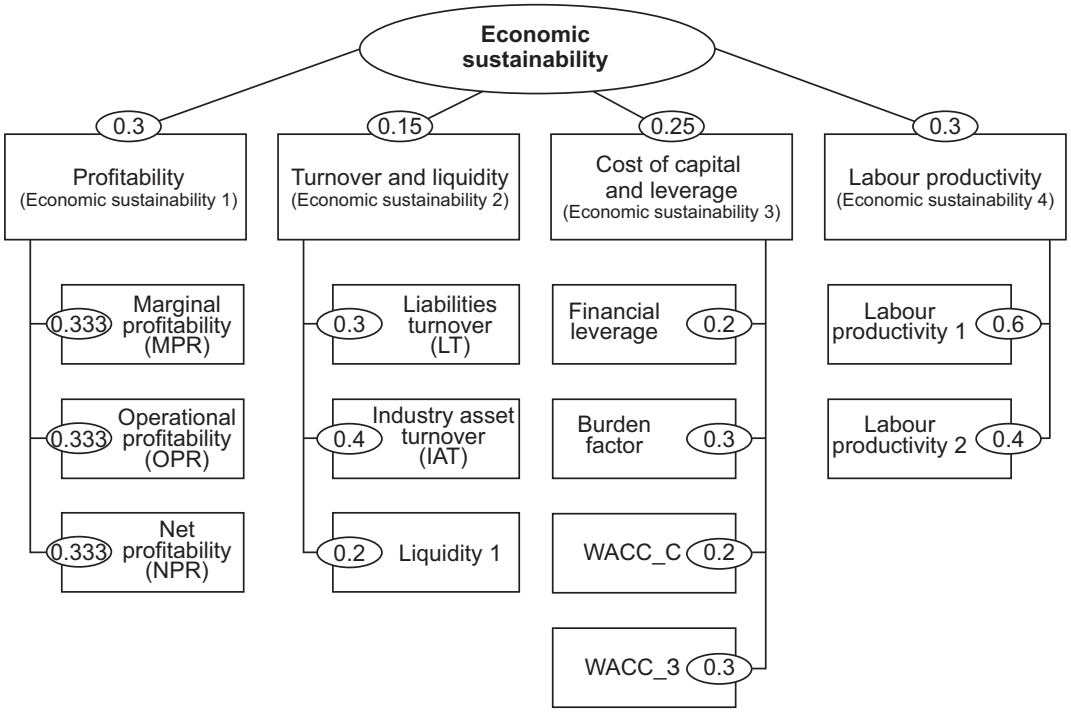
1. Methods for researching the sustainability of companies and industries

1.1. Assessing company sustainability using MAC technology

In our research over the past eight years, we have observed more than one hundred of the largest international companies, grouped into seven industry groups, namely:

- C11 - oil and gas sector;
- DJ27 - metallurgy;
- DK29 - general machine building;
- DL31 - electric machine engineering;
- E40 - production and distribution of electricity, heat and water;

Fig. 1. Hierarchical tree of support factors



Source: [Malyukov et al., 2023a].

- DB - light industry (manufacture of clothing and footwear);
- AA01 - agriculture (food production).

For each enterprise, we simultaneously diagnose twelve supporting factors (Fig. 1) and two integral factors: RI and ROE.

ROE is calculated using the classic DuPont formula:

$$ROE = Net\ profit\ /\ Equity\ capital = Net\ profitability \times \times Liabilities\ turnover \times (1 + Financial\ leverage), \quad (2)$$

The *RI* index, in turn, is calculated using the double convolution method [Nedosekin et al., 2020]:

$$RI = \sum_{i=1}^{N} p_i \sum_{j=1}^{M} y_i * \mu_{ij}, \quad (3)$$

where p is a set of support factor weights, y is an anchor point vector {0.1, 0.3, 0.5, 0.7, 0.9}, μ is a matrix whose rows are support factors with their own weights; columns are qualitative gradations {OH, H, Cr, B, OB}, indicating very low, medium, high and very high levels of factors. At the intersection of the rows and columns in the matrix μ there are functions of membership of quantitative levels of factors to qualitative gradations in accordance with previously defined industry standards for all factors.

1.2. Building an industry R lens

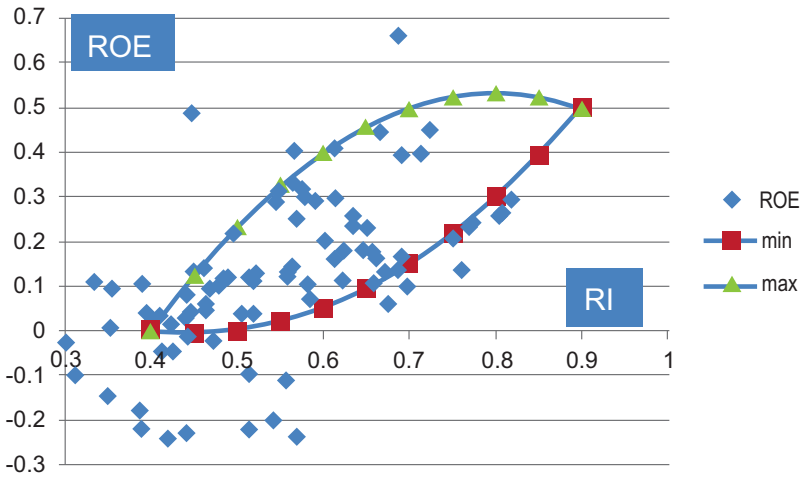
When all the measurement points have been carried out as part of the study in the previous subsection of the article, it is possible to construct industrial R lenses according to the methodology described in [Kozlovsky et al.] The R lens is actually a fuzzy function in the form of a parabola.

Fig. 2 shows the resulting stability analysis data (in the form of isolated points) and the boundaries of the covering R lens (in the form of solid lines).

The R lens is designed to pass through the following four points:

- the left point with coordinates (0.4, 0%). It is assumed that when RI < 0.4, stable net profit generation by the company is impossible;
- the bottom point with coordinates (0.6, 5%). RI = 0.6 is a fairly high level of stability and must be accompanied by profitability at least at the level of the deposit rate in a reliable bank;

Fig. 2. Source data and R lens (DB industry)



Source: compiled by the author.

Table 1
Industry indices RI

Year	Ind_RI для отраслей				
	C11	DJ27	DK29	DL31	E40
2015	0.398	0.368	0.518	0.389	0.445
2016	0.356	0.371	0.490	0.424	0.448
2017	0.434	0.409	0.516	0.380	0.473
2018	0.469	0.458	0.476	0.395	0.461
2019	0.418	0.399	0.463	0.442	0.468
2020	0.310	0.376	0.422	0.421	0.438
2021	0.459	0.533	0.499	0.490	0.485
2022	0.506	0.581	0.498	0.417	0.476

Source: [Nedosekin et al., 2023].

- the upper point with coordinates (0.6, 40%). As can be seen from Fig. 2, some companies easily cross this bar (albeit at the cost of a loss of stability). This is largely influenced by the insufficient amount of equity (as an alarm bell before going into negative equity);
- the right point with coordinates (0.9, 50%). This point is located in a rather sparse space of the initial data and expresses a certain unattainable ideal of profitability while ensuring maximum stability.

The points entered correspond to an R lens with the following regression boundary equations:

$$ROE_{min} = 2.5 \times RI^2 - 2.25 \times RI + 0.5,$$
$$ROE_{max} = -3.3334 \times RI^2 + 5.3334 \times RI - 1.6. \quad (4)$$

The coefficients in regression equation (4) were obtained using an online calculator[1].

A comparison of the original data array and the coordinates of the R lens shown in Fig. 2 shows that approximately half of the measuring points are outside the lens, i.e. they are characterised by a temporary loss of stability. In the best case scenario, there has been a critical drop in equity and it must be replenished as soon as possible. Sometimes (very rarely) there is simply too much equity and it is not working well - either capital has to be withdrawn from the business or financial leverage has to be increased. In the worst case, the company finds itself in a temporary loss zone: equity is being used up and the leak in the hold needs to be fixed before the ship sinks.

Table 2
Industry indices ROE

Year	Ind_ROE for the industries				
	C11	DJ27	DK29	DL31	E40
2015	0.210	–0.252	0.273	0.018	0.030
2016	0.027	0.028	0.627	0.107	0.344
2017	0.070	0.068	0.432	–0.001	0.134
2018	0.110	0.122	0.258	–0.219	0.114
2019	0.072	0.013	0.247	0.014	0.102
2020	–0.085	0.115	0.133	0.104	0.080
2021	0.126	0.208	0.171	–0.012	0.091
2022	0.183	0.165	0.181	0.066	–0.037

Source: [Nedosekin et al., 2023].

[1] IFEL.ru: Online calculator for R lens identification. http://an.ifel.ru/js/r-lens.html.

1.3. Construction of industry sustainability indexes

If 20 companies are selected within an industry segment and measurements are taken over 8 years, this gives 20 × 8 = 160 measurement points. This is a sufficient number of measurements to build a preliminary model description of the industry by entering industry indices for each of the selected indicators. The following rule is valid. If X_{it} is a measurement of factor X for the *i*-th enterprise in the industry segment, carried out in year number *t*, and A_{it} is the balance sheet currency of the *i*-th enterprise in year *t*, then the industry index *Ind_X(t)* should be found using the formula [Nedosekin et al., 2023]:

$$Ind\_X(t) = \sum_{(i)} A_{it} \times X_{it} / \sum_{i} A_{it}. \quad (5)$$

Tables 1 and 2 summarise the indicators for the industry indices RI and ROE.

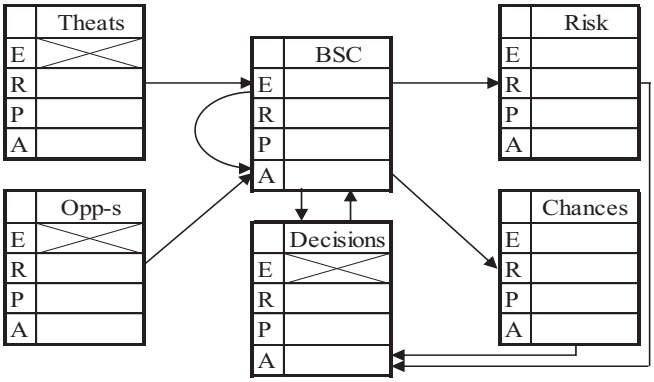
Similar indices can be constructed for the remaining 12 selected industry parameters using relationship (5).

All historical data on industry indices can be used to feed industry sustainability models and to calibrate the corresponding model factors. However, for the purpose of forecasting the levels of industry indices, it is appropriate to use fuzzy numbers and fuzzy functions. The information contained in the historical data is sufficient to make a fuzzy prediction for a future year (2023). This forecast can be made in the form of fuzzy numbers using the following relationships:

$$Min\_I\_X = min_{(t)}\ Ind\_X(t),$$
$$Av\_I\_X = average_{(t)}\ Ind\_X(t),$$
$$Max\_I\_X = max_{(t)}\ Ind\_X(t). \quad (6)$$

Here *FI = FI (Min_I_X, Av_I_X, Max_I_X)* – is a triangular fuzzy number with abscissae expressing the minimum, average and maximum values of the *I_X* measurements for the whole observation period. This is the forecast of the index for the coming year.

Fig. 3. Matrix 4×6



Sources: [Nedosekin et al., 2020; Nedosekin et al., 2023a; 2023b].

Table 3 summarises data on triangular fuzzy numbers within individual industry sustainability indices for industry C11 (as a separate industry example). We can do this work both within industries and within individual companies.

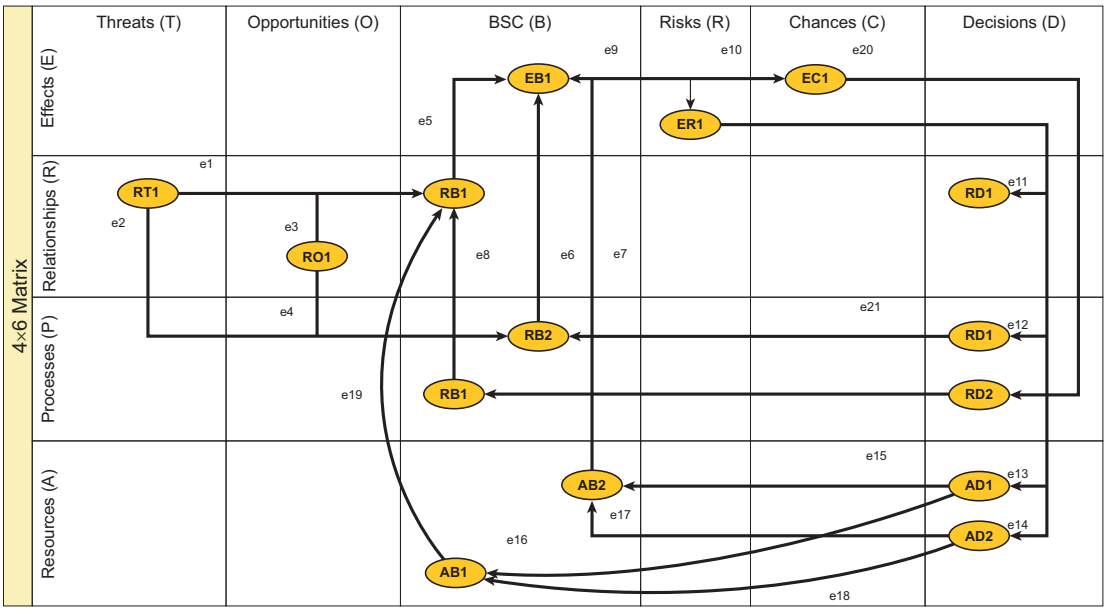
1.4. Formation of a 4x6 matrix

The 4×6 matrix is a system of six interconnected strategic cards (Fig. 3), each with four strategic perspectives.

Card names:

- Threats – threat card;
- Opp-s – opportunity card (opportunities in terms of the SWOT matrix);
- BSC – balanced score card
- Risk – risk card;
- Chances – chance card;
- Decisions – decision card.

Fig. 4. The simplest example of a 4×6 industry matrix



Source: [Malyukov et al., 2023b].

Table 3
Fuzzy industry sustainability factors (C11)

Factor code	Sustainability index	FI for C11 indices		
		Min_I_X	Av_I_X	Max_I_X
Z1	Ind_MP	0.178	0.301	0.368
Z2	Ind_OP	–0.021	0.079	0.155
Z3	Ind_ЧР	–0.055	0.044	0.104
Z4	Ind_ОбП	0.557	0.745	1.106
Z5	Ind_ОбОА	2.672	4.136	9.909
Z6	Ind_Л1	1.165	1.221	1.308
Z7	Ind_ФР	1.005	1.304	1.512
Z8	Ind_KO	0.074	0.323	0.789
Z9	Ind_WACC_C	0.042	0.056	0.081
Z10	Ind_WACC_З	0.013	0.019	0.048
Z11	Ind_ПТ1	1610	2533	4040
Z12	Ind_ПТ2	–128	106	411
RI	Ind_RI	0.310	0.419	0.506
ROE	Ind_ROE	–0.085	0.066	0.183

Source: [Nedosekin et al., 2023].

Table 4
Indicators with 4×6 matrix

Indicator code	Indicator name	Scale
RT1	Industry demand contraction index	% to previous year
RO1	Industry demand expansion index	% to previous year
EB1	Return on equity index (ROE)	% per annum
RB1	Net profitability index	%
PB1	Labour productivity index	thousand dollars in revenue per employee per year
PB2	Liability turnover index	once a year
AB1	Weighted average cost of borrowed capital index	% per annum
AB2	Financial leverage index	dimensionless
ER1	Integral industry risk	from 0 to 1
EC1	Integral industry chance	from 0 to 1
RD1	Industry decision factor 1: increase in net profitability	%
PD1	Industry decision factor 2: increase in liability turnover	once a year
PD2	Industry decision factor 3: increase in labour productivity	thousand dollars in revenue per employee per year
AD1	Industry decision factor 4: increase in financial leverage, decrease in the weighted average cost of borrowed capital	by leverage - dimensionless, by weighted average cost of capital - % per annum
AD2	Industry decision factor 5: increase in financial leverage, decrease in the weighted average cost of borrowed capital	by leverage - dimensionless, by weighted average cost of capital - % per annum

Source: [Malyukov et al., 2023b].

Names of strategic perspectives:

- A - assets;
- P - processes;
- R - relationships between the industry and its key stakeholders (consumers, suppliers, banks, employees, government, etc.);
- E - effects - the results presented by the industry.

The simplest example of a 4×6 industry matrix [Malyukov et al., 2023b] is shown in Fig. 4. Indicators on strategic maps are labelled according to a single XYZ principle, where X is the code of the strategic perspective, Y is the code of the card, Z is the number of the indicator in order (within a cell of the matrix). The indicators shown in Fig. 4 are summarised in Table. 4.

The data in Table 4 should be accompanied by the following comments:

- the matrix model is mainly built on indices obtained for the enterprises included in the industry using average weighting methods of type (5);
- the indicators are represented in a 4x6 matrix model either as fuzzy numbers or as Zadeh linguistic variables;
- the model is dynamic; there are time lags between observations, decisions and the reaction of the industrial system to decisions;
- Decisions affecting the industry are made by the government and are aimed at increasing the sustainability of the industry. Such decisions, made within the framework of the Public-Private Mobilisation Partnership (PPMP), include:
  1) Formation of a unified pricing policy within the framework of specially created inter-industry syndicates, with the net profitability (NPR) of all key players in the syndicate being fixed at the level of NPR = 5-7%;
  2) Voluntary transfer of part of the long-term industrial assets to the State Property Fund under the conditions of a repayable industrial mortgage at the rate of 3% per annum, bringing the liability turnover (LT) to the level of LT = 1.5 times per annum;
  3) Development of a unified industrial system of personnel motivation for the task of developing new market niches and technologies for closing these niches, with the labour productivity in terms of sales (LP1) being brought to a level corresponding to the industrial quality grade 'B' (high level);
  4) Establish a factoring programme for the industry's suppliers at a rate of 2% per annum, bringing the industry's average financial leverage (FL) to a level of FL = 1.6. This decision, taken independently of other decisions, should also bring the Weighted Average Cost of Capital (WACC_3) to the level of WACC_3 = 2% per annum;

Table 5
Relationships between indicators in a 4×6 matrix

Communication cipher	Source node	Receiver node	Communication entity
e1	RT1	RB1	Fall in industrial demand leads to decline in NPR
e2	RT1	PB2	Falling industrial demand leads to lower LT
e3	RO1	RB1	Growing industrial demand drives growth in NPR
e4	RO1	PB2	Growing industrial demand drives growth in LT
e5	RB1	EB1	NPR directly affects ROE (Dupont formula)
e6	PB2	EB1	LT directly affects ROE (Dupont formula)
e7	AB2	EB1	FL directly affects ROE (Dupont formula)
e8	PB1	RB1	Increase in LP1 leads to increase in NPR
e9	EB1	ER1	Decrease in ROE leads to increase in integral risk
e10	EB1	EC1	Increase in ROE leads to increase in integral Decision 1
e11	ER1	RD1	An increase in integral risk triggers the start of Decision 2
e12	ER1	PD1	An increase in integral risk triggers the start of Decision 3
e13	ER1	AD1	An increase in integral risk triggers the start of Decision 4
e14	ER1	AD2	An increase in integral risk triggers the start of Decision 5
e15	AD1	AB2	Decision 4 causes FL to increase
e16	AD1	AB1	Decision 4 causes WACC_3 to decrease
e17	AD2	AB2	Decision 5 causes FL to increase
e18	AD2	AB1	Decision 5 causes WACC_3 to decrease
e19	AB1	RB1	Decreasing WACC_3 causes FL to increase
e20	EC1	PD2	Increasing the integral chance causes Decision 3 to start
e21	PD1	PB2	Removal of obsolete funds leads to increase in LT
e22	PD2	PB1	An increase in the quality of motivation leads to an increase in labour productivity.

Source: [Malyukov et al., 2023b].

5) State industry programme for the leasing of new technologies to industry at a rate of 2% per annum.

If the above solutions 1-5 achieve their objective, the industry will achieve an investment-acceptable level of return on equity.

ROE = 20% per annum (three interest rates for a deposit in a reliable bank). This is a necessary condition for the industry to reach a level of economic sustainability with a qualitative grading no worse than 'B'.

The relationships between the indicators are shown in Table 5.

1.5. Industry risk assessment

From the data in Table 3, the main strengths, weaknesses, opportunities and threats (traditional components of the SWOT matrix) are as follows:

Strengths:

- there is no significant dependence on capital and related rents, financial leverage is relatively low;
- high labour productivity (up to $4 million in revenue per employee per year);
- good margin.

Weaknesses:

- the industry is unattractive for investment (weighted average ROE level above 20% per annum);
- low turnover of all assets (the industry is overloaded with production assets);
- the sustainability of the industry is below average.

Opportunities:

- There is potential to increase ROE to investment levels;
- there are mechanisms to increase the sustainability of the industry (at the level of government regulation);
- as a result of the special military operation, the redistribution of oil and gas flows leads to the transfer of corresponding production from the Russian Federation to the USA (2022 experience).

Threats:

- significant volatility in commodity prices leads to the phenomenon of market compression and a corresponding drop in profitability throughout the year, including the emergence of massive losses for companies in the industry;
- the same market compression is caused by a large-scale pandemic (the experience of 2020) due to a reduction in inter-industry demand.

Determining the components of the SWOT matrix is a useful exercise aimed at identifying targets for threats and opportunities. In the model, such targets need to be represented by exogenous parameters.

Let's estimate the risk of unprofitability for the oil and gas sector using the Ind_NPR index, the triangular number Ind_NPR = (-0.055, 0.044, 0.104) taken from Table. 1. In this case, taking into account (1)

Risk = Poss {Ind_NPR < 0} = 0.122. (7)

Risk assessment using an online calculator[2], Standard risk levels have been established:

- acceptable and irreducible: Risk < 0.15;
- borderline: 0.15 < risk < 0.2;
- unacceptable: Risk > 0.2. (8)

According to the classifier (8), the risk of loss on the sector index is acceptable. In order for the negative of unprofitability to materialise, the industry would have to experience the threat of a pandemic again, as it did in 2020. However, as such a negative event has already occurred in the past and the industry has learnt the right lessons in dealing with a catastrophic drop in production, the possibility of the industry suffering a loss in a similar adverse impact scenario is considered to be tolerably low.

1.6. Integral chance estimate

Let's use the index Ind_ROE > 0.2 to assess the likelihood of industry C11 reaching the investment level. If nothing is done, there is no chance of such an outcome (all abscissa of Ind_ROE from Table 3 are less than 0.2). Let's consider the option of government support for the industry in an international format as part of a programme to radically increase the turnover of the industry's assets. One possible option here is the inclusion of a reverse production mortgage, whereby the fixed assets of oil and gas companies are transferred to the government's balance sheet in exchange for the corresponding rent.

Let us assume that, as a result of the measures taken, the strictly defined standard level Ind_LR = 1.5 times per year is reached. This is in accordance with the Dupont formula (2) for the data in Table. 3 gives an expectation of Ind_ROE = ={- 0.165, 0.152, 0.391}. Then

Chance = Poss {Ind_ROE > 0.2} = 0.205. (9)

Estimation (9) was obtained using the same calculator [Martin, Sunley, 2013] with all initial data transformed to negative values. This technique can in some cases avoid the use of more complex analytical relationships for chance analysis.

Standard chance levels are defined in [Kozlovsky et al., 2020]:

- incentive chance: 0.75 < Chance < 1;
- borderline chance: 0.5 < Chance < 0.75;
- unacceptable chance: Chance < 0.5. (10)

According to the normalisation (10), the probability of reaching the investment level is lower than the normatively acceptable level. This means that simply increasing asset turnover is not a sufficient measure to reach the investment level ROE in the industry; additional efforts need to be made. Such additional measures include, in particular, government factoring of the supplier.

1.7. Pareto portfolio management

If we define a space (X, Y) of dimension 2 and specify two points with coordinates (X1, Y1) and (X2, Y2), then these points form a pair of non-dominated Pareto alternatives[3], if the logical condition is satisfied:

(X1 > X2 И Y1 > Y2) OR (X1 < X2 И Y1 < Y2). (11)

Condition (11) is true if the coordinates X and Y form an oppositional pair (competing in meaning), e.g. 'risk-return'. If

[2] IFEL.ru: Online risk assessment calculator. St Petersburg, 2023. http://an.ifel.ru/js/risk-calculator.html.

[3] https://ru.wikipedia.org/wiki/Эффективность по Парето.

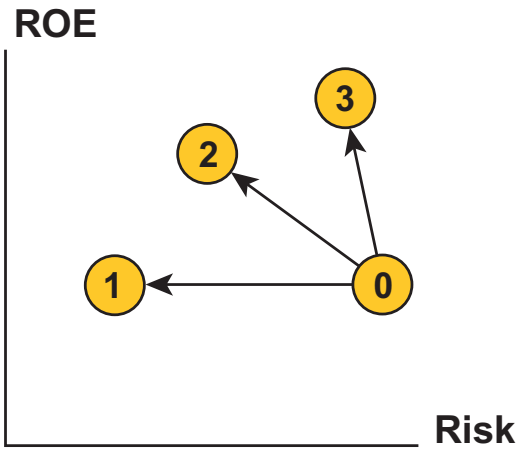
X and Y are not oppositional, then condition (11) is replaced by condition (12):

(X1 > X2 И Y1 < Y2) OR (X1 < X2 И Y1 > Y2). (12)

The set (portfolio) of representative points can be continuous or discrete. A typical example of the former is a portfolio set for the stock market in the 'risk – return' coordinates. In all cases, Pareto optimisation involves selecting all non-dominated alternatives from the portfolio; in the continuous case, the corresponding set is called the effective bound.

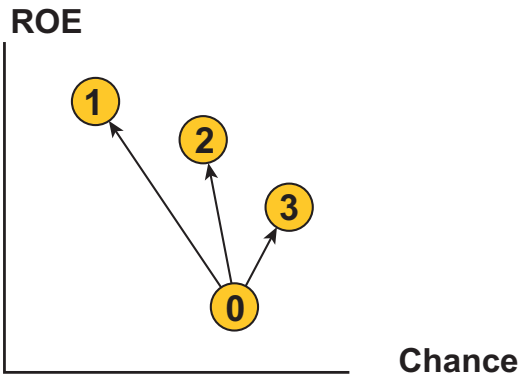
If we are dealing with a company, each of the possible solutions (decision map in a 4×6 matrix) to bring the company to a new state (more stable or more strategically promising) is a representative point in the 'Risk - ROE' or 'Opportunity - ROE' spaces. If the representative point of the solution is not dominated by other points in the portfolio, the solution is optimal. Figures 5 and 6 show the corresponding cases of anti-risk and pro-chance solutions. By default, the initial representative point of the company is dominated by all other points, otherwise there is no point in making appropriate decisions.

Fig. 5. Portfolio of anti-risk solutions in 'Risk – ROE' coordinates



Source: compiled by the authors.

Fig. 6. Portfolio of random solutions in 'Chance – ROE' coordinates



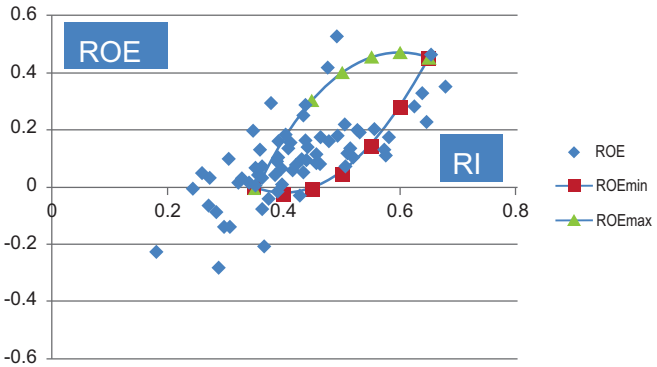
Source: compiled by the authors.

2. Calculation part of the study

2.1. Stability management in 'RI – ROE' coordinates

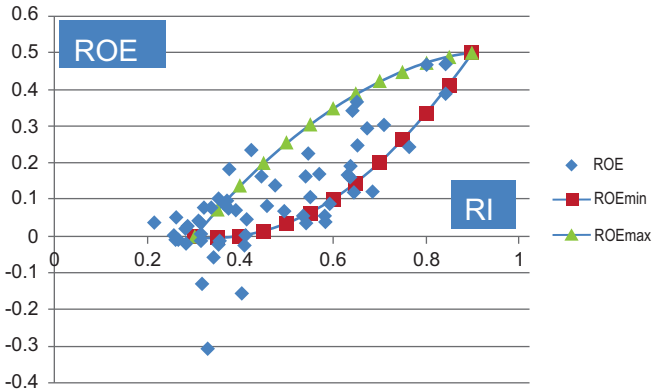
Figures 7-11 show the industrial R-lenses in 'RI – ROE' coordinates obtained from the simulation results.

Fig. 7. R lens for industry C11



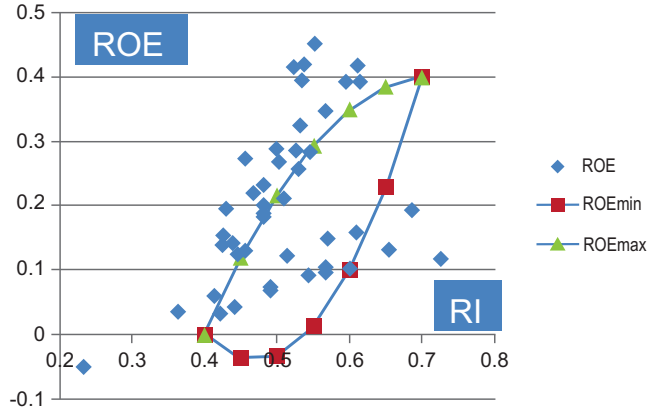
Source: compiled by the authors.

Fig. 8. R lens for industry DJ27



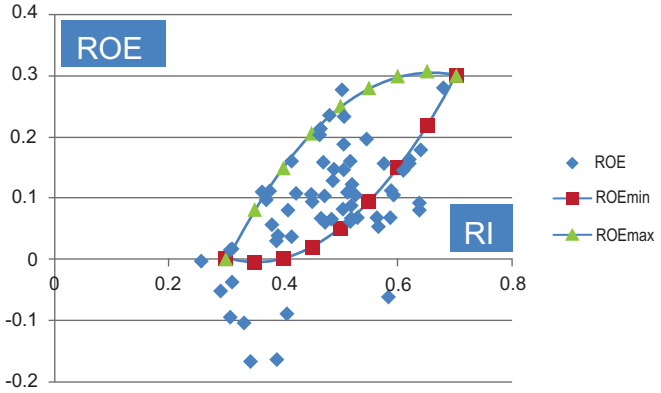
Source: compiled by the authors.

Fig. 9. R lens for industry DK29



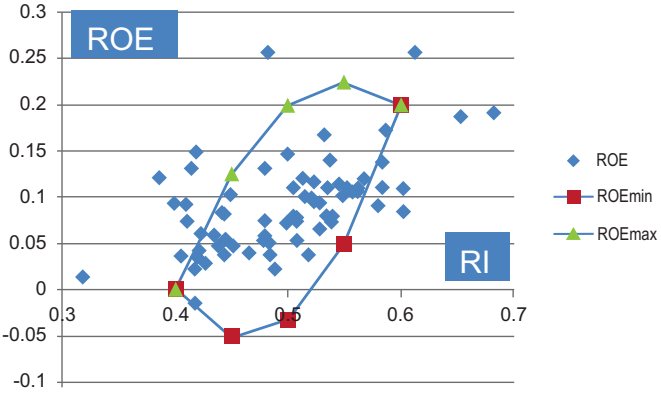
Source: compiled by the authors.

Fig. 10. R lens for industry DL31



Source: compiled by the authors.

Fig. 11. R lens for industry E40



Source: compiled by the authors.

It can be seen that the lenses in Figures 7-11 have varying degrees of occupancy. The less crowded the lens, the more confident we can be about the loss of sustainability of the industry, in a positive or negative sense. The industry is either configuring a new market niche for itself (positive impact), or it is exposed to negative external impacts and is trying to reduce all kinds of risks.

2.2. Stability management in the 'Risk – ROE' coordinates

Let's look at the activities of General Electric (ticker GE) for the period 2015-2022. Tables 6 and 7 summarise the factors of interest to us in terms of sustainability management. It is clear that the company is in deep decline and all its key characteristics are 'dislocated'. The proposed mitigation measures are as follows:

- partial nationalisation of the company with transfer of surplus assets to the state (together with corresponding debts) in the regime of reverse mortgage of real estate;
- reorganisation of the company with regulation of income and expenses to the level of NPR = 5%.

Table 6
GE financials ($ bln)

Year	Revenue (R)	Net Profit (NPR)	Equity Capital (EC)	Balance sheet assets (A)
2015	115.8	–6.1	98.3	493.1
2016	119.5	7.5	75.8	365.2
2017	118.2	–8.5	56.0	369.2
2018	121.6	–22.3	31.0	309.1
2019	95.2	–5.0	29.9	266.1
2020	79.6	5.7	35.6	253.5
2021	74.2	–6.8	41.6	198.9
2022	58.1	–0.1	37.6	188.0

Source: compiled by the authors.

Table 7
Fuzzy numbers and risks for GE

Indicator	min	av	max	Norm	Risk
NPR	–0.183	–0.040	0.072	0.050	0.991
LR	0.235	0.329	0.393	1.500	1.000
FL	3.818	5.525	8.971	1.600	0.000
ROE	–0.719	–0.126	0.160	0.200	1.000

Source: compiled by the authors.

We will design the company for the expected indicators of the forecast year, based on the minimum allowable turnover. Turnover = USD 60 billion. To achieve the required turnover LR = 1.5 times a year, the company's assets must be A = 40 billion dollars. Accordingly, the government needs to transfer about $150 billion of assets, which are then immediately returned to long-term lease (and thus neatly removed from the balance sheet). To ensure a leverage ratio of 1.6, it is necessary to set EC = USD 15 billion, Borrowed Capital (BC) = A - EC = USD 25 billion. Accordingly, the assets transferred to the government for USD 25 billion are backed by equity (expected to be sold) and the remaining USD 125 billion by debt (expected to be transferred from private to public).

If the recommended projects are implemented, the company will move to an investment-attractive ROE level of 20% per annum, and the risks of unprofitability will be reduced to zero. It is absolutely clear that the company's management will never take the proposed measures under normal conditions. It is necessary for another negative wave to hit the market ('the roast rooster has pecked'), and then the option of partial nationalisation will not seem so incredible. After all, it was the path of nationalisation that the insurance company AIG took in 2008 as a result of the global mortgage crisis.

2.3. Stability management in 'Opportunity – ROE' coordinates

Throughout its history, GE has been driven by innovation. One of its founding fathers, Jack Welch, recounts in [Welch, Byrne, 2006] how he revived the company's finance division

and turned it into a profitable business in its own right. Today, GE's survival is directly linked to its entry into new market niches, such as artificial intelligence in electrical engineering. The use of neural networks in the design of new high-voltage equipment and networks could be a promising new business for the company with an extremely high return on investment.

Let's assume that EC1 = USD 2 billion of equity and BC1 = USD 3 billion of debt are invested in a new business with revenue expectations of R1 = USD 10 billion. We set vague expectations for marginal, operating and net profitability, typical of blue ocean conditions in the IT industry (Table 8).

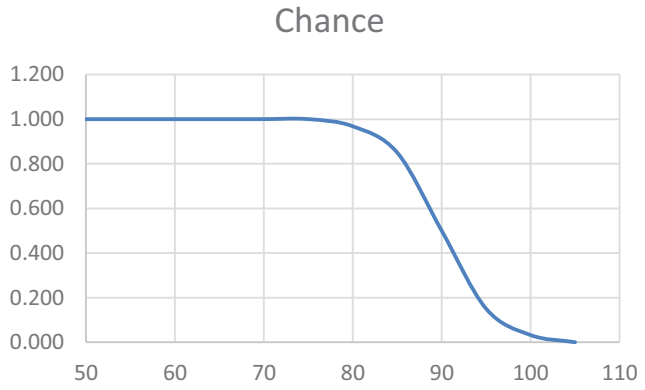
Table 8
Expected profitability for GE's innovation business (%)

Profitability	min	av	max
Marginal profitability (MPR)	50	60	70
Operational profitability (OPR)	25	30	35
Net profitability (NPR)	15	18	21

Source: compiled by the authors.

If, according to the conditions of the problem, LR = 2 times a year and FL = 1.5, we obtain a triangular expectation for ROE = (75%, 90%, 105%) per annum. Let's construct a probability function whose argument is the standard value of ROE from 50 to 100% per annum (Fig. 12). It is clear that as the requirements for the coming ROE level become more stringent, the chances of an innovative breakthrough fall from 1 to 0.

Fig. 12. Opportunity for an innovative project



Source: compiled by the authors.

3. Research findings and discussion

The choice of coordinate space for analysing the sustainability of companies and industries is primarily determined by the intentions of the decision-maker. The first step is to consider the industry lens and the position of the company relative to that lens. If the trajectory of the dynamics of the point representing the company is within the lens, then stability is assured and no special additional solutions need to be taken. If stability is lost, then you need to understand what caused the loss of stability and in what sense (positive or negative) this event should be considered.

In the vast majority of cases, the loss of stability is negative. If the dot is below the lens, the business lacks profitability and it comes down to the ratio of costs to revenues. If the dot is above the lens, the first thing to look at is the size of your net assets. Outliers in ROE are often caused by inadequate EC: either it is continually being washed away by losses, or it is being inappropriately divested by the owners. In both cases, EC needs to be brought to a rational level (the dot needs to return to the lens).

When a company decides to enter new markets with a new innovative product, such a decision is obviously of a random nature. It is necessary to model this decision in 'Chance – ROE' coordinates (in the spirit of Fig. 6) and compare decisions with rational expectations for ROE within the newly outlined segment. We also need to take into account that innovations are quickly copied and the corresponding blue oceans in the Kim-Mauborgne sense collapse. Therefore, random activities should not be the nature of individual actions from time to time, but should be carried out permanently.

All the modelling experience we have accumulated leads to the conclusion that the fuzzy-probabilistic descriptions we use here are an incredibly powerful descriptive platform. This makes it easy to move beyond the boundaries of the company or industry itself and start modelling the impacts themselves, treating them in the model as independent systems with their own structure and deployment logic.

Conclusion

The article presents a wide range of techniques for analysing the sustainability of companies and industries, including taking into account the level of integral risks and opportunities. Quantitative examples show that anti-risk solutions lead to an increase in the sustainability of companies and industries, but at the same time can reduce the company's chances of breakthrough. On the contrary, increasing opportunities across the company automatically leads to a decrease in sustainability; every time capital is diverted to innovation, it means a temporary loss of stability in the name of securing the company's future.

Companies and industries (under government control) must constantly manoeuvre in the coordinate space of 'efficiency - risk – opportunity', choosing acceptable strategies for increasing or decreasing sustainability. In many ways, strategic decisions are influenced by regulatory parametric constraints of an industry nature. For example, in the context of the global economic crisis, a leverage ratio of FL = 3 is tantamount to a catastrophe; the risks of bankruptcy for such a company (especially in view of the FRS turnaround) are off the charts. This means that decisions taken must have a reliable methodological justification. We hope that our work has laid another brick in this foundation.

References

Abdoulaeva Z.I., Nedosekin A.O. (2017). *Industrial and economic risk assessment of enterprises.* St. Petersburg, Publishing House of Peter the Great St. Petersburg Polytechnic University, 2017. (In Russ.)

Kim W.C., Mauborgne R. (2015). *Blue ocean strategy. How to find or create a market free from competitor.* Trans. from Eng. by I. Yushchenko. Moscow, Mann, Ivanov and Ferber. (In Russ.)

Kozlovsky A.N., Nedosekin A.O., Abdulayeva Z.I. (2016). *Management of a portfolio of industrial innovations.* St. Petersburg, Publishing House of Peter the Great St. Petersburg Polytechnic University. (In Russ.)

Malyukov Y.A., Nedosekin A.O., Abdulayeva Z.I. (2023a). *Assessment of economic sustainability of public industrial companies.* St. Petersburg, Publishing House of Peter the Great St. Petersburg Polytechnic University. (In Russ.)

Malyukov Y.A., Nedosekin A.O., Abdulayeva Z.I. (2023b). Application of the 4x6 matrix model for analysis of industry sustainability. *Soft Measurements and Computing,* 6(67): 47-58. (In Russ.)

Malyukov Y.A., Nedosekin A.O., Abdulayeva Z.I., Silakov A.V. (2023c). *Assessment and enhancement of economic sustainability of an industrial enterprise using a balanced scorecard.* St. Petersburg, Publishing House of Peter the Great St. Petersburg Polytechnic University. (In Russ.)

Nedosekin A.O., Malyukov Y.A., Abdulayeva Z.I. (2023). Formation of industry sustainability indices in the fuzzy-logical paradigm. In: *Modern issues of sustainable development of society in the era of transformational processes:* Proceedings of the IX International Scientific and Practical Conference, Moscow, May 19, 2023. Moscow, Alef, 258-263. DOI 10.34755/IROK.2023.63.14.025. (In Russ.)

Welch J., Byrne J. (2006). *My years at GE.* Moscow, Mann, Ivanov and Ferber. (In Russ.)

Buheji M. (2018). *Understanding the power of resilience economy: An inter-disciplinary perspective to change the world attitude to socio-economic crisis.* UK, AuthorHouse. ISBN-10 1546286675.

De Graaf T., Reggiani A., Nijkamp P. (2000). Resilience: An evolutionary approach to spatial economic systems. *Networks and Spatial Economics,* 2: 211-229.

Gunderson L., Pritchard L. (2002). *Resilience and the behavior of large scale system.* Washington, DC, Island Press.

Hill E.W., Wial H., Wolman H. (2008). Exploring regional economic resilience. *Institute of Urban and Regional Development, University of California,* Working Paper. https://escholarship.org/uc/item/7fq4n2cv.

Holling C.S. (1973). Resilience and stability of ecological systems. *Annual Review of Ecology and Systematics,* 4: 1-23.

Holling C.S. (1996). Engineering resilience versus ecological resilience. In: Schulze P. (ed.). *Engineering within ecological constraints.* Washington, DC, National Academy Press.

Hosseini S., Barker K., Ramirez-Marquez J.E. (2016). A review of definitions and measures of system resilience. Reliability *Engineering & System Safety,* 145: 47-61.

Kozlovsky A.N., Nedosekin A.O., Abdoulaeva Z.I., Reyshakhrit E.I. (2020). R-Lenses as a tool for the enterprise resilience analysis. In: *Proceedings of the 2nd International Scientific and Practical Conference "Modern management trends and the digital economy: From Regional development to global economic growth" (MTDE 2020).* https://www.atlantis-press.com/proceedings/mtde-20/125939875.

Martin R. (2011). Regional economic resilience, hysteresis and recessionary shocks. *Journal of Economic Geography,* 12: 1-32.

Martin R., Sunley P. (2013). On the notion of regional economic resilience: Conceptualization and explanation. *Papers in Evolutionary Economic Geography,* 13.20: 1-45.

Muller G., Koslowski T., Accorsi R. (2013). Resilience - A new research field in business information systems? In: Abramowicz W. (ed.). *Business information systems workshops, Lecture notes in business information processing,* 160: 3-14. Berlin, Heidelberg, Springer.

Nedosekin A., Abdoulaeva Z., Konnikov E., Zhuk A. (2020). Fuzzy set models for economic resilience estimation. *Mathematics,* 8(9): 1516.

Perrings C. (2006). Resilience and sustainable development. *Environment and Development Economics,* 11(4): 417-427.

Sabatino M. (2019). Economic resilience and social capital of the Italian region. *International Review of Economics & Finance,* 61. DOI: 10.1016/j.iref.2019.02.011.

Walker B.H., Gunderson L.H., Kinzig A.P., Folke C., Carpenter S.R., Schultz L. (2006). A handful of heuristics and some propositions for understanding resilience in social-ecological systems. *Ecology and Society,* 11(1): 13. http://www.ecologyandsociety.org/vol11/iss1/art13/.

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The impact of digital platforms on industrial enterprises: An empirical analysis in the context of external sanction pressure

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Abstract

The rapid technological revolution, the shortening of the life cycle of many products, the spread of the principles of 'universal connectivity' in industry are forcing manufacturers to develop new business models that reduce the time to market products, increase productivity, and create new principles for delivering value to consumers and interacting with partners. Platform business models are the answer to these challenges. At the same time, industrial companies are increasingly not only platform participants but also platform registrants themselves. Based on the identified strategies for the implementation of different types of business models by industrial companies, the article discusses the potential impact of their implementation. The research presented provides a new perspective on the relationship between the chosen combined models of platform solutions and the performance of industrial companies in the context of sanctioned restrictions on access to financial capital. The empirical analysis allowed us to draw conclusions about the greatest impact on the financial results of the choice of the 'leader', 'diversifier' and 'advanced e-commerce' models when these companies operate on international platforms. To diversify and enter new markets — the 'leader' and 'diversifier' models and the choice of the 'extended e-commerce' model prevent the creation of new markets. The choice of a particular model for implementing platform solutions is influenced (with the highest degree of significance) by the availability and access to the financial capital of industrial companies.

Keywords: industrial enterprises, digital platforms, competitiveness, effects, access to foreign markets, strategy, ecosystem.

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数字平台对工业企业的效应：外部制裁压力下的实证分析

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摘要
技术革命、许多产品生命周期的缩短以及“通用连接”原则在工业中的普及，迫使制造商形成新的商业模式。它们有助于缩短产品上市时间，提高生产率，为向客户提供物资和与合作伙伴互动创造新的原则。应对这些挑战的办法就是建立数字平台商业模式。与此同时，越来越多的工业企业不仅是平台成员，而且注册自己的平台。本文研究了平台采用的潜在效应。它们以工业企业实施不同类型商业模式的某些战略为基础。本研究从一个新的角度探讨了在限制获得金融资本的制裁背景下所选择的平台解决模式（模式组合）与工业企业绩效之间的关系。通过实证分析作者得出结论：当企业在国际平台上运营时，选择“领导者”、“多样化者”和“扩展电子商务”模式对财务业绩的影响最大。“领导者”和“多样化者”模式对多样化和进入新市场的影响最大，同时选择“扩展电子商务”模式阻碍了新市场的创建。工业企业金融资本的可用性和获取途径对平台解决实施模式的选择产生了（最大程度的）影响。
关键词：工业企业、数字平台、竞争力、效应、进入外国市场、战略、生态系统。

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Introduction

The technological revolution, the shortening of the life cycle of many products, and the spread of the principles of ‘universal connectivity’ in industry are forcing manufacturers to create new business models that help reduce time to market, increase productivity, and formulate new principles for delivering value to consumers and interacting with partners. The answer to these challenges is the creation of platform business models. Over the past decade, the landscape of platform business models for industrial companies has changed significantly and become more heterogeneous. This is evidenced by the increasing complexity of the organisational structures of industrial companies with the use of digital business models, the increase in the number and variety of digital technologies used, the emergence of new digital platforms and entrepreneurial initiatives aimed at further transforming the traditional business models of industrial companies.

According to many analysts and top managers, the use of platform business models, including digital platform tools, helps organisations improve their brand reputation, customer service quality and customer retention rates [Ehret et al., 2013; Gatignon et al., 2017; Chakravorti, Chaturvedi, 2018].

The use of digital platform tools for industrial companies is based on:

- emerging virtual markets characterised by strong interconnectedness and focused on the convenience of transactions. In such markets, information plays a special role, being transmitted to a larger number of people in a very short time and at a much lower cost than in traditional markets [Yang et al., 2017; Dabbs et al., 2018];
- recombinating the value chain. The model proposed by M. Porter in 1985 is significantly modified in virtual markets, where value creation is the result of a new combination of information, physical products and real services, a new configuration of transactions and a reconfiguration of resources, capabilities and relationships between suppliers, partners and buyers [Keen, Qureshi, 2006; Sharma, Mehrotra, 2007; Rust, 2020];
- creating a flow of innovation and entrepreneurship (according to J. Schumpeter) [Teece, 2010; Schneider, Spieth, 2013];

- using the resource theory of the firm. Information resources enhance a firm's capabilities and have a much higher level of mobility than others, making them more important for the platform economy and value creation [Velu, 2016; Chakravorti et al., 2017].

In its 2020 research, PricewaterhouseCoopers describes digital platforms as fundamentally new operating technologies that enable a company to gain a competitive advantage by improving service to customers and optimising business relationships with partners. It is emphasised that internet technologies are one of the key aspects of the platform economy, but not the only one.

Thus, platform business models differ significantly from traditional ones in the value chain.

For example, virtual value chains play a strategic role in collecting, organising, selecting, synthesising and disseminating information [Flavián et al., 2019]. Virtual markets are highly diverse and interconnected [Foss, Saebi, 2017; Robertson, 2017], focusing on operations, information, products and networks. Both electronic and mobile wireless business models, which use open standards to support networks, have the potential to break down traditional boundaries between firms in the value chain. New forms of relationships between buyers and sellers in existing markets create value and are highly efficient by reducing transaction costs. Virtual markets are also characterised by high coverage and completeness of the information presented [Evans et al., 2017; Leischnig et al., 2017].

The purpose of this article is to assess the impact of implementing one or the other of the platform business models on the availability of financial capital for industrial companies.

The article attempts to answer the following research questions:

- Which type of platform business model or tool is most effective for industrial enterprises in the context of sanctions pressure and limited access to financial capital?
- How do sanctions and restrictions on access to financial capital affect the choice of platform business models and firm performance?

1. Theoretical review

The main difference between platform business models is the development of a value creation model based on facilitating the exchange of resources, information, etc. between several interdependent groups [Nenonen, Storbacka, 2010; Arora,

Table 1
Classification of platform business models by end-user groups

	Government	Business	Consumer	Collective users
Government	G2G (coordination and interaction)	G2B (information; public services portal)	G2C (information; public services portal)	G2E (information model to improve the quality of government services for users)
Business	B2G (government procurements)	B2B (various forms of e-business)	B2C (various forms of e-business)	B2E (internal company system to ensure the participation of geographically remote employees in business processes)
Consumer	C2G (enquiries and interaction; public services portal)	C2B (searching and analysing information, interaction)	C2C (personal interaction)	C2E (systems for the participation of individual users)
Collective users	E2G (monitoring the quality of the receiving online consultations, information from different users)	E2B (systems for the monitoring of enterprise systems to ensure the participation of geographically remote employees in business processes)	E2C (online platforms for individual users)	E2E (a model for integrating online exchanges so that trading participants can access many exchanges simultaneously from a single point)

Source: compiled by the authors.

2019]. Examples of such groups include producers and consumers of goods and services, consumers of information contained in government information systems, etc.

In our view, the criteria for the existence of a platform business model could be.

- the ease with which new participants can join the platform;
- the ability to attract the necessary number of participants to create a critical mass of users and customers;
- the creation of conditions for exchange and value creation by platform participants.

At the same time, the key success factors for the use of digital platform tools for industrial companies are [Foss, Saebi, 2017; Gatignon et al., 2017; Ronte et al., 2018; Flavián et al., 2019]:

- the ability to create and maintain the company's competitive advantages;
- maintaining the company's strategic positioning;
- the ability to track market changes in consumer preferences, personalise customer needs and meet those needs;
- short time to market;
- cost reduction and more effective control of cost drivers;
- the ability to better train employees and implement effective human resource management systems;
- the ability to monitor competitors' behaviour, market pricing and market shares;
- high quality of service, logistics (as opposed to traditional markets);
- creating new supply chains and improving delivery services;
- high quality website design that meets or exceeds customer expectations;
- the ability to discover the company's virtual consumer market faster.

There are currently many classifications of platform business models, for example segmentation by end-user groups (Table 1).

Next, we will look at the platform business models used by industrial companies.

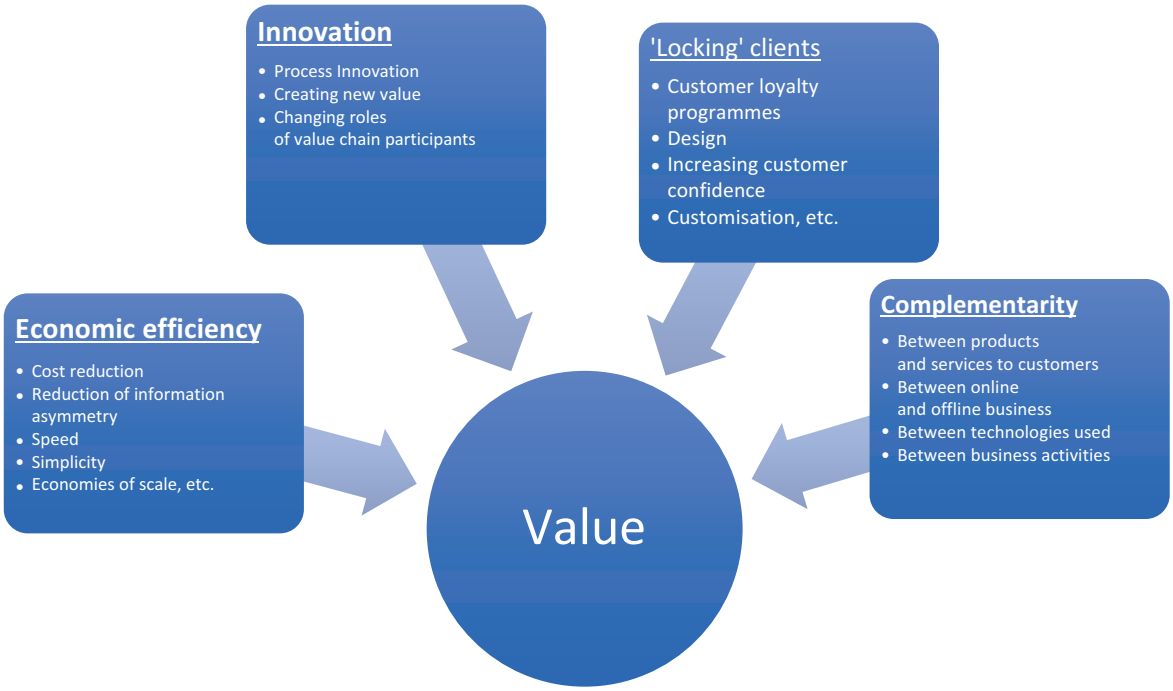
B2C (business-to-consumer) platform business models. On these platforms, businesses interact directly with consumers, usually in the retail sale of goods. The main value that businesses offer to consumers is the simplification

Table 2
Classification of business segments of B2C platform business models for industrial enterprises

Business model	Examples	Description	Revenue model
Internet Portal	Mail.ru Yandex	The resource provides content and the ability to search for content on the site. Services: mail, music, news, video, etc. Positioned by the user's home page	Advertising, subscription, affiliate, sale of goods
Content provider	WSJ.com Vedomosti.ru ESPN.com	Provides users with information, entertainment content, online broadcasts, etc.	Advertising, subscription, affiliate
Brokerage model	Booking.com Kayak.com Hotels.com	Allows users to optimise their search for options based on various parameters	Transactional
New market creation model	Ebay.com Avito.ru Airbnb.com	Companies that use Internet technology to connect potential buyers and sellers	Transactional
Services	Umi.com Renins.ru	Providing various services to users	Selling services
Social media	Vk.com Facebook.com "Odnoklassniki"	Online communities that help users to group together around interests and interact with each other.	Advertising, subscription, affiliate

Source: compiled by the authors.

Fig. 1. Sources of value creation in platform business models



Источник: составлено авторами по [Amit, Zott, 2012].

and acceleration of the purchasing process. The platform allows a company to quickly monitor demand and save on premises and staff. According to experts, the B2C sector is currently the most popular platform business model among industrial companies.

Table 2 shows the segments of industrial companies' platform business models in B2C markets.

Platform e-government models (G2B - Government to Business, between the State and businesses; G2C - Government to Citizen, between the State and citizens; G2E - Government to Employee, between the State and civil servants; G2G - Government to Government, between government agencies). Interaction between government and industry can be mediated through the capabilities of platform business models. Such interaction is commonly referred to as e-government, which is understood as the transformation of the internal and external relationships of government organisations based on the use of platform capabilities to optimise the services provided, increase public participation in public administration issues and improve internal business processes.

The exchange-to-exchange (E2E) platform business model is a model for integrating online exchanges so that trading participants can access many exchanges simultaneously from a single point. E2E companies focus on the interests of the end user: they use modern software to bring together people who want to buy or sell different services. The model focuses on the interests of the individual customer, making quality a key element of the overall equation. The growth of E2E companies is due to the proliferation of smartphones.

Another factor driving the growth of the E2E sector is the fact that consumer sentiment moves at lightning speed. Online media and social networks provide companies with instant feedback. E2E companies have great potential to create value for customers, employees and shareholders by focusing on quality of service.

The B2E (Business-to-Employee) platform business model is an internal corporate system for ensuring the participation of geographically dispersed employees in business processes, based on the creation of various networks. Many industrial companies use such automation networks to provide products and/or services to their employees. Typically, companies use B2E networks to automate corporate HR processes. Examples of B2E applications include online management of insurance policies, distribution of company announcements, online submission of applications to other employees, etc.

Thus, platform business models encompass the following interrelated market segments:

1) the sale of goods and services using ICT (e-commerce);
2) e-procurement;
3) electronic distribution;
4) automation of internal business processes
5) remote customer service;
6) e-mail marketing;
7) creation of a communication environment and information brokerage;

8) providing information and communication infrastructure and electronic interaction.

The sources of value creation for all platform business models are shown in Fig. 1.

The first source is increased efficiency, which occurs primarily by reducing transaction costs, reducing information asymmetry, increasing the speed of transactions, etc. [Lindgren et al., 2010; Kushwaha, Shankar, 2013; King et al., 2020].

The second source is complementarity: the interdependence between products and services for customers (both vertically and horizontally), between types of online and offline businesses, between technologies used and strategies of entrepreneurial activity [Lindgren et al., 2010; Kemp, 2019].

The third source is the so-called locking of customers. It suggests that in the context of the spread of digital platforms, the level of competition between companies increases, and then strategies for 'locking' customers are needed, i.e. the creation of various loyalty programmes for customers, deepening customisation, creating 'happiness' of the customer as a sales driver [Kushwaha, Shankar, 2013; Klimanov, Tretyak, 2014; Klimanov, Tretyak, 2019].

The fourth source is innovativeness. It suggests that achieving leadership in digital platforms requires constant (daily) innovation: in services offered, content, etc. [Lindgren et al., 2010; Palo, Tähtinen, 2013; Hynes, Elwell, 2016].

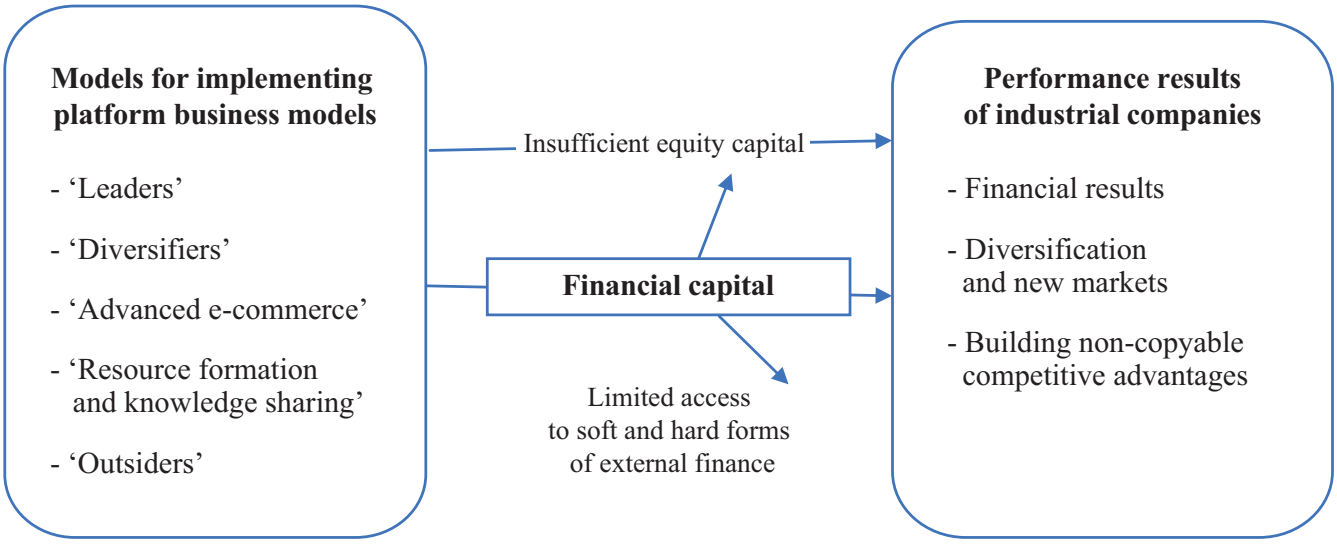
The article examines the implications for industrial companies of implementing different types of platform business models.

2. Research methodology

In the applied research paper 'The Use of Digital Platforms and Digital Financial Assets by Russian Industrial Enterprises under Sanctions Restrictions',[1] the authors identified clusters of industrial enterprises using platform business models and tools as 'leaders', 'diversifiers' and 'extended e-commerce', 'resource formation and knowledge exchange', 'atypical', 'outsiders'. Thus, we include the elements of a business model as signs of cluster identification: strategic, economic, operational and a model for building interaction. At the same time, as shown in the first part of the study, companies can implement several platform models - aimed both at generating income and at developing new competences, open or closed. Since the strategy that generates the highest revenues for companies is when the implementation of platform business models is spun off as a separate business (a new line of business), such strategies are capital intensive. We can therefore assume that access to financial capital is important when developing a specific strategy for using platform business models or their tools.

The developed research model is based on the methodology described in [Trachuk, Linder, 2021] and is tested on 2023 data collected during the period of sanctions imposed on the Russian economy and restrictions on access to resources, including financial capital. The empirical analysis was conducted on a sample of data from 276 industrial enterprises.

Fig. 2. Theoretical model of the study



Source: compiled by the authors.

[1] The use of digital platforms and digital financial assets by Russian industrial enterprises in the context of sanctions restrictions: a report on Research. M., Financial University, 2023.

Table 3
Results of reliability and dependability of measurement models

Measurement models	Cronbach's alpha	Reliability statistics
First-order models		
Performance results of industrial enterprises	from 0.714 to 0.795***	χ^2/df = 1.996; GFI = 0.627; CFI = 0.912; AGFI = 0.669; TLI = 0.749; RMSEA = 0.025
Availability and access to financial capital	0.769–0.812***	
Second-order models		
'Leaders'	from 0.726 to 0.811***	χ^2/df = 1.994; GFI = 0.822; CFI = 0.901; AGFI = 0.879; TLI = 0.934; RMSEA = 0.041
Cost of registering and running your own platform	from 0.711 to 0.876***	
Revenue share from new markets	from 0.735 to 0.884***	
Interaction costs with partners	from 0.749 to 0.825***	
Improving the quality of service	from 0.722 to 0.939***	
'Diversifiers'	from 0.709 to 0.983***	χ^2/df = 1.873; GFI = 0.808; CFI = 0.829; AGFI = 0.849; TLI = 0.962; RMSEA = 0.039
Availability of goods	from 0.731 to 0.873***	
Cost of registering and operating the exchange	from 0.818 to 0.902***	
Cost of developing and launching new products	from 0.779 to 0.895***	
Cost of staff training	from 0.717 to 0.839***	
'Advanced e-commerce'	from 0.714 to 0.944***	χ^2/df = 1.833; GFI = 0.819; CFI = 0.805; AGFI = 0.822; TLI = 0.911; RMSEA = 0.036
Marketing innovation costs	from 0.743 to 0.885***	
Cost of developing and launching new products	from 0.774 to 0.886***	
Number of new products/services launched	from 0.716 to 0.908***	
'Training of resources and skills'	from 0.854 to 0.983***	χ^2/df = 1.917; GFI = 0.842; CFI = 0.854; AGFI = 0.866; TLI = 0.906; RMSEA = 0.042
Cost of staff training	from 0.809 to 0.916***	
Availability of patents	from 0.761 to 0.829***	
Cost of basic research	from 0.779 to 0.889***	
Cost of applied research	from 0.902 to 0.955***	
Cost of developing and launching new products	from 0.889 to 0.942***	
Share of products new to the world	from 0.819 to 0.908***	
'The outsiders'	from 0.828 to 0.915***	χ^2/df = 1.995; GFI = 0.831; CFI = 0.878; AGFI = 0.819; TLI = 0.947; RMSEA = 0.038
Cost of interacting with partners	from 0.889 to 0.926***	
Cost of doing business on platforms	from 0.877 to 0.907***	
Cost of running creative simulations	from 0.819 to 0.948***	

Note. *** – $p < 0.001$.
Source: compiled by the authors.

Table 4
Analysis of reliability and dependability of the variables used in the model

Variable	Cronbach's alpha	Composite reliability	Average variance explained	1	2	3	4	5	6	7
'Leaders'	0.772	0.903	0.64	**0.64**						
'Diversifiers'	0.751	0.759	0.76	0.11	**0.76**					
'Advanced e-commerce'	0.829	0.803	0.78	0.23	0.294	**0.78**				
'Creating resources and sharing knowledge'	0.911	0.937	0.61	0.17	0.019	0.029	**0.61**			
'The outsiders'	0.849	0.884	9.59	0.09	0.008	0.017	0.059	**0.59**		
Financial capital	0.629	0.617	0.63	0.31	0.308	0.207	0.113	0.169	0.63	
Performance results	0.819	0.684	0.74	0.34	0.054	0.048	0.079	0.134	0.109	**0.74**

Source: compiled by the authors.

2.1. The influence of financial capital on the implementation of platform business models in the activities of industrial companies

Financial capital is the most important resource for implementing development strategies and therefore for choosing a strategy for implementing platform business models. The availability of and access to financial capital allows you to diversify your business and open up new areas of development using platform models. For example, for 'leaders', this strategy allows them to register their own marketplaces (usually industry-specific ones for B2B markets) and generate income not only from selling their products, but also from owning the marketplace assets. For 'diversifiers', the availability of and access to financial capital provides the opportunity to introduce digital platforms for the development of many non-core activities. Owners of exchange-traded commodities have the opportunity to develop their own exchange platforms.

According to the results of the survey, industrial companies expect the following effects from the implementation of platform business models:

- the opportunity to build and maintain the company's competitive advantage (87% of respondents);
- maintaining the company's strategic positioning (34%);
- the opportunity to track market changes in consumer preferences, personalise customer needs and meet those needs (54%);
- reduced time to market (23%);
- cost reduction and more effective control of cost drivers (47%);
- the opportunity to better train employees and implement effective human resource management systems (91%);
- the opportunity to monitor competitors' behaviour, market pricing and market shares (44%);
- high quality of service and logistics (as opposed to traditional markets) (67%);
- creating new supply chains and improving delivery services (62%);
- high quality website design that meets or exceeds customer expectations (28%);
- the opportunity to discover the company's virtual consumer market more quickly (14%).

We therefore group the expected impact of digital platform adoption into three areas:

- improving financial performance;
- business diversification and entry into new markets;
- the creation of non-copyable competitive advantages (knowledge and skills).

Therefore, the following hypotheses can be made.

Hypothesis 1: The financial performance of industrial companies depends on the model of platform business model implementation, while the use of a combination of platform implementation models help achieve the highest possible performance results.

Table 5
Descriptive statistics and correlation matrix

Variables	Average	Standard deviation	Minimum value	Maximum value	1	2	3	4	5	6	7	8	9
Performance results	6.28	1.03	1	7	1								
Access to financial capital	6.54	1.09	4.23	6.95	0.639	1							
Company size	5.09	1.22	1.49	6.3	0.74	0.187	1						
Company age	6.79	1.26	1.23	10.2	–0.044	0.105	0.148	1					
‘Leaders’ (L)	5.74	1.11	1.03	7.47	0.036	0.139	0.084	0.039	1				
‘Diversifiers’ (D)	4.98	1.32	0.01	4.78	0.407	0.438	0.217	0.439	0.509	1			
‘Advanced e-commerce’	4.54	1.35	1.02	7.05	0.502	0.519	0.377	0.156	0.472	0.442	1		
‘Resource Formation and Knowledge Exchange’	2.37	1.28	1.04	6.99	0.278	0.212	0.274	0.103	0.513	0.567	0.372	1	
‘Outsiders’ (O)	3.29	1.74	1.03	7.12	0.179	0.198	0.182	0.116	0.438	0.471	0.589	0.43	1

Note. $n = 648$; ** – $p < 0{,}05$.
Source: compiled by the authors.

Hypothesis 2: Financial capital has a significant positive effect on the diversification of the core business and the entry into new markets, which ensures higher financial performance.

As described in the methodology [Trachuk, Linder, 2021], we will consider two types of restrictions on access to financial capital: in a soft form, when the rate of return from the company’s activities is lower than the interest rate on loans, and in a hard form, which assumes that the company does not have access to the credit market.

The theoretical research model developed is presented in Fig. 2.

2.2. Research variables

Three groups of indicators were used as dependent variables, each scored on a 7-point scale where 1 - the indicator has significantly decreased, 4 - the indicator has not changed, 7 - the indicator has significantly increased:

- indicators of financial performance: turnover, profitability of sales;
- indicators of the creation of non-copyable competitive advantages: revenue from sales of new products, presence of investment in research and development, presence of patents;
- indicators of diversification and entry into new markets: market share, number of new markets/ segments, increase in customer value.

Subjective indicators of performance are often used in management research because objective results vary widely across industries, while subjective indicators reflect the dynamics of change from the perspective of management. Furthermore, the correlation between subjective and objective assessments has been confirmed. The use of

Table 6
Relationship between financial capital, the application pattern of the platform business model and performance results on a general sample of industrial enterprises. Results of the analysis

Research variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Control variables						
Costs of creating and operating platform business models	0.0059*** (0.0022)	0.0089*** (0.0027)	0.0069*** (0.0017)	0.0079*** (0.0033)	0.0073*** (0.0021)	0.0088*** (0.0013)
Costs of transforming business processes	0.0066*** (0.0024)	0.0067*** (0.0038)	0.0095*** (0.0026)	0.0069*** (0.0019)	0.0097*** (0.0026)	0.0079*** (0.0021)
Costs for cloud services and data centers	0.0058*** (0.0013)	0.0074** (0.0029)	0.0099*** (0.0035)	0.0088*** (0.0019)	0.0052*** (0.0018)	0.0116*** (0.0014)
Costs of technological innovation	0.0083*** (0.0018)	0.0065*** (0.0017)	0.0072*** (0.0021)	0.0084*** (0.0032)	0.0093*** (0.0018)	0.0059*** (0.0033)
Education	0.0031*** (0.0017)	0.0054*** (0.0018)	0.0049*** (0.0026)	0.0052*** (0.0015)	0.0073*** (0.0019)	0.0046*** (0.0028)
Marketing innovation expenses	0.0054*** (0.0016)	0.0068** (0.0022)	0.0027*** (0.0027)	0.0042** (0.0037)	0.0053 (0.0014)	0.0079*** (0.0019)
Company size	0.0028*** (0.0011)	0.0034*** (0.0009)	0.0029*** (0.0015)	0.0037*** (0.0016)	0.0041 (0.0023)	0.0016*** (0.0014)
Company age	–0.0124** (0.0051)	–0.0153*** (0.0069)	–0.0125** (0.0075)	–0.0167*** (0.0063)	–0.0183*** (0.0082)	–0.0195** (0.0091)
Financial capital	0.0297*** (0.0032)	0.0213*** (0.0052)	0.0199*** (0.0037)	0.0187*** (0.0028)	0.0171*** (0.0035)	0.0224*** (0.0041)
Revenue from export activities	0.0153*** (0.0028)	0.0149*** (0.0037)	0.0191*** (0.0044)	0.0176*** (0.0045)	0.0173*** (0.0048)	0.0184** (0.0014)
Economic sectors	Incl	Incl	Incl	Incl	Incl	Incl
Key Variables						
'Leaders' (L)		0.0129*** (0.0047)	0.0148*** (0.0061)	0.0139*** (0.0052)	0.0146*** (0.0057)	0.0169*** (0.0046)
'Diversifiers' (D)		–0.0008*** (0.0048)	–0.0026*** (0.0044)	–0.0081*** (0.0052)	–0.0069*** (0.0065)	–0.0038*** (0.0075)
'Advanced e-commerce'		0.0158*** (0.0024)	0.0136*** (0.0021)	0.0178*** (0.0032)	0.0151** (0.0039)	0.0191*** (0.0057)
‘Formation of resources and exchange of knowledge’		–0.0024*** (0.0022)	–0.0059*** (0.0031)	–0.0093*** (0.0042)	–0.0086*** (0.0037)	–0.0046*** (0.0016)
'Outsiders' (O)		0.1067*** (0.0026)	0.0182*** (0.0035)	0.0174** (0.0028)	0.0198*** (0.0026)	0.0106** (0.0044)
Double cross variable						
L × D			–0.0217*** (0.055)			–0.0012*** (0.0033)
D × 'Advanced e-commerce'				–0.0162*** (0.0029)		–0.0071*** (0.034)
L × 'Advanced e-commerce'					–0.0179*** (0.0082)	–0.0167*** (0.0059)
Triple cross variable						
L × D × 'Advanced e-commerce'						–0.0068*** (0.0037)
Constant	1.442*** (0.351)	2.589** (0.475)	2.981*** (0.644)	3.058 *** (0.392)	2.533*** (0.489)	3.062*** (0.358)
F-statistics	42.12***	38.17***	29.87***	34.83***	35.28***	31.56***
R^2 corrected	0.18	0.15	0.16	0.15	0.18	0.17

Note. $n = 648$; Standard errors are given in brackets; *** – $p < 0{,}001$; ** – $p < 0{,}05$; * – $p < 0{,}10$.
Source: compiled by the authors.

subjective indicators is therefore justified and can be considered reliable.

Independent variables: assignment of industrial companies to a particular cluster according to the type of platform solutions implementation model.

Based on the results of the study[2], industrial companies were classified into five clusters: 'leaders', 'diversifiers', 'advanced e-commerce', 'resource formation and knowledge sharing', 'outsiders'.

Control variables: The performance of industrial companies varies significantly according to industry, company size and age, and these parameters are used as control variables. The industry variable is treated as a binary variable, equal to 1 if the enterprise belongs to this industry and 0 otherwise[3]. The age of an enterprise is measured by the number of years it has been in existence and its size by the number of average employees. All variables are transformed using the natural logarithm, which allows the assumptions of normal distribution to be met.

2.3. Empirical research results

As described in the methodology [Trachuk, Linder, 2021], the data must first be analysed for reliability and validity using the method of confirmatory factor analysis (CFA). The results of this analysis are presented in Table 3.

The significance of the variables used is confirmed by Cronbach's alpha, whose threshold must be at least 0.7. In our case, all the variables have values between 0.709 and 0.983, which confirms the reliability of the measurements. As shown in [Trachuk, Linder, 2021], it is also necessary to assess the consistency of the second-order component variables using the average variance explained (AVE)[4], the threshold value of which must exceed 0.5. For all variables, the value was higher than the normative value. The results are presented in Table 4.

It is also necessary to use the Harman test to analyse the data, since the variables were obtained using the subjective opinions of the same respondents. The results of the test showed the presence of seven principal components with values greater than 1, none of which accounted for more than 50% of the variance. Therefore, it can be said that there is no general assessment of bias. The values of all variables were calculated as the arithmetic mean of the responses to the question. For the clusters based on the platform business model application model, the averages for each dimension were calculated first, and then the average for the constituent elements. The results are shown in Table 5.

Correlation analysis revealed a fairly high correlation between the models of innovative behaviour: 'leaders' and 'diversifiers'; 'diversifiers' and 'advanced e-commerce', 'advanced e-commerce' and 'outsiders'. There is no correlation between other models of innovative behaviour. Therefore, to reduce the problem of multicollinearity, double and triple crossover variables were included in the model.

In the second stage, linear regression was used to analyse the relationships between patterns of platform business model adoption, restrictions on access to capital and firm performance. The empirical study involved a step-by-step analysis:

- in the first stage (Model 1): the analysis of the basic model and the control variables;
- in the second stage (Model 2): the analysis of the basic model and the direct effects of the choice of model for the use of platform business models ('leaders', 'diversifiers', 'advanced e-commerce', 'resource and competence formation', 'outsiders');
- in the third stage (Models 3-5): the analysis of double cross effect ('leaders' and 'diversifiers' (Model 3), 'diversifiers' and 'extended e-commerce' (Model 4), 'leaders' and 'advanced e-commerce' (model 5);
- in the fourth stage (Model 6): the analysis of the triple cross effect ('leaders', 'diversifiers' and 'extended e-commerce').

In order to ensure the absence of multicollinearity in the models constructed, we used the variance inflation factors (VIFs) according to the specified methodology; in all cases their value did not exceed 6.8 (with a standard of 10), therefore there is no multicollinearity in the models studied. The results of the analysis are presented in Table. 6.

As the results of the analysis show, the best results are achieved by companies that choose the 'leaders' ($b = 0.0129$, $p < 0.05$), 'diversifiers' ($b = 0.0158$, $p < 0.05$), 'extended e-commerce' ($b = 0.0167$, $p < 0.05$). At the same time, 'advanced e-commerce' achieves the greatest results when the platform operates in international markets and companies have revenues from export activities, i.e. they operate on an international platform. The increasing cost of marketing innovation is encouraging companies to choose more profitable models for building platform business models – 'leaders' and 'diversifiers'. Investments in new technologies and equipment (data centres) stimulate the introduction of new platform solutions and have a greater impact on companies' diversification and entry into new markets. The choice of the 'advanced e-commerce' model has a negative impact on diversification and entry into new markets, but a stronger positive relationship with the financial performance of industrial enterprises. Industry specifics have an impact on the choice of platform business model only for 'leaders' and 'diversifiers'. The result of testing Models 3-5 indicates a negative relationship between the combination of platform solution models and performance results ($L \times D$: $b = –0{,}0217$, $p < 0{,}10$; $D \times$ 'advanced e-commerce': $b= –0{,}0162$, $p<0{,}05$; $L \times$ 'advanced e-commerce': $b = –0{,}0179$, $p < 0{,}10$). The effects of the triple combination of models for adopting platform business models do not affect the performance of

[2] The use of digital platforms and digital financial assets... 2023.

[3] Classification of industries: food production, including beverages, and tobacco; textile and clothing production; leather, leather products and footwear production; wood processing and production of wood products; pulp and paper production; publishing and printing activities; chemical production; production of rubber and plastic products; production of other non-metallic minerals products; metallurgical production and production of finished metal products; production of machinery and equipment; manufacture of electrical, electronic and optical equipment; manufacture of vehicles and equipment; production and distribution of electricity, gas and water; exploration and mining.

[4] Calculated using the formula: sum of squares of standardized loads / (sum of squares of standardized loads + sum of measurement errors).

industrial enterprises (when analysing the whole sample - Model 6). Accordingly, focusing a company on one or two types of implementation of platform solutions gives more significant results than following mixed strategies.

This confirms our first hypothesis. The chosen type of platform solution implementation model does influence the performance of industrial companies.

The second hypothesis - about the influence of financial capital - is also confirmed, and its presence has a statically significant positive effect with the maximum level of significance ($b = 0.0297$, $p < 0.05$).

3. Conclusions and future research

The study shows that access to financial capital is a strategically important resource that influences the implementation of platform business models and the performance of industrial firms. The research presented provides a new perspective on the relationship between the chosen model/combination of platform solution models and the performance of industrial firms in the context of sanctions-related restrictions on access to financial capital.

The empirical analysis carried out allowed us to draw the following conclusions. The choice of 'leaders', 'diversifiers' and 'extended e-commerce' models has the greatest impact on financial performance when these companies operate on international platforms. The choice of the 'leaders' and 'diversifiers' models also has the greatest impact on diversification and entry into new markets, while the choice of the 'advanced e-commerce' model prevents the creation of new markets. The choice of one or the other model for implementing platform solutions is influenced (with the highest level of significance) by the availability and access to financial capital of industrial companies.

The results obtained are of practical value for managers of industrial companies, business owners and entrepreneurs and indicate the need to allocate resources to the implementation of platform business models, even in conditions of limited access to financial capital.

A limitation of this study is the subjective nature of the respondents' assessments. In the future, it would be possible to use objective data in studies and compare the results obtained. In addition, this study was conducted on a sample of industrial companies; the analysis could be extended to other industries in the future.

References

Klimanov D., Tretyak O. (2014). Business models: Major research directions and search of conceptual foundations. *Russian Management Journal,* 12(3), 107-130. (In Russ.)

Trachuk A.V., linder N.V. (2021). The impact of financial capital on innovative behavior of industrial companies. *Finance: Theory and Practice,* 25(1): 51-69. https://doi.org/10.26794/2587-5671-2021-25-1-51-69. (In Russ.)

Amit R., Zott C. (2012). Creating value through business model innovation. *MIT Sloan Management Review,* 53(3): 41-49.

Arora P. (2019). *The next billion users: Digital life beyond the West.* Cambridge, MA, Harvard University Press.

Chakravorti B., Bhalla A., Chaturvedi R. (2017). 60 countries' digital competitiveness, indexed. *Harvard Business Review,* July. https://hbr.org/2017/07/60-countries-digital-competitiveness-indexed.

Chakravorti B., Chaturvedi R.S. (2018). *Digital planet 2017: How competitiveness and trust in digital economies vary across the world. Medford,* MA, Tufts University. https://sites.tufts.edu/digitalplanet/dei17/, дата обращения 08.07.2021.

Dabbs G., Rickwood S., Smith A., Wooden C. (2018). *Channel preference versus promotional reality.* IQVIA White Paper. Durham, NC, IQVIA. https://www.iqvia.com/-/media/iqvia/pdfs/library/white-papers/channel-preference-versus-promotional-reality.pdf.

Ehret M., Kashyap V., Wirtz J. (eds.) (2013). Business models: Impact on business markets and opportunities for marketing research. *Industrial Marketing Management,* 42(5): 649-655. https://doi.org/10.1016/j.indmarman.2013.06.003.

Evans S., Vladimirova D., Holgado M., Van Fossen K., Yang M., Silva E.A., Barlow C.Y. (2017). Business model innovation for sustainability: Towards a unified perspective for creation of sustainable business models. *Business Strategy and the Environment,* 26(5): 597-608. https://doi.org/10.1002/bse.1939.

Flavián C., Ibáñez-Sánchez S., Orús C. (2019). The impact of virtual, augmented and mixed reality technologies on the customer experience. *Journal of Business Research,* 100: 547-560. https://doi.org/10.1016/j.jbusres.2018.10.050.

Foss N.J., Saebi T. (2017). Fifteen years of research on business model innovation: How far have we come, and where should we go? *Journal of Management,* 43(1): 200-227. https://doi.org/10.1177%2F0149206316675927.

Gatignon H., Lecocq X., Pauwels K., Sorescu A. (2017). A marketing perspective on business models. *Academy of Marketing Science,* 7(3-4): 85-89. https://doi.org/10.1007/s13162-017-0108-5.

Hynes N., Elwell A.D. (2016). The role of inter-organizational networks in enabling or delaying disruptive innovation: A case study of mVoIP. *Journal of Business and Industrial Marketing,* 31(6): 722-731. https://doi.org/10.1108/JBIM-10-2012-0168.

Keen P., Qureshi S. (2006). *Organizational transformation through business models: A framework for business model design.* 39th Annual Hawaii International Conference on System Sciences, 4-7 January 2006, Kauai, HI, USA. DOI: 10.1109/HICSS.2006.376.

Kemp S. (2019). *Digital 2019: Global Internet use accelerates.* London, We Are Social. https://wearesocial.com/blog/2019/01/digital-2019- global-internet-use-accelerates, дата обращения 08.07.2021.

King A., Mcdermott J., Kulkarni A., Bansal N. (2020). *Reflecting and reframing: Assessing the impact of COVID-19 on strategic plans & programs and paving the path forward.* Washington, DC, IPSOS Global Advisor. https://www.ipsos.com/sites/default/files/ipsos-research- opportunities-for-reframing-plans-against-covid.pdf.

Klimanov D., Tretyak O. (2019). Linking business model research and marketing: New network-based approach to business model analysis. *Journal of Business and Industrial Marketing,* 34(1): 117-136. https://doi.org/10.1108/JBIM-12-2017-0330.

Kushwaha T., Shankar V. (2013). Are multichannel customers really more valuable? The moderating role of product category characteristics. *Journal of Marketing,* 77(4): 67-85. https://doi.org/10.1509%2Fjm.11.0297.

Leischnig A., Ivens B.S., Kammerlander N. (2017). A new conceptual lens for marketing: A configurational perspective based on the business model concept. *AMS Review,* 7(3-4): 138-153. https://doi.org/10.1007/s13162-017-0107-6.

Lindgren P., Taran Y., Boer H. (2010). From single firm to network-based business model innovation. *International Journal of Entrepreneurship and Innovation Management,* 12(2): 122-137. DOI: 10.1504/IJEIM.2010.034417.

Nenonen S., Storbacka K. (2010). Business model design: Conceptualizing network value co-creation. *International Journal of Quality and Service Sciences,* 2(1): 43-59. https://doi.org/10.1108/17566691011026595.

Palo T., Tähtinen J. (2013). Networked business model development for emerging technology-based services. *Industrial Marketing Management,* 42(5): 773-782. https://doi.org/10.1016/j.indmarman.2013.05.015.

Robertson T.S. (2017). Business model innovation: A marketing ecosystem view. *AMS Review,* 7(3-4): 90-100. https://doi.org/10.1007/ s13162-017-0101-z.

Ronte H., Taylor K., Haughey J. (2018). *Medtech and Internet of Medical Things: How connected medical devices are transforming healthcare.* London, Deloitte Centre for Health Solutions.

Rust R.T. (2020). The future of marketing. *International Journal of Research in Marketing,* 37(1): 15-26. https://doi.org/10.1016/j. ijresmar.2019.08.002

Schneider S., Spieth P. (2013). Business model innovation: Towards an integrated future research agenda. *International Journal of Innovation Management,* 17(1): 1-34. https://doi.org/10.1142/S136391961340001X.

Sharma A., Mehrotra A. (2007). Choosing an optimal channel mix in multichannel environments. *Industrial Marketing Management,* 36(1): 21-28. https://doi.org/10.1016/j.indmarman.2006.06.012.

Teece D.J. (2010). Business models, business strategy and innovation. *Long Range Planning,* 43(2-3): 172-194. https://doi.org/10.1016/j. lrp.2009.07.003.

Velu C. (2016). Evolutionary or revolutionary business model innovation through coopetition? The role of dominance in network markets. *Industrial Marketing Management,* 53: 124-135. https://doi.org/10.1016/j.indmarman.2015.11.007.

Yang M., Evans S., Vladimirova D., Rana P. (2017). Value uncaptured perspective for sustainable business model innovation. *Journal of Cleaner Production,* 140: 1794-1800. https://doi.org/10.1016/j.jclepro.2016.07.102.

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Analysis of key directions and proposals to minimise the economic impact of the global energy transition on large energy-intensive industrial consumers of electricity and capacity

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Abstract

Over the past decade, the global energy sector has undergone major fundamental and structural changes as part of the global energy transition. The energy industry of the Russian Federation, as a key player in the global energy market and the world economy as a whole, is undergoing similar changes. In this case, in terms of ensuring high competitiveness and long-term energy security of the state, it is crucial to set priorities and build models of sustainable development for each of the industries related to the energy sector. Indeed, the process of replacing carbon-intensive energy sources with a systematic increase in the share of new, renewable energy sources (RES) should be gradual and consistent to avoid imbalances in energy systems and maintain equity for all stakeholders. In this context, the search for advanced, low-carbon energy sources is a priority for the vast majority of countries around the world. In addition, the development of renewable energy is one of the goals of Russia's energy strategy until 2035. At the same time, despite the obvious advantages of the Russian power industry such as the absence of dependence on budget funds, the overwhelming majority of private investment in the industry, the availability of effective mechanisms for attracting investment and the basic principle of balancing the interests of all market participants, there are also negative consequences of this approach. The nationwide task of developing the energy system and increasing the availability of electricity on the territory of the Russian Federation in terms of financing is becoming an exclusive burden on electricity consumers themselves; even insignificant risks in their operation can turn into a threat not only to sustainable development, but also to their very existence. In this context, the analysis of key directions and proposals to minimise the economic impact of the global energy transition on large energy-intensive industrial consumers of electricity and capacity is of particular relevance.

Keywords: global energy transition, mechanisms to stimulate investment, low-carbon generation, activities to minimise economic impact.

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大型能源密集型工业用户的全球能源转型重点领域分析与尽量减少经济影响的建议

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摘要
最近十年中作为全球能源转型的一部分，全球能源行业经历了重大的根本性结构变革。作为全球能源市场和整个世界经济的主要参与者之一，俄罗斯联邦的能源工业也面临着类似的变化。优先考虑并建立各能源相关产业的可持续发展模式，对于确保国家的高竞争力和长期能源安全至关重要。应逐步取代传统的高碳排放化石资源（主要是石油产品和煤炭），同时系统地增加新的可再生能源（RES）的比例。尤其重要的是，这一过程必须顺序进行，以避免能源系统失衡，并避免破坏所有参与者的利益平衡。
目前寻找先进的、碳密集度最低的能源是世界上绝大多数国家的优先事项。此外，俄罗斯能源战略的目标之一是发展可再生能源：计划到 2035 年投资超过 1 万亿卢布发展可再生能源。俄罗斯电力工业优势明显：不依赖预算资金、该行业绝大多数为私人投资、存在吸引投资的有效机制以及平衡所有市场参与者利益的基本原则。然而，这种方法的弊端也很大：在俄罗斯联邦，发展能源系统和增加电力供应的国家任务正成为电力消费者自身的唯一负担，在更大程度上，成为能源密集型大消费者的融资负担。同时，即使是很小的风险也可能不仅威胁到可持续发展，而且威胁到它们的整体生存。
因此，大型能源密集型工业用户的全球能源转型重点领域与尽量减少经济影响的建议分析非常有意义。
关键词：全球能源转型、吸引投资的机制、低碳发电、尽量减少经济影响的工具。

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Introduction

In order to analyse the key directions and proposals for minimising the economic consequences of the global energy transition for large energy-intensive industrial consumers of electricity and capacity, it is necessary to determine the basic conditions of the upcoming energy transition. They will provide the basis for setting the direction for reducing the additional economic burden on energy-intensive industrial consumers associated with the inevitable increase in electricity prices:

1. Major decarbonisation projects will be more expensive and their feasibility will depend heavily on the market value of emissions.
2. In the power sector, the decarbonisation process has two distinct phases. In the first phase, projects are being implemented to convert coal-fired power plants to gas combustion and to replace old generation with lower carbon footprint capacity (NPP, HPP, SPP, WPP). The second stage involves the intensive replacement of fossil fuel-fired generation with carbon-free one. The commissioning of this capacity is a major contributor to the increase in the cost of electricity to end users [Lee, 2026].
3. The decarbonisation of Russia's power industry is inevitable; it has already begun and will continue.
4. Large electricity intensive consumers are most exposed to the negative impact of electricity price increases. If all energy construction and reconstruction plans in the generation sector are implemented, by 2035 the single price in the wholesale electricity and capacity market will increase by 80%, calculated in 2023 prices.[1]
5. The financial burden on electricity consumers from the increase in electricity prices correlates with the share of electricity costs in their production costs.

The task of minimising the economic impact is defined, taking into account the specified conditions.

Before formulating and systematising the main directions of solving the problem of minimising the economic consequences for large energy-intensive consumers in Russia, it is important to note that the valorisation of greenhouse gas emissions and,

[1] Publication of actual and forecast values of the unregulated single-rate price for electricity and capacity for the wholesale market buyers for the period 2011–2035. https://www.np-sr.ru/ru/announce/50135-o-publikacii-fakticheskih-i-prognoznyh-znacheniy-nereguliruemoy-odnostavochnoy-ceny.

accordingly, the transformation of emissions into an additional element of production costs will be formed with the formation of the global emissions trading system. This process inevitably leads to an increase in costs for all manufacturers, i.e. to the growth of the global average cost of production [Marku, 2021].

However, there will be significant competitive advantages result for manufacturers in those countries where the cost of emitting 1 tonne of CO_2-equivalent emissions in their national emissions trading systems will be below the global average [Daumas, 2021].

The key global drivers of these benefits are as follows:

- access to significant primary energy resources for the production of electricity with no carbon footprint (or with a carbon footprint many times lower than conventional technologies): water, wind, solar energy;
- access to modern high-efficiency technologies enabling the implementation of projects for the production, transmission, storage, and efficient consumption of 'decarbonised' electricity (including access to nuclear and thermonuclear technologies);
- availability of significant forest areas that absorb CO_2;
- access to industrial CO_2 capture and absorption technologies and their economically viable deployment.

With regard to the Russian Federation, the following factors should be taken into account:

- availability of significant hydropower potential: according to the Energy Strategy of the Russian Federation for the period up to 2035, the hydropower potential of the Russian Federation is about 9 per cent of the world's potential;
- availability of indigenous and competitive nuclear power generation technologies;
- availability of large woodlands, particularly in Siberia and the Far East.

Thus, the effective use of the above-mentioned potential advantages, as a result of the expected energy transition, allows us to assert that the competitiveness of most Russian energy-intensive producers on the international markets will not decrease, but, on the contrary, will increase [Kodaneva, 2022].

At the same time, industrial energy-intensive consumers with access to relatively cheap sources of 'clean' energy will be the best position.

So, the key directions for solving the problem of minimising the economic burden for large electricity intensive consumers in Russia at the state and corporate level are as follows:

- encouraging access to modern technologies for participants in economic activity;
- formation (at the state level) of effective incentives for participants of economic activity to implement sustainable development programmes;
- development of effective regulatory policy methods;
- formation of effective strategic decisions by electricity intensive consumers themselves.

The correct choice of methods of state regulatory policy and corporate strategies, as well as the use of already implemented market mechanisms of power and capacity trading, will significantly reduce the economic burden of the intensive transformation of the Russian electric power industry. Thus, it will facilitate the process of adaptation to the changing conditions of economic activity.

1. Directions for minimising economic impacts at the state level: stimulation of technology development, regulatory policy, investment attraction and business community activity

1.1. State regulatory policy in planning and implementation of the energy transition programme

As noted above, an important factor determining the conditions and opportunities for effective adaptation of large energy-intensive consumers to changes in the business environment caused by the energy transition is the regulatory policy of the state.

The first step is to improve approaches to influencing the price of electricity for large energy-intensive consumers.

Decarbonisation affects all types of economic activity of the state without exception, and the goal of the process is the consistent achievement of certain emission levels and the formation of optimal (in terms of decarbonisation costs and their impact on the cost of goods produced in Russia) measures in the aggregate for all participants of economic activity.

This approach makes it possible to secure consistent results without 'overachieving' in certain sectors of the economy, especially those whose costs are included in the price of products and services for consumers in Russia, such as the electricity industry.

In practice, such a mechanism is proposed to be implemented in the system of inter-sectoral balancing of plans to reduce greenhouse gas emissions and improve energy efficiency, which allows the 'decarbonised' investments of energy producers to be shifted to the right along the time axis. The bonus in this process is the improvement and decreasing cost of RES technologies over time and the resulting reduction in investment costs.

In mathematical terms, the problem can be described by the following expression:

$$T_{gov} - \sum_{i=1}^{n} T_{ni} = \sum_{j=1}^{k} T_{Ej}, \quad (1)$$

where T_{gov} is the state's commitment (in a specific time period) to reduce emissions, $\sum_{i=1}^{n} T_{ni}$ is plans of business community and other consumers (in a specific time period) to reduce emissions, $\sum_{j=1}^{k} T_{Ej}$ is assignment to energy consumers (in a specific time period) to reduce emissions.

As an example of the need for cross-sectoral balancing of GHG mitigation plans, as well as the need for related methodological and accounting measures, we should consider the potential of the Russian forestry sector in terms of its impact on CO_2 emission reductions.

According to the all-Russian organisation Roslesinforg[2], which specialises in the integrated solution of forest inventory tasks in the interests of the state, the leading regions in terms of the volume of carbon dioxide absorption by forests (annual values of emission absorption) are:

- Irkutsk Oblast – 148.6 million tonnes;
- Krasnoyarsk Krai – 114.2 million tonnes;
- Komi Republic – 60.7 million tonnes;

[2] Leading regions in terms of carbon dioxide absorption by forests. https://roslesinforg.ru/.

Table 1
Emission targets for Russian oil and gas companies

Company	Target corporate benchmarks	Target year for achieving carbon neutrality
Gazprom	A 26–30% reduction in carbon intensity by 2030 from 2019 levels	n/a
Rosneft	Reducing emissions and carbon intensity of production by 30% from 2019 by 2035, avoiding 20 million tonnes of CO_2 emissions equivalent (t CO_2e)	Carbon neutrality by 2050
Lukoil	Reducing CO_2 emissions by 10 million tonnes from 2017 levels by 2030, equivalent to a 20% reduction in carbon intensity	Carbon neutrality by 2050
Gazprom Neft	Complete cessation of associated gas flaring by 2030 and reduce Scope 1 and 2 emissions by 30% to approximately 20.2 million tonnes CO_2e, reducing carbon intensity by one third	n/a
Novatek	A 6% reduction in carbon intensity from 2019 levels in mining, a 5% reduction in LNG production, a 20% reduction in air pollution and a 4% reduction in methane emissions	n/a
Tatneft	Reducing Scope 1 emissions from 2016 levels: 10% by 2025 and 20% by 2030	Carbon neutrality by 2050
TMK	Reducing CO_2e emissions by 8% from 2020 levels by the end of 2023	n/a
Transneft	Reducing relative emissions by 0.7% in 2021 by implementing a number of technical measures; developing medium- and long-term GHG emission reduction targets	n/a

Table 2
Emission targets for Russian mining and metallurgical companies

Company	Target corporate benchmarks	Target year for achieving carbon neutrality
Evraz	Reducing carbon intensity by 20% (t CO_2e/t steel; GHG emissions of Evraz's Scope 1 and 2 steelmaking facilities) by 2030 compared to 2019 levels	n/a
NLMK	Reduction of carbon intensity by 1% by 2023 from 2018 levels (kg per tonne of steel)	n/a
Rusal	Reducing direct GHG emissions from existing aluminum plants by 15% from 2014 levels by 2025. 10% reduction for alumina plants. Achieving an average level of direct and indirect GHG emissions of no more than 2.7 t CO_2e per tonne of aluminum (target achieved in 2017). Reducing GHG emissions En+ (scope 1+2) by at least 35% by 2030 compared to 2018	n/a
Severstal	Reducing carbon intensity by 10% by 2030 (–3% by 2023) from 2020 levels (per tonne of steel)	n/a
MMK	Reducing Scope 1 and 2 CO_2 emissions by 15% to 22.9 million tonnes by 2025; reducing carbon intensity to 1.8 tonnes CO_2/tonne of steel by 2025 from 2019 levels (–15%)	n/a
Metalloinvest	Reducing direct and indirect 'energy' GHG emissions from 2019 levels by 2025 by 1.8%, reducing indirect 'non-energy' GHG emissions by 25% from 2019 levels; reducing direct GHG emissions by 15% from 2019 levels by 2036	n/a
Nornickel	Reducing carbon intensity by 23–29% (coverage 1 and 2) from 2020 levels by 2030; achieving GHG emissions of less than 10 million tonnes of CO_2e with a 30–40% increase in production	Carbon neutrality by 2060
Polus	The calculation of Scope 1 and 2 emissions is ongoing; the goal to reduce carbon intensity by 15% by 2020 compared to 2015 levels has been met (actual reduction to 2018 levels was 28%). In 2021, a Scope 3 emissions assessment should be completed and a climate strategy including decarbonisation targets should be developed	n/a
Petropavlovsk	Formalising medium and long term GHG emission reduction targets	n/a

– Perm Krai – 47 million tonnes;
– Khanty-Mansiysk Autonomous Okrug – 45.3 million tonnes.

It should be noted that the annual volume of emissions from coal-fired power plants in Russia is comparable to the absorption capacity of the forests in Irkutsk Oblast alone.

Russia has more than 20% of the world's forests, according to various estimates, ranging from 815 million hectares[3] to 897 million hectares.[4]

It is important to note the lack of reliable data on Russia's forest reserves, even from government authorities. For example, according to the Accounts Chamber of the Russian Federation for 2020, more than 84% of the data on Russia's forests (areas and reserves) have no reason to be considered reliable.

In addition, only so-called managed forests (where accounting and fire protection are organised) are recognised as having a positive effect on the climate. In Russia, hundreds of millions of hectares of forest are unmanaged.[5]

Therefore, in addition to the contribution of forestry to the reduction of greenhouse gas emissions in the cross-sectoral balance, one of the key factors that can facilitate the adaptation of large energy-intensive consumers to the consequences of the energy transition by reducing the overall carbon footprint of their products, is the implementation of so-called NBS

[3] FAO (2020) Interactive Report "Forest resources assessment" https://www.fao.org/3/ca8753ru/CA8753RU.pdf.
[4] National inventory report on anthropogenic emissions by sources and absorption of greenhouse gases not controlled by the Montreal Protocol for 1990–2019.
[5] National anthropogenic greenhouse gas emissions inventory report 1990-2019. Section 6.4.1. 'Forest lands'.

Table 3
Emission targets for Russian fertiliser producers and chemical industry companies

Company	Target corporate benchmarks	Target year for achieving carbon neutrality
Sibur	Reducing carbon intensity in gas production to 0.236 t CO_2e/tonne of product by 2025; in petrochemicals – to 1.54 t CO_2e/tonne	n/a
Akron	n/a	n/a
PhosAgro	A 14% reduction in Scope 1,2 and 3 emissions by 2028 from 2018 levels, a 30.9% reduction in Scope 1 emissions by 2028 from 2018 levels, a 14% reduction in carbon intensity by 2028 from 2018 levels, a 10% reduction in carbon intensity by 2025 from 2018 levels	n/a
Uralkali	The company plans to set goals in 2021	n/a
Eurochem	n/a	n/a

Table 4
Emission targets of Russian transport companies

Company	Target corporate benchmarks	Target year for achieving carbon neutrality
Russian Railways	Reducing carbon intensity by 5–11.7% by 2030 compared to 2018. In the Long Term Development Plan, the goal was set to reduce GHG emissions by at least 4.5% by 2025 compared to 2018 levels (by the end of 2020, the indicator was reduced to 1.6%)	n/a
Aeroflot	n/a	n/a
Sovcomflot	The company has adopted a Green Charter, the objectives of which are in line with the IMO's goal to reduce carbon intensity by 40% from 2008 levels by 2030 and by 70% by 2050 (a 50% reduction in absolute emissions)	n/a

projects (Natural Based Solutions). These projects are based on increasing the absorption capacity of forests (certified by the World Community) through integrated and sustainable management of forests and rural areas. Thus, the full realisation of the above-mentioned advantages requires the implementation of a number of measures, in particular, in the sphere of ensuring the completeness of accounting and certification of the absorption capacity of Russia's forest resources.

According to the Moscow office of the Boston Consulting Group, the creation of *a fully-fledged forest accounting system* will have an effect many times greater than the effect of all energy transition measures in the power sector. *There is an opportunity to triple the estimated absorption capacity of Russia's forests* to 1.8 billion tonnes of CO_2 equivalent per year in the medium term and up to 2.2 billion tonnes of CO_2 equivalent per year in the long term.[6]

Another example confirming the relevance of cross-sectoral balancing of energy transition measures are the plans and target benchmarks of the largest Russian participants in the main industries and sectors of the Russian economy. Tables 1–4 show data obtained from open sources (company websites, analytical review by VTB Capital, Russian Ministry of Economic Development, Russian Ministry of Energy) on the target benchmarks of the largest Russian companies in the oil and gas, mining and metallurgy, petrochemicals and transport sectors.

Table 5 provides an assessment of investment plans for the main industrial sectors and branches of the Russian economy.

Table 5
Emissions and decarbonisation by industry and sector

Sector, industry	CO_2e emissions in 2019		Investment plans up to 2030, trillion rubles per year (estimate)	Annual decarbonisation costs for 100% emissions reduction, trillion rubles
	mln tonnes	% of total by country		
Electric power engineering (networks and generation)	720	34	0.9	1.5
Oil and gas	268	13	3.7	2.4
Transport	185	9	2.0	4.8
Metallurgy	250	12	0.8	1.2
Chemical	87	4	0.4	1.2
Concrete	20	1	0.03	0.1
Total RF	**2119**	—	—	—

[6] Undiscovered wealth: why it is important for Russia to realize the true value of forests. https://web-assets.bcg.com/c4/5a/5fb9ad2e4780944dcaf9a9168100/2021-bcg-forests.pdf.

1.2. The role of government in stimulating technological development

The economic burden on large energy-intensive consumers of implementing the energy transition (decarbonisation) programme will largely depend on its cost, the dynamics of which we believe will be influenced by two key factors:

- innovative reduction in the cost of renewable electricity generation technologies;
- the cost of capital raised during the implementation of the decarbonisation programme.

Accordingly, reducing the cost of energy transition in itself facilitates the adaptation of energy-intensive industries to this process and should be considered as one of the key areas of levelling negative impacts.

Therefore, access to innovation (advanced state-of-the-art technology) and cheap capital is necessary to achieve a cost-effective transition to renewable energy.

Fig. 1. Comparison of the global weighted average of the present value of electricity from renewable energy sources (2021 compared to 2010)

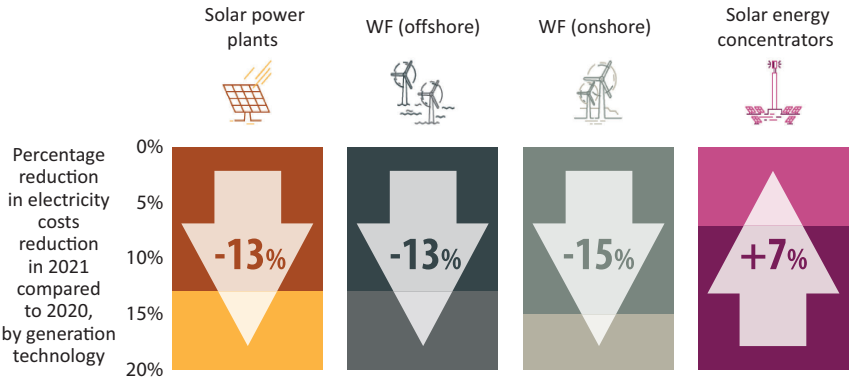
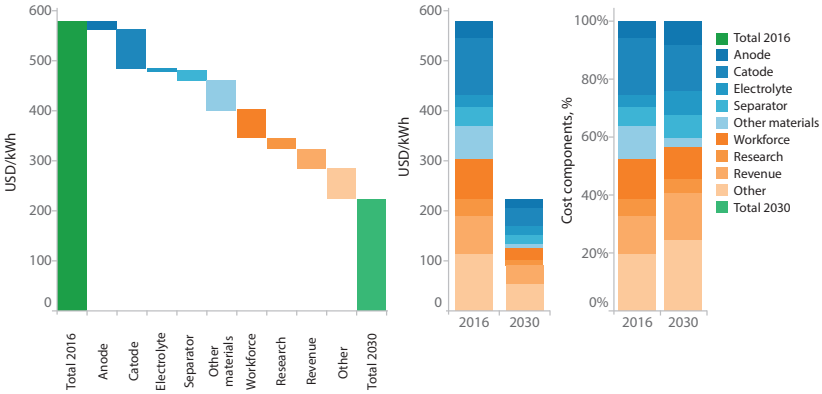


Fig. 2 Predicted cost reduction for lithium fermium phosphate battery energy storage systems



Considerable knowledge has been accumulated worldwide on many aspects of designing, planning and implementing the technological transformation of the energy system.

Over the past decade, renewable energy generation technologies (especially solar and wind) have moved from an expensive niche to become the cheapest source of electricity in most countries today. This has been driven by the rapid expansion of generation capacity, improved performance and lower capital and operating costs, as well as the impact of continuous technological innovation.

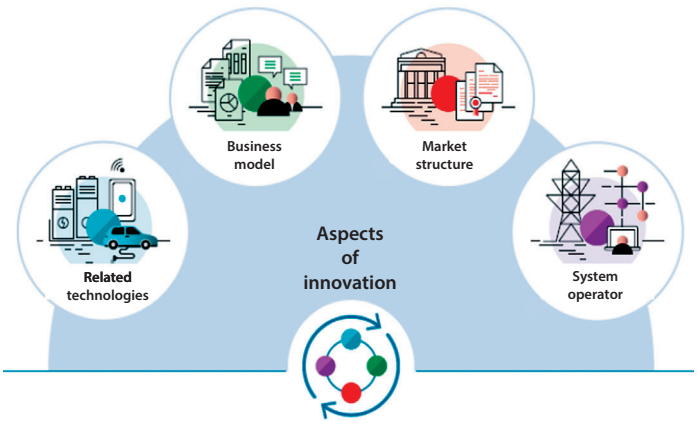
In this context, it is important to note that the global experience of the last decade clearly shows a multiple reduction in the cost of technologies for production of energy from renewable primary sources, in particular solar and wind energy.

Figure 1 compares the global weighted average of the levelized cost of electricity (LCOE) produced from renewable sources and the projected LCOE of newly installed renewable electricity generation technologies, 2021 compared to 2010.[7]

It should be noted that the situation in the electricity storage segment is developing in a similar way. According to the 2017 IRENA report,[8] by 2030, the unit cost of battery storage systems for electricity is expected to decrease by up to three times compared to the base year 2016 (Figure 2) [Usacheva et al., 2022].

The creation of effective and competitive national innovation structures is an essential component for accelerating the deployment of new and critical technologies for the transition to renewable energy, attracting investment, and reducing the costs of relevant innovative projects [Hund et al., 2020]. At the initial stage, it is of great importance to develop and implement coordinated actions in four areas (Figure 3) – enabling technologies, business models, market structure and system operation – to help solve key problems and support the development of the target technology market, thereby accelerating the transition to renewable energy. In addition, coordinated action in these areas can reduce the transaction costs of technology transfer and encourage foreign direct investment and/or the creation of local private ecosystems.

Fig. 3. Aspects of innovation



[7] Based on data from the International Renewable Energy Agency. https://www.irena.org/.
[8] Electricity storage and renewables: Costs and markets to 2030. https://www.irena.org/.

Among the technologies of the transition to renewable energy in the world and in Russia, solar, wind and hydrogen technologies are the youngest and therefore require the most attention and support.

At the same time, the level of support required also differs between the three technologies mentioned (depending on the current state of development of the respective technology). These are used as examples to illustrate this support.

Support for solar energy

Solar energy is the most mature of the three technologies identified above. In solar energy, technology and business model innovation has occurred in parallel with technology cost reductions. This has not only accelerated the introduction of technologies, but also driven many regulatory decisions. However, for its further development, it is obviously necessary to finalise the structures of the existing traditional electricity markets (due to the instability of the primary energy source on which the technology depends – the sun) and to strengthen the business models that already working. It is important to improve the rules in such aspects as:

- defining medium- and long-term technology development goals;
- creating new sustainable financial support mechanisms;
- making targeted cost reduction and productivity improvement efforts for solar energy technologies (goal for R&D);
- providing infrastructure support: access to the grid for new solar power plants, creation of smart grid models, development of standard solutions for rural electrification based on solar power plants, creation of technical and economic guarantees for new projects.

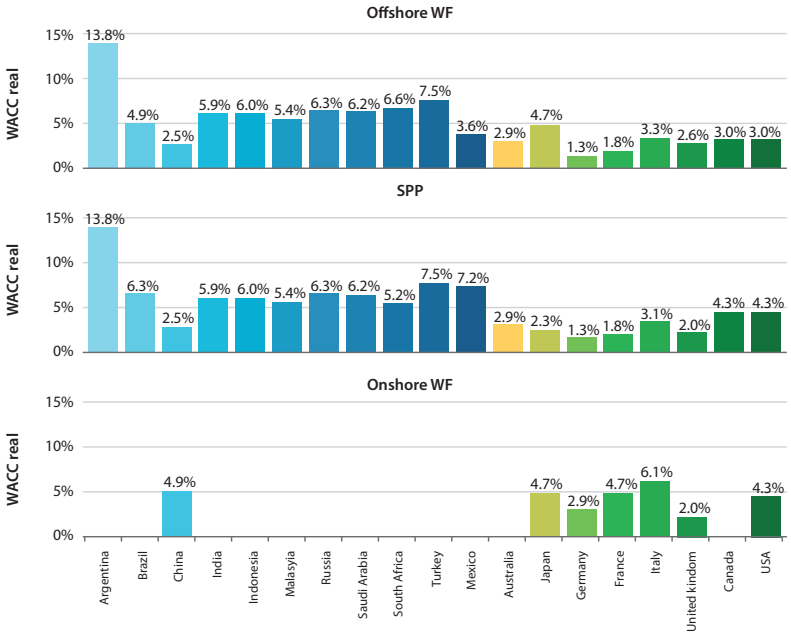
Wind power support

Wind power is also a relatively mature technology. In many ways, the above applies to solar energy and to the development of wind energy. However, offshore wind farm projects (which are often more efficient than onshore ones) face complex and costly procedures to obtain the necessary permits around the world [Nallapaneni et al., 2020]. For this reason, support in the form of simplification of existing and developing new licensing procedures is very important for offshore wind project participants. Simplifying procedures will reduce project implementation time and accelerate the development of new technologies for the deployment of offshore wind generation facilities.

Support for hydrogen energy

Hydrogen energy is the newest, but most promising technology with huge potential. However, at this stage, in order to establish a hydrogen energy market, it is necessary to first develop a consensus among potential market participants on the environmental friendliness of hydrogen production and a reliable system of environmental certification of such production [Sologubova et al., 2020]. Today more than 90% of hydrogen is produced using fossil fuels with a large carbon footprint. Such a system will be used as a basis for making investment decisions on projects for the production of 'green' hydrogen and its use in the electricity industry of the future. In addition to the environmental aspects of hydrogen production, efforts must be made to support research into the development of hydrogen energy infrastructure and cost reduction in hydrogen production. Reducing the cost of producing 'green' hydrogen may be a key decision in the transition to hydrogen energy [Beloborodov et al., 2021].

Fig. 4. Estimation of the average cost of capital in key countries depending on renewable energy technology for projects implemented in 2021



2. Key opportunities for the public and private sectors to reduce the cost of capital for renewable energy investment projects

2.1. Cost of capital as a driver for renewable energy investment projects

The cost of capital for renewable energy investment projects is a very important factor in the overall cost of implementing the energy transition. It is the main determinant of the cost of renewable electricity, as the fuel component of its production costs is either minimal or non-existent.

For example, for a solar or onshore wind farm construction project, the levelised cost of electricity (LCOE) increases by 80% if the cost of capital is 10% instead of 2%.[9]

Access to low-cost finance reduces the cost of energy for consumers.

The cost of capital for a renewable energy generation project depends on a number of different factors, the three most important of which are as follows:

1. Country risks: the so-called 'country risk premium' is the total cost above of the risk-free rate due to the country's political, institutional and regulatory risks. In the current geopolitical environment, the country risk for

[9] Based on data from the International Renewable Energy Agency. https://www.irena.org/.

Russia is mainly managed through the effective use of its own financial capabilities, as well as by targeting the capital markets of Northeast Asia (particularly China), as well as the Middle East and West Asia (Republic of Turkey).

2. Withdrawal risks: if the revenue from the project is secured by a bilateral agreement, the perceived risk of investors in relation to the solvency of the consumer will affect the expected rate of return. Regulatory risks may also arise if the buyer is a government entity. Where international developers are involved, currency risk also has an impact, although hedging can reduce this risk for a fee.
3. Technological risks: technologies have different risk profiles based on technological maturity, previous experience in specific markets, the experience of the developer, and confidence in the resource, for example, the extent and quality of local solar radiation data. However, the latter factor is no longer as important as it once was, thanks to the growth of world experience.

Other factors also affect the cost of capital, such as the size of the internal financial market, the experience of developers, cost allocation rules, etc.

Given the critical importance of access to low-cost finance to achieve the necessary capital mobilisation to support the energy transition, understanding the reasons for the high cost of capital and methods to reduce it is essential to determine the direction of public policy to implement the Decarbonisation Scheme and to protect large energy intensive consumers.

An estimate of the average cost of capital in the main countries, depending on the renewable energy technology, for projects implemented in 2021 is shown in Figure 4.

As a result of the above factors and the underdevelopment of national innovation and investment structures, the unit cost of 1 MW of installed renewable energy capacity in Russia is typically significantly higher than the global average.

2.2. Problems of reducing the cost of capital for the implementation of the Energy Transition Programme. The role of the public sector. The role of the private sector

Differences in the cost of financing decarbonisation programmes are, as noted above, mainly due to non-technical risks, of which country risk, exchange rate risk and withdrawal risk are usually the most important and, therefore, the biggest obstacles to mobilising cheap capital. There is therefore a clear need to develop effective public policies and innovative financing schemes to reduce the cost of capital.

The public sector cannot solve the problem alone.

Public-private partnerships will be key. Both private and public sectors have a critical role to play in driving forward the energy transition agenda. One cannot do without the other. This requires close cooperation between the parties in the form of partnerships on specific and clearly defined tasks between sectors, leading to jointly developed action plans with accountability and responsibility for achieving measurable results.

The public sector should play a crucial role as a catalyst, providing a favourable and predictable enabling environment (policy framework) for long-term investment decisions in the private sector. An effective enabling environment will stimulate and facilitate decision making by private investors and developers to finance and deliver the volume of projects required for the energy transition. As public sector financial resources are increasingly limited by macroeconomic and sanctions constraints, the importance of using these public resources to leverage private sector investment becomes even more critical. Well-designed public sector support, which reduces the risks for private investors and increases their financial returns, can play a central role in efforts to adapt and mitigate the effects of the energy transition on energy-intensive industries [Maksimov, 2020].

The private sector, even when presented with attractive investment opportunities in the energy transition, will only invest if the projects meet strict models for the allocation of private sector resources to direct their investments to projects with appropriate risk and reward profiles. Non-investment countries have problems accessing cheap finance because international institutional investors with trillions of dollars under management are often unable or unwilling to invest in such markets. Similarly, smaller and riskier projects and new decarbonisation technologies may also not have access to the capital they need. In these cases, joint public-private financial intervention can play an important role in bridging the gap between the availability and cost of capital and the needs of developers and government.

There are two ways to attract capital: international versus domestic and commercial versus concessional.

Domestic financial markets are the main important source of capital for financing the energy transition. This is because they provide diversified funding sources, access to local equity and corporate bond markets, and much-needed rouble funding to avoid currency risks and mitigate macroeconomic shocks. They are also crucial because international institutional investors are reluctant to invest in projects unless local investors or lenders such as banks, pension funds and insurance companies themselves are involved in financing the projects. International players tend to be concerned about the asymmetry of information in the risk assessment of projects in the market.

In 2021, global pension fund assets will total USD 56.6 trillion (TAI, 2022), while the global insurance sector will manage USD 41.6 trillion in the same year (source: Statista), for a total of more than USD 100 trillion. However, these institutional investors will not put money into small or unprofitable projects and often cannot finance non-investment grade or unrated countries.

Another important distinction is between commercial and concession capital. The energy transition involves major projects that require a balance between risk and return on investment. Some projects are needed to achieve the goals of the global energy transition, but they are not yet being implemented. They remain on a small scale and are located in non-investment grade countries. These are two limiting factors which prevent large international institutional investors from participating in such investments. Given the limited government funding available for such projects, the investment attracted will also have a significant impact on the viability of the energy transfer.

In this case, the most promising mechanisms are blended financing mechanisms, which aim to attract private sector capital in the most popular areas and to reduce the cost of capital for the projects concerned.

The state and institutional investors provide capital on preferential terms (i.e., capital at below market rates) in order to change the risk-return ratio of investments so that venture capitalists are interested in financing at normal market rates. The resulting structure combines both types of capital (commercial and preferred) and allows each side of the transaction to achieve its specific objectives.

Typical risk mitigation instruments may include (partial) risk guarantees, compensation for initial project losses, grants, technical assistance, subordinated debt. Subordinated debt is a debt that ranks after other debt in the event of the liquidation or bankruptcy of the company; such debt is called 'subordinated', because lenders have a subordinate status to ordinary debt. They are also subordinated shares, which do not confer voting rights or only partial voting and dividend rights, are not fully liquid and may only be converted into ordinary shares in the future if the company achieves certain performance criteria. The sources of commercial and concessional finance for financing sustainable infrastructure vary depending on the development cycle of energy transition investment projects.

It is expected that the relationship between commercial and concessional (concessional) capital will change as the project moves through the early development and preparation stages, the formation and construction phases, the operational phase and finally the market exit (through appropriate exit strategies).

In the early, high-risk stages of project development, investors can provide grants or technical assistance for project development and preparation on preferential terms. This will enable concessionary and commercial capital providers to participate in equity investments at an early stage to pay for legal and other start-up costs. Providers of commercial capital will take the initiative once the project has entered the construction phase, while the provider of preferential capital can cover the initial losses in the event of project failure. Finally, during the operation and maintenance phase (which can last for decades) and eventual exit, commercial parties jointly monitor the progress of the project.

There are many tools and schemes that can be used to reduce the risks, and therefore the cost of capital when financing an energy transition programme. At the same time, the study will analyse the mechanism for stimulating investment in the energy transition through blended finance through the issuance of green bonds.

Green bonds are part of responsible investment, an approach to selecting securities based on environmental, social and governance factors. They are issued to fund environmental projects, including those that reduce CO_2 emissions.

In terms of mechanics, green bonds are no different from ordinary bonds; they are the same fixed-income debt instruments. The investor lends his money for a certain period of time to issuers – organisations that have issued bonds. In this case, however, the money will be used to improve the environment and minimise damage to nature:

- general adaptation to climate change;
- development of renewable energy;
- increasing the absorption capacity of forests through sustainable management of forests and agricultural land;
- land reclamation;
- introduction of electric transport, etc.

To be officially 'green'; a bond issue must comply with the Green Bond Principles (GBP) developed by the International Capital Markets Association (ICMA) or meet the requirements of the Climate Bonds Initiative. An external expert – a verifier company – must confirm the 'greenness' of the bonds. If an independent audit raises no questions about the use of funds, the project selection process and reporting, the bonds can be considered 'green'. However, even after listing, issuers are required to report regularly on the costs and implementation of their environmental work.

In 2007, the European Investment Bank issued the first 'environmental' bond, called Climate Awareness Bonds. The funds were to finance alternative energy and energy efficiency projects. A year later, the International Bank for Reconstruction and Development issued a 'green' bond. Then other supranational institutions and development banks began to issue similar ones. The turning point came in 2013, when large corporations entered the market with green bonds. Since then, the issue of such bonds has grown steadily.

According to the international organisation Climate Bonds Initiative, the total amount of green bonds issued between 2007 and 2020 reached USD 1.1 trillion, although this figure did not exceed USD 3.1 billion in 2012. Among the regions, Europe ranks first in terms of green bond issuance with USD 432.5 billion, followed by North America (USD 237.6 billion) and Asia-Pacific (USD 219.3 billion).

In the Russian Federation, the responsible investment trend is still in its infancy, but the first steps have already been taken. The first official green bond issue took place in 2018 – the company KhMAO Resource Saving placed a RUB 1.1 billion bond on the Moscow Stock Exchange. Funding was raised for the construction of an inter-municipal landfill for the dumping, neutralisation and treatment of municipal solid waste in the Nefteyugansky District. According to foreign experts, the securities comply with GBP's green principles. In 2019, they were included in the International Register of Environmental Finance Bond Database, and then in the Green, Social and Sustainability Bond Database.

The first Russian company to place green bonds on the foreign market was Russian Railways. The issue took place in May 2019 – the volume amounted to EUR 500 million. Loans for the purchase of electric locomotives and Lastochka passenger trains are to be financed with green money.

In the summer of 2019, a separate 'sustainable development' sector appeared on the Moscow Stock Exchange, where you can find a list of traded green and social bonds. Investors now have access to green bonds issued by the Moscow developer FPC Garant-Invest, the financial company RuSol 1, the bank Center-Invest and the transport company TKK LLC.

In addition, for the first time sub-federal green bonds were issued on the Moscow Stock Exchange – the capital's government placed them for RUB 70 billion. The Moscow authorities intend to allocate funds for the implementation of projects to reduce carbon dioxide emissions and pollutants from motor vehicles. This involved replacing Moscow's bus fleet with electric buses, building new metro stations and renovating old ones. The placement was successful – demand exceeded production by 20%.

According to expert estimates, the total volume of 'green' loans in Russia will amount to about RUB 1.85 trillion by 2023. The volume of issued target bonds in the format of sustainable development of Russian companies and their foreign subsidiaries and dependent organisations for 3 years is estimated at more than RUB 524 billion. These bonds are generally focused on the transport, industrial machinery and energy sectors. The funds raised were used to finance projects in 51 regions of Russia worth more than RUB 223 billion.[10]

Tax incentives applied in world practice for issuers and investors of green bonds are attractive because of their economic efficiency, as they can provide a significant boost to investments with a relatively small impact on public finances.

There are several types of tax incentives the governments can introduce to encourage the issuance of green bonds. Incentives can be provided to both the investor and the issuer.

Tax Credit Bonds: Bond investors receive tax benefits instead of interest payments, so issuers do not have to pay interest on their green bond issues.

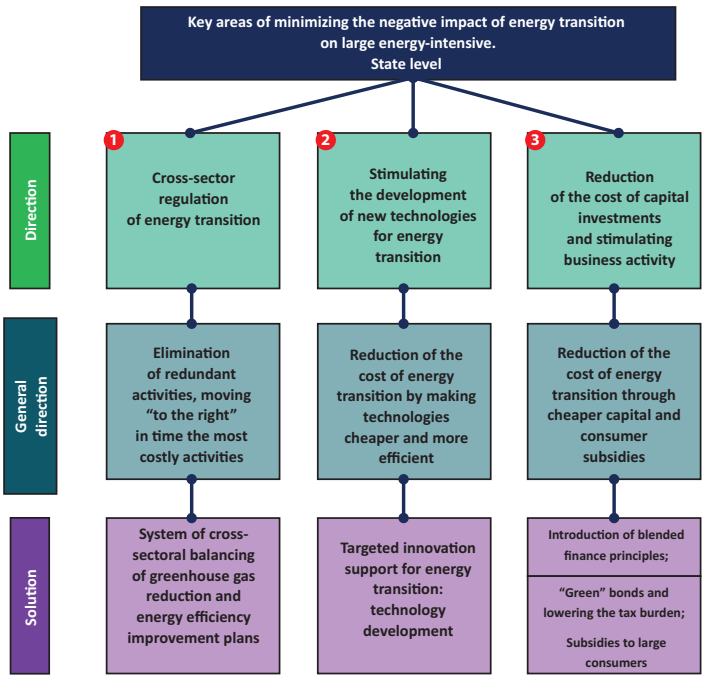
Direct Subsidized bonds: Bond issuers receive cash rebates from the government to subsidise their net interest payments.

Tax-exempt bonds: Bond investors do not have to pay income tax on the interest from green bonds they own (so the issuer can pay a lower interest rate).

For example, as a result of the issuance and placement of government-backed green bonds:

- the state receives a guarantee for the implementation of the necessary project aimed at reducing CO_2 emissions or absorbing greenhouse gases;
- issued on preferential terms;
- investors are tax exempt income.

Fig. 5. Key areas of minimising the negative impact if energy transition on large energy-intensive consumers. State level



2.3. Government instruments to reduce the cost of purchasing electricity for energy-intensive industrial consumer

Another way of reducing the costs of large energy-intensive consumers is to subsidise part of the electricity costs of large energy-intensive consumers, as well as to compensate part of the costs of building new energy infrastructure from the state decarbonisation fund, which is replenished from the collection of carbon payments in the country [Tsakhaeva, 2015].

In particular, subsidisation involves the conclusion of regulated long-term contracts (RLCs) for the supply of electrical energy and capacity at discounted prices by state-controlled power generation companies that mainly produce 'clean' electricity (Rosenergoatom, Rushydro, etc.), with a phased approach to market prices within 3–5 years. It is clear that such contracts should be limited in nature and scope and should only be concluded with those energy-intensive consumers who are experiencing extreme difficulties in adapting to the increase in electricity costs and whose uninterrupted functioning is of particular strategic and/or social importance.

In addition, one of the subsidy mechanisms could be the regional differentiation of the number of free carbon certificates issued by the state (within the overall country limit on the total amount of emissions in the corresponding year), depending on the absorption capacity of the forests in the region. As the large energy-intensive industries of the Russian Federation are concentrated mainly beyond the Urals, in regions rich in forests with a high capacity to absorb carbon, the increase in the cost of electricity for these consumers will be lower in the context of the energy transition. It will also provide an economic incentive for the relocation of energy-intensive industries from the European part of the country and the Urals to regions with cheap 'clean' energy.

Thus, the main effect of creating a national system of carbon payments and a national decarbonisation fund is the ability to 'keep' the money collected in the country and use it for measures to decarbonise the economy. It is necessary to reduce the financial burden of large consumers on energy transmission through direct state subsidies for the implementation of renewable energy projects in the electricity industry.

Taking into account the analysis, the system of measures at state level to minimise the economic impact on large electricity consumers and key tasks can be graphically presented (Figure 5).

3. Promising corporate actions to adapt energy-intensive industries to the consequences of the increasing share of renewable energy in the electricity balance

3.1. The experience of the Russian energy-intensive industry in adapting to structural changes in the electricity industry

The traditional approach of large energy-intensive consumers to reduce electricity costs (reducing the price of purchased electricity and relocating production facilities to regions with cheap electricity), takes on a new 'dimension' in the context of decarbonisation measures in the electricity industry.

The 'reducing the price of purchased electricity' part (combating cross-subsidisation, participating in the pricing of

[10] ESG, Decarbonisation and Green finance – Summary of results 2022. https://energiavita.ru/2023/03/12/esg-dekarbonizaciya-i-zelenye-finansy-rezyume-itogov-2022/.

individual services, changing the proportions of decarbonisation costs in the final price of electricity, etc.) implies more intensive pricing work by large electricity consumers. The part about 'moving production to regions with cheap electricity' has additional meaning: moving production from the west to the east of Russia means moving from a zone with a larger share of thermal power plants in the regional structure of electricity generation to zones with a larger share of hydroelectric power plants in the regional structure of electricity generation. It helps reduce the country's overall GHG emissions.

It should be noted that the approach of "moving production to regions with cheap electricity" is relevant to all economic systems (not just market ones), which is confirmed by the history of industrialisation and electrification of Russia in the last century.

The key stages (waves) of Russia's industrialisation during the USSR have pronounced resource-geographic features (energy-intensive industries 'run' for cheaper energy):

Stage 1. The beginning of the 20th century. Initial development of the energy potential of the European part of the country (local fossil fuels, linking generation to pre-existing industrial production).

Stage 2. The second quarter of the 20th century. Construction of energy-industrial complexes in the European part of Russia and in the Urals (with the establishment of new large energy-intensive industries in the Urals zone). The main source of primary energy is coal from the Ural region and hydroelectric power plants (HPPs) in the European part of Russia.

Stage 3. The third quarter of the 20th century. Construction of energy-industrial complexes in Western and Central Siberia (with the establishment of new large energy-intensive industries in these regions). It is connected with the development of the energy of Siberian rivers and the development of coal and gas deposits.

Stsge 4. The second half of the third and the first decade of the fourth quarters of the 20th century. In Eastern Siberia and the Far East, large hydroelectric power stations and modern coal-fired power stations are being built in anticipation of industrial production. The fourth stage should be considered as incomplete (a significant part of the HPPs is not in demand by industrial consumers).

Today, the trend continues: new energy-intensive production facilities are located closer to the east of the country, next to large hydroelectric power plants, and large energy-intensive enterprises that were established in the European part of the country and in the Urals in the middle of the last century are gradually being converted or closed down.

Relevant international experience should be taken into account. Companies from countries with quantitative commitments to reduce emissions are incentivised to move production with a significant carbon footprint to developing countries with no such commitments (so-called 'pollution heavens') and then import products back. About 25–30% of global emissions are imported and exported from country to country. The European Union is a net carbon importer, with the main CO_2 exporters to the EU being North America, Russia and China. However, this practice will be significantly reduced following the introduction of cross-border carbon regulation.

3.2. Key corporate to ensure that large energy-intensive consumers adapt to the consequences of the energy transition

Action at company level in all areas can be divided into three main types: management, energy consumption and energy supply.

1. Management actions

These actions tend to be comprehensive and strategic in nature, in particular:

- Change in the management structure of the company to improve the efficiency of the development and implementation of the strategy, in particular in the area of energy efficiency and decarbonisation:
  1) creation of a dedicated unit to manage the energy efficiency and decarbonisation strategy;
  2) assigning responsibility to an internal energy efficiency specialist to ensure the definition and successful implementation of a realistic overall strategy;
  3) expanding the ownership of energy efficiency solutions at senior management level;
  4) aligning energy efficiency and decarbonisation key KPIs with general management key KPIs.
- Encouraging decarbonisation activities in the supply chain, as this will affect the carbon content of each product purchased.
- Providing support to consumers/customers in the decarbonisation process leading to an overall reduction in carbon emissions as a result of the company's activities.

The scheme for organising the management of climate change issues at *Norilsk Nickel* can serve as an example.

Addressing climate change issues at all levels of corporate governance – from the board to senior management.[11]

2. Actions in the field of energy consumption

The main objective of these actions is to save energy, which will translate into reduced carbon emissions and, ultimately lower operating costs.

Typical actions in the area of energy consumption include:

- Replacing and modernising outdated equipment is one of the standard ways of improving energy efficiency in the plant. The measures can range from a simple change to LED lighting to a more complex upgrade of electric motors and their drives in production or improving the efficiency of the building's HVAC system.
- Using intelligent load management systems based on digital solutions allows you to go beyond simple monitoring. With proper management and automation, an enterprise can achieve significant energy savings; modern building energy management systems are able to simulate an object and its response to load changes.
- Electrifying the company's transport fleet can significantly reduce direct CO_2 emissions, especially when combined with intelligent charging systems. A striking example of this is the experience of the mining company Rio Tinto, which, in an effort to reduce the carbon footprint of its production, has ordered shunting locomotives powered by lithium-ion batteries to transport coal within the mine site in Australia.[12]

[11] Report on the sustainable development of PJSC MMC Norilsk Nickel for 2021. https://www.nornickel.ru/files/ru/investors/disclosure/NN_CSO2021_RUS_0706.pdf.

[12] Rio Tinto orders Battery-electric locomotives for Mining Rail in Australia. https://www.energytech.com/emobility/article/21213991/rio-tinto-orders-batteryelectric-locomotives-for-mining-rail-in-australia.

- Analysis of the production process. This means that any energy savings can be achieved by making changes to individual stages of the production process, such as reducing the steam temperature, without compromising the overall quality of the process.

3. Actions in the field of energy supply

The main objective in this case is to reduce the volume of indirect emissions in the overall carbon footprint of the products of a large energy-intensive consumer.

Typical actions in the field of energy supply include:

- Local production of green electricity, i.e. the production of electricity using low-carbon technologies, such as solar photovoltaic energy, wind energy, bioenergy, etc.
- Switching to low-carbon heat can lead to a significant reduction in direct emissions. Decarbonising the heat supply is one of the biggest issues facing the energy industry. Efforts should be made to improve the efficiency of the supply (e.g. using a CHP system), to electrify the heat (e.g. low or high temperature heat pumps, depending on the application) or to decarbonise the fuel source (e.g. switching from natural gas to clean gas).
- Becoming a 'producing consumer' on the energy markets, i.e. producing excess electricity that can be sold. This is a typical way for companies to achieve negative carbon emissions in the energy supply sector, which are used to offset carbon emissions in other business areas. It also helps to generate new revenue streams from the sale of excess energy.
- Purchasing zero-carbon electricity involves the signing of contracts with energy suppliers at green tariffs or an agreement to purchase electricity from a renewable energy producer that guarantees of the origin of the energy consumed.
- Introducing energy storage systems alone does not guarantee a reduction in carbon emissions, but it can contribute to a reduction if it is used as a means of optimisation (e.g. optimising the flow of energy from local production).
- Optimising energy supply based on consumption and energy tariffs.
- Implementing the methodology for assessing the impact of climate risks on the company's financial performance and financial stability based on the recommendations of the TCFD (Task Force on Climate-related Financial Disclosures) at the level of the company, its divisions, subsidiaries and affiliates. This is a working group on the disclosure of financial information related to climate change under the auspices of the Financial Stability Board.

Risks assessed using this methodology:

- Physical risks associated with the occurrence of adverse meteorological conditions and natural disasters. They take the form of a reduction in climate predictability and an increase in dangerous hydro-meteorological phenomena (droughts, floods, hurricanes, prolonged torrential rain, large hailstorms, etc.);
- The risks of the transition period in the form of changes in legislation (taxation of greenhouse gas emissions, obligations to use new technologies, bans on certain activities and the use of certain substances); a decrease in public tolerance of 'dirty' industries and in investor interest in certain industries. There is also an increase in insurance and borrowing costs as a result of higher risks.

Electricity prices and the reliability of energy supplies are key factors in many strategic decisions faced by large energy-intensive consumers, but they are particularly important in decisions related to the need to adapt to radically changing production conditions.

Possible options for adapting energy-intensive consumers to the increase in energy prices due to the energy transition:

- *Market purchase of electricity through the conclusion of long-term contracts (free or regulated)* – electricity and/or power is usually purchased under a long-term contract with upper and lower price limits. Energy supply conditions and price risk are limited for the duration of the contract. The options for concluding long-term contracts, which allow consumers to temporarily adjust to an increase in the price of electricity, are discussed in more detail in the next subsection.
- *Independent power generation* is when a large energy-intensive consumer builds or buys (leases) a power plant that produces relatively 'clean' electricity (ideally hydroelectric). This allows the consumer to ensure a stable supply of energy for production and to fix electricity prices. Electricity can be sold to other users (if connections are available). Example: acquisition of RUSAL (Eurosibenergo) Onda HPP, lease of Bratskaya HPP, construction of Lukoil's own associated gas generation.
- *Acquiring ownership of a fuel source* – a consumer can own a fuel source (gas field, coal methane absorber, etc.) and 'convert' the fuel into electricity using an independent power plant. This can give the consumer some control over the risks of energy supply and electricity prices, and can also provide protection against falling prices for their products (if the fuel is available for sale). PJSC Lukoil's construction of its own associated gas power plant in the Astrakhan region.
- *Full integration of the main production of a large energy-intensive consumer and a source of cheap and 'clean' electricity*. As a result, the consumer is largely protected from the influence of the external electricity market. Example: Boguchansk Energy and Metallurgical Association (BEMA) is an association of a single legal entity and a single production complex of the Boguchansk HPP and the Boguchansk Aluminium Plant.

3.3. Possible options for the unregulated bilateral contracts that balance the interests of electricity producers and consumers and hedge consumer risks

Indexation of energy prices to commodity prices – for consumers of electrical energy and energy producing commodities

This option is based on the adjustment of energy prices according to changes in the prices of electricity consuming products, although it introduces a new risk factor for the seller, as the revenue from energy production will be directly dependent on the price of electricity consuming products. For an electricity supplier directly connected to one specific consumer (without the possibility of selling the electricity produced on the free market), such a risk already exists, since the energy company is dependent

on the level of profitability of the customer. If a consumer closes its plant, the energy producer is likely to suffer losses, since the probability of finding a new consumer with the same consumption in the surrounding area is extremely low. In such cases, linking to the share price does not significantly increase the risk. The approximate formula can be described as follows:

Revenue = (Volume for a given period) × (energy price under the contract) × (correction factor for changes in commodity prices).

There are several examples of such contractual price adjustments on the world market.

For example, in Europe, for contracts based on an approximate 25% share of electricity costs in the total costs of aluminum producing companies, the contractual energy price was adjusted by a coefficient of 0.25 (25% increase in electricity prices equals 100% increase in aluminum prices and vice versa). The price is adjusted monthly, which means that every month the price of electricity has to be adjusted according to changes in the exchange market.

The reference price for a commodity is taken from the exchange, for example, if the commodity is metal, then the price is often taken from the London Metal Exchange (LME). Prices for deliveries 3 months ahead can be based on the exchange price. Next, let's look at examples of long-term contracts whose price is linked to the price of metals whose production requires significant energy costs on the LME.

One of the opportunities for the parties is to agree to use spot prices at the exchange rate (or at the rate of another market or point on the network) but with a fixed maximum, i.e. to use the maximum agreed price if prices at the time of payment exceed a certain level. The maximum price then acts as a price limit or ceiling.

Such contracts are similar to an option where the client automatically uses the limit price if prices exceed the agreed maximum level. Under such contracts, the client is obliged to pay a premium equivalent to the premium on option transactions. Depending on level of the limit, the duration and the type of contract, an additional option premium on the maximum price without restrictions on the minimum level can be 5–20% of the current market price. If there is a minimum price limit that works in favour of the seller, the total amount of the premium is reduced compared to the option where there is no minimum limit.

If the price is below the agreed maximum, the following calculation method will be used:

Revenue = (Volume for a certain period) × (price at the time of payment) + (Volume for a certain period) × (option premium).

If the price is above the agreed maximum, then:

Revenue = (Volume for a certain period) × (fixed maximum price) + + (Volume for a certain period) × (option premium).

This structure gives the consumer an extra incentive to buy cheaper energy when the price at the time of payment is low, but still guarantees that the price will not exceed a certain level. The seller has no fixed minimum price and risks prices falling, but receives income from option premiums.

The maximum price can be any price. The higher the ceiling price, the lower the premium. With a very high maximum price, the structure is more like a contract with prices at the time of payment, but with an insurance element to protect against extreme price values. The probability of future price changes is used to calculate the premium.

In addition to the maximum limit, the contract may also include restrictions on the minimum price level.

Like the maximum price, the minimum price is applied when the prices at the time of payment are formed below a certain level.

Bilateral energy supply contracts that give the buyer (or sometimes the seller) the right to decide when to consume energy under the contracts

This freedom is determined by the ratio of the maximum energy supply capacity in MW to the total amount of energy under the contract.

The formula can be described as follows:

Energy volume under the contract (GWh) = capacity limit under the contract (MW) × hours of use.

Base load contract with number of hours

Any contract where the buyer can choose when to use the energy (hours of use less than the annual maximum of 8760), and also undertakes obligations to reduce consumption at certain hours has a lower cost than a baseload contract.

Limiting the level of the price of electrical energy to the share of the cost of purchasing electrical energy in the total production costs of the consumer

An example of a long-term contract with an electricity price limited by the share of electricity costs in the total costs of a large energy-intensive consumer – the company Albras (Brazil): The cost of electricity should not exceed 25% of the company's total production costs.

Fixed-price contracts

Selling at a fixed price reduces the risk for the electricity consumer. A typical calculation approach is described below:

Revenue = (Volumes for a certain period) × (contractual fixed price).

In addition, such contracts can be adjusted annually to reflect changes in general price levels, such as inflation:

Price for the year n+1 = (Fixed contractual price for the year n) × × (100 + percentage change in total price level from year n to year n + 1) / 100.

Indexation can also be more frequent, for example monthly. Contracts may be fully or partially inflation-linked (inflation index less than 100%).

Such indexation is usually only possible with direct bilateral contracts between buyer and seller. Selling electricity at a fixed price also guarantees revenue and reduces the price risk for the energy producer. To spread the risk evenly between the parties, it is possible to split the volumes in half, with one half paid at a fixed price and the other at a variable price (at the time of payment).

Examples of long-term contracts with inflation-adjusted electricity prices:

Aluminium Dunkerque (France) – annually the price of electricity changes anually in proportion to the inflation rate in France, reduced by 1%;

1) Elkem Aluminium (Norway) – the electricity price for the plant in Norway increases annually by 60% of the level of increase in wholesale prices in Norway (but not more than 6% per year).

Linking electricity prices to the interest rates

For the owner of a hydroelectric or nuclear power plant, the main component of the price will be the cost of capital. In this case, in order to compensate the consumer for the increase in the market price of electricity, on the one hand, and to maintain

the supplier's income, on the other hand, it is possible to link the energy prices to the interest rate:

Revenue = (volume for a given period) × (price of energy under the contract) × (adjustments due to changes in the interest rate for financing power plants).

The 'synthetic' formula is a multifactorial binding of electricity prices

In the case of long-term contracts for the supply of electricity to large energy-intensive consumers that export a significant volume of manufactured goods at market prices, it is proposed that the following 'synthetic' formula be used to determine the price of electricity.

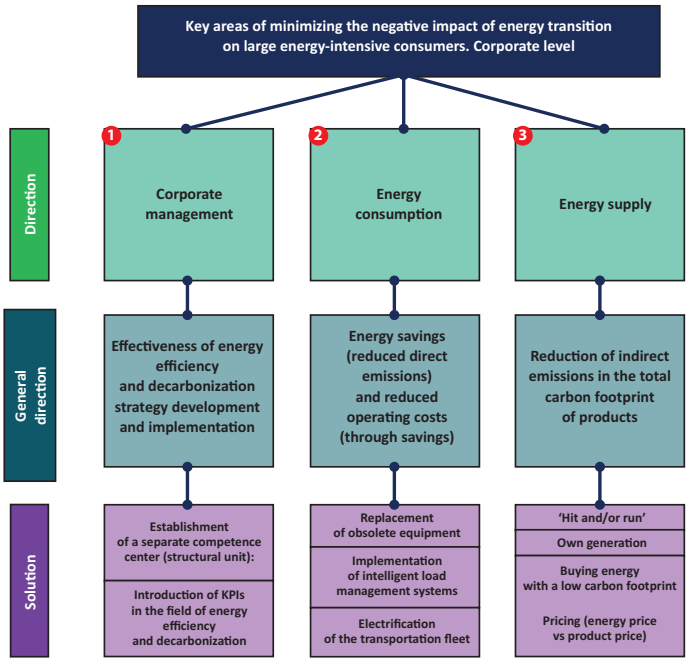
In order to hedge the currency risks of both the electricity producer (seller) and a large energy-intensive consumer (buyer), the contract price for electricity is determined annually by 50% of the volume of electricity consumed in roubles and by 50% of the volume of electricity consumed in US dollars.

The formula for calculating the contract price for electricity is applied *at the level (Minimum price per ton) ≤ (Exchange price per ton) ≤ (Maximum price per ton):*

$$P_c = P_b + \left(0,5 \cdot (И_p - И_б) \cdot V \cdot \frac{(P_w - P_b) \cdot E}{(P_W - P_b) \cdot E + (T_p - T_e) \cdot V}\right) / E + A, \qquad (2)$$

where P_c is the contract price of electricity, P_b is the initial (base) price of electricity in kopecks / kWh (the projected weighted average price of electricity for the facilities of a large energy-intensive consumer in the base (initial) year); P_w is the weighted average price of electricity on the market in the previous year; T_p is the exchange price of products of a large energy-intensive consumer (cash) in the previous year; V is the volume of production of the exchange product of a large energy-intensive consumer; E is the volume of electricity consumption; A is 'premium' to the contract price (can be positive or negative).

Fig. 6. Key areas of minimising the negative impact of energy transition on large energy-intensive consumers at the corporate level



The premium on the contract price is determined as follows:

1) At *(Exchange price per ton) > (Maximum price per ton)*:

$$A = 0,1 \cdot (T_p - T_{\max}) \cdot \frac{V}{E}, \qquad (2.1)$$

where T_{max} is the maximum exchange price of products of a large energy-intensive consumer used to calculate the contractual price of electricity under a long-term contract;

2) At *(Exchange price per ton) < (Minimum price per ton)*:

$$A = -0,1 \cdot (T_p - T_{\min}) \cdot \frac{V}{E}, \qquad (2.2)$$

where T_{min} is the minimum exchange price of products of a large energy-intensive consumer used to calculate the contractual price of electric energy under a long-term contract.

The ratio between the V and E indicators is defined as the ratio between the documented actual volume of electricity supplied in the base (starting) year and the volume of production of the exchange product of a large energy-intensive consumer in the base (starting) year.

When determining the contract price in roubles and currency (USD), the production volume of the exchange product of a large energy-intensive consumer and the electricity consumption (V and E, respectively) are taken into account at 50% each in the calculations.

Indicators P_b and T_e remain unchanged during the execution of long-term contracts for the purchase and sale of electricity.

When *calculating the hard currency contract price, if the* value $P_w \geq$ *(maximum contract price), then* P_w equals *(maximum contract price)*.

When calculating the *contract price in rubles, if* the value $P_{c\ rub} \geq$ *{(maximum contract price).* Z_{basic}*}*, then P_w = *{ (maximum contract price) .* Z_{basic}*}*.

Z_{basic} – base rate (currency conversion in roubles).

When calculating the hard currency contract price, if the value of $T_p \leq T_{min}$ then $T_p = T_{min}$.

When calculating the contract price in roubles, if the value of $T_p \leq T_{min} \cdot Z_{basic}$, then $T_p = T_{min} \cdot Z_{basic}$.

The proposed formula (2) for determining the price of electric energy within the framework of a long-term contract for the purchase and sale of electric energy, which to a certain extent synthesises the above-mentioned options for the formation of the contract price at the same time:

- makes the contractual price of electricity dependent on both the market (exchange) price of a large energy-intensive consumer's products and the market (exchange) price of electricity, thereby hedging the price risks of both the buyer and the seller;establishes flexible upper and lower limits of the contractual price of electric energy, thereby providing a known price predictability for both parties to the contract;
- hedges the risks of significant fluctuations in the rouble exchange rate for both the buyer and the seller.

Conclusion

The greater the financial burden on large energy-intensive consumers, the more expensive it will be to implement decarbonisation measures. As a result, the cost of electricity consumed by energy-intensive industries will rise.

Two factors have a key influence on the cost of the transition: the reduction in the cost of electricity generation technologies from both traditional and new (renewable) sources due to continuous scientific and technological progress; and the cost of capital required to implement the decarbonisation programme.

We believe that the partnership between the public and private sectors will play a crucial role in solving this problem. The state should play a decisive role in the formation of such a partnership by providing a favourable policy framework for entrepreneurs and investors to take long-term decisions in developing, financing and creating the volume of projects necessary for the energy transition.

The efforts of the state as a catalyst and regulator of innovation processes should aim at creating and supporting effective and competitive national innovation institutions. An equally important area for government attention is reducing the cost of capital required to implement the Energy Transition Programme. As noted in the paper, the main obstacle to mobilising cheap capital is the high level of risk for investors, including country risk, exchange rate risk and withdrawal risk, as well as commercial and purely technological risks. Accordingly, the first and most important task of the government is to implement measures aimed at reducing risks for investors and ensuring a balance between risk and return on investment.

One of the most important methods of ensuring such a balance is the mechanism of blended (concessional) financing, which aims to attract private sector capital where it is most needed and to reduce the cost of capital for such projects. The key principle of blended finance is the provision of capital on concessionary terms (i.e. below market rates) by the government and individual institutional investors (development banks, etc.) in order to change the risk/reward relationship so that private investors are interested in investing their commercial capital on normal market terms.

An effective and actively used (including in Russian practice) method of stimulating investment in the energy transition, reducing the risks of private investors and lowering the cost of attracted capital, is mixed (preferential) financing of the issue of green bonds or sustainable development bonds.

The systemic policy orientations considered in this study will be most effective in supporting energy intensive consumers who are experiencing extreme difficulties in adapting to the increase in electricity costs and whose continued functioning is of particular strategic and/or social importance. Of great interest is the conclusion of long-term contracts by state-controlled electricity generating companies for the supply of electric energy and power to these consumers at discounted prices with a gradual approach to market prices, as well as other direct support measures.

Successful adaptation of large energy-intensive consumers to the consequences of the energy transition also requires changes in corporate policy, management structure and economic behaviour. Access to relatively cheap ‘clean’ electricity becomes an important competitive advantage, encouraging the gradual relocation of large energy-intensive industries from a zone with a high share of thermal power plants in the regional electricity generation structure to zones with a higher share of hydroelectric power plants and renewable energy sources.

Important ways of adapting large energy-intensive consumers, which can be found both in the world and in Russian practice, are various forms of their integration with producers of cheap electric energy. These range from the conclusion of long-term direct contracts for the purchase and sale of electrical energy and capacity, hedging the risks of the contracting parties, to the purchase or lease of generating capacity and the formation of joint ventures with large generating companies.

The research will help to further improve the concept of integrated transformation of the electric power industry within the framework of the global energy transition, to ensure the application of systemic measures, and to prevent a slowdown in the sustainable development of the energy-intensive industries of the Russian Federation.

References

Beloborodov S.S., Gasho E.G., Nenashev A.V. (2021). *Renewable energy sources and hydrogen in the power system: Problems and advantages.* Saint Petersburg, Naukoemkie tekhnologii, 151. (In Russ.)

Daumas L. (2021). *Should we be afraid of transition risks - Review of applied literature*. French Association of Environmental and Resource Economists (FAERE), May: 3-11.

Hund K., La Porta D., Fabregas T., Laing T., Drexhage J. (2020). *Minerals to combat climate change: The mineral intensity of the transition to clean energy.* International Bank for Reconstruction and Development, 12-14.

Kodaneva S.I. (2022). Energy transition: Global trends and their consequences for Russia. *Contours of Global Transformations: Politics, Economics, Law,* 1(15): 167-185. (In Russ.)

Lee B. (2016). Transformation of our world: Implementation of the 2030 Agenda with the help of indicators of the sustainable development goals. *Journal of Public Health Policy,* 37: 13-31. DOI: 10.1057/s41271-016-0002-7.

Maksimov A. (2020). RES 2.0: A new program for the development of 'green' energy in Russia. *Energy Policy,* 11(153): 22-23. DOI: 10.46920/2409-5516_2020_11153_22. (In Russ.)

Marku A. (2021). Mechanism of adjustment of the EU carbon border (CBAM). *ERCST,* 14: 564.

Nallapaneni M., Satish K., Shaurat S. (2020). Operational characteristics of a network solar photovoltaic system integrated into prefabricated portable houses in a warm and temperate climate. *Energy for Sustainable Development,* 57: 109-118. https://doi.org/10.1016/j.esd.2020.05.008.

Sologubova G.S., Bogachev V.F., Gorenburgov M.A. (2020). Barriers to financing the renewable energy sector. *Global Energy,* 4. (In Russ.)

Tsakhaeva K.N. (2015). Analysis of the effectiveness of state support for renewable energy sources. *Management of Economic Systems,* 2(74): 22. (In Russ.)

Usacheva I.V., Gladkaya E.A., Landin S.V. (2022). Hybrid energy storage: Problems and prospects of energy storage technologies. *Scientific Works of the Free Economic Society of Russia,* 4(236): 149-167. (In Russ.)

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Unmanned transport and the reformatting of human needs: Niche and evolutionary scenarios

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Abstract

There are quite a few phenomena in human civilisation that could be compared to transport in terms of the scale and irreversibility of their impact on the development of society. The domestication of the horse and the invention of the wheel are rightly regarded as some of mankind's greatest achievements. The current stage of transport development claims to be a Revolution 2.0: the advent of the Global Navigation Satellite System (GPS) has made it possible not only to locate but also to remotely control unmanned vehicles. In the near future, this could radically change both the transportation system and human life as a whole.

The purpose of the article is to consider niche and evolutionary scenarios for the development of unmanned vehicles. It is proved that unmanned transport involves large scale and very similar transportation of homogeneous products in order to cover higher investment costs through economies of scale. In addition, such transport requires extreme predictability in the entire chain: from the receipt of raw materials to the delivery of the finished product to the end user. The accident intolerance of unmanned vehicles can be solved by creating an isolated transportation system along closed circuits in which there is no room for a person.

The article notes that there is a non-zero probability that unmanned vehicles will not be able to outperform traditional transport in terms of their characteristics and will therefore only operate in certain market niches.

Keywords: unmanned transport, cargo transportation, region, dehumanised, unpopulated transport.

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无人运输与人类需求的重新格式化：利基和进化设想

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摘要

在人类文明中，就其规模和对社会发展的不可逆转的影响而言能与交通相提并论的现象并不多。马的驯化和车轮的发明被认为是人类最伟大的成就之一。现阶段的交通发展可以说是 2.0 革命：全球定位系统（GPS）的出现不仅使确定位置成为可能，也使遥控无人 器械成为可能。这在不久的将来将极大地改变交通系统和人类的整体生活。

本文章介绍无人运输发展的利基和进化设想。作者已经证明，无人运输涉及同质产品的大规模统一运输，以便利用积极的规模经济来支付较高的投资成本。此外，这种运输要求整个运输链具有极高的可预测性：从接收原材料到将成品运送给最终消费者的整个过程。无人运输对偶然性的不容忍。因此，有必要建立一个与世隔绝的闭环不涉及人类的参与的运输系统。

本文章指出，无人运输在性能方面可能无法超越传统运输，因此只能在某些特定市场内运行。

关键词： 无人运输、货运、地区、非人化。

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Introduction

Currently, there is a huge amount of research being done on unmanned vehicles, and at the same time there is terminological uncertainty. Thus, in the English language a number of terms with similar meanings are used: driverless car, autonomous car, connected vehicles, robotic car, self-driving car, self-driving transport, autonomous vehicle, etc. Russian publications also use many terms: unmanned vehicle, autonomous vehicle, highly automated vehicle, robotic vehicle, self-driving vehicle, unmanned vehicle, etc. For example, in the draft federal law[1], a highly automated vehicle is defined as 'a wheeled vehicle equipped with an automated control system during its manufacture or as a result of changes in its design, which moves in an automated control mode'.

Such a variety of terms suggests that this technology is still in the active design phase and that its basic characteristics have not yet been defined.

In general, we can say that unmanned vehicles have at least two key components:

1) many sensors for orientation in space (radars, satellite navigation, range finders, lidars, etc.);
2) a programme that processes the information received and controls all the vehicle's systems.

The third element of unmanned transport should be an external information technology support system (ITS) that analyses traffic, regulates intersections, etc. ITS seems to be a necessary component to increase the level of vehicle autonomy: from level 0 (no autonomy: transport is completely controlled by a person) to level 5 (full autonomy: automation controls the system without any human intervention) according to the Society of Automotive Engineers (SAE) scale)[2].

This article argues that unmanned transport requires a fundamental transformation not only of the means of transport itself, but also of all participants in the transport system, including shippers, consignees and transport organisers. In this case, transport will not only be unmanned, but also completely deserted and dehumanised.

1. The evolution of transport

History shows that the emergence of transport links radically and forever changes the social landscape: warring tribes move to exchange, bandits begin to ensure the safety of transport, and populations no longer produce for themselves but for people they do not know. A clear example of this process is the Great Silk Road, which fundamentally changed not only the cultures and civilisations through which it passed, but also the entire continent ('world island'). In this sense, transport has a kind of social magic.

Moreover, the more different the societies linked by transport (in terms of natural resources, climate, list of products, etc.), the more profitable trade is for each of them and the greater the importance of freight transport. Conversely, the more similar societies are, the fewer reasons they have to trade and the more likely they are to engage in violent confrontation. For this reason, transport links between geographically distant areas have the most significant consequences.

When it is possible to establish sustainable transport links between previously isolated economies, these economies actually become a single economic whole. Transport opens up the flow of people and goods first, then technology and finance. The winner is the economy with a deeper division of labour.

It follows from the above that the historical importance of freight transport is incomparably greater than that of passenger transport. Therefore, we will continue to look at the transformation of the freight transport sector.

If we apply the apparatus of the Theory of Inventive Problem Solving (TRIZ) [Altshuller, 2011; Shpakovsky, Novitskaya, 2011] to the problem at hand, then in the most simplified version the transport system includes a number of subsystems:

- a subsystem of the transport movement relative to the earth's surface (let's call it 'Carrier'). This subsystem can be considered as a wheel, the hull of a ship or the wings of an aircraft;
- a subsystem in which cargo is stored during transport ('Storage'). Bags, crates, pallets, containers, etc. can be considered as this subsystem;
- a subsystem 'Engine' that powers the 'Carrier'. In different historical eras, this has been the physical strength of man, the strength of pack animals, a sail, an internal combustion engine, etc.;
- a subsystem designed to plan a route and manage loading, transport, unloading and storage ('Computer'). This function is assigned to drivers, machinists, dispatchers, etc.;
- an infrastructure subsystem (including roads, paths, canals, etc.).

Let's look at the simplest way to move loads - using the muscle power of one person (Fig. 1).

Fig. 1 shows that even in a scheme with one person, the above subsystems can be distinguished, each of which has developed along its own trajectory. At the same time, all these trajectories are united by a pattern: a person consistently rejects all new functions from himself and transfers them to technical systems.

Improvements in freight transport technology can occur under the influence of both random causes and conscious research. In both cases, however, their practical application takes place under the control of the 'computer'.

The history of mankind convincingly shows that the transport system has made a colossal leap forward. Today, however, many researchers argue that a fundamentally new stage of unmanned transport is coming, which will radically change the economy and society.

[1] The draft Federal Law 'On Highly Automated Vehicles and on Amendments to Certain Legislative Acts of the Russian Federation', prepared by the Ministry of Transport of the Russian Federation, project ID 02/04/06–21/00116763 (not included in the State Duma of the Federal Assembly of the Russian Federation). http://www.consultant.ru.
[2] Taxonomy and definitions for terms related to on-road motor vehicle automated driving systems (2018). Warrendale, PA, USA, SAE International.

2. Modernity

Transport is a much more complex system than individual production. This is particularly noticeable in times of crisis: any disruption to the transport system immediately affects the activities of producers and consumers. On the other hand, the dependency of transport on a specific customer is usually radically lower. This is because transport provides the basis for trade and not vice versa. Trade, in turn, leads to market-oriented production.

The key trend in the development of modern transport is unmanned vehicles. It is taken for granted (if not proven) that transport without human intervention is efficient. What is overlooked, however, is that the economic efficiency and feasibility of this technology can only be achieved if two conditions are met simultaneously:

1) significantly lower transport costs for unmanned transport than for traditional industrial transport;
2) guaranteed volume, frequency and uninterrupted transport.

These two conditions, in turn, can only be achieved if the transport becomes massive and, crucially, of the same type (along the same route, according to a single schedule, with the same type of cargo, etc.). This is where self-driving vehicles could theoretically offer the lowest variable costs not achievable by human-driven vehicles and recoup the higher capital investment of advanced transport.

In such favourable conditions, unmanned vehicles will be able to demonstrate all their advantages:

– The possibility of working around the clock and even all year round;
– Minimal variable costs;
– Easy and cheap scalability to all areas of the same type of transport.

The disadvantages should not be overlooked:

– Significant initial investment;
– Functional rigidity: technology, unlike people, is not able to adapt quickly to a qualitatively different type of activity;
– Absolute rhythm and predictability of transport: unmanned transport is intolerant of accidents;
– The inertia of transport technology: it can only be developed jointly with other entities (from software manufacturers to road builders and authorities).

It is the inflexibility and high cost of modern unmanned systems, as well as the unstable external environment, that do not allow them to displace humans from the field of transport today. The technology is almost there, but contrary to the dreams of science fiction writers, artificially intelligent systems today draw pictures, play chess, write songs, but the physical work, including the manual control of transport, is still done by or under the direct control of a human.

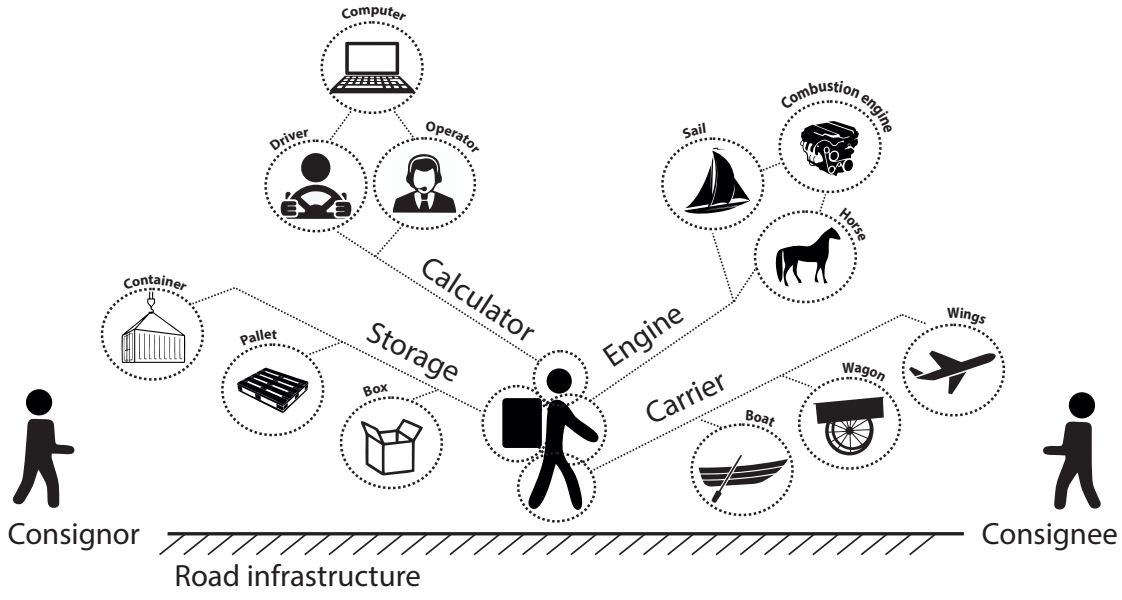
The current level of unmanned transport is such that its effectiveness in unpredictable traffic situations remains low. A clear example is autopilots in civil aviation: automation can control the aircraft, but in an emergency, control is immediately transferred to a human pilot.

In fact, drones claim to completely remove humans not only from direct manual control of transport vehicles, but also from dispatching and logistics (i.e. to become a completely dehumanised, unmanned mode of transport).

If we transform Fig. 1, we get a diagram of dehumanised, unattended transport (Fig. 2).

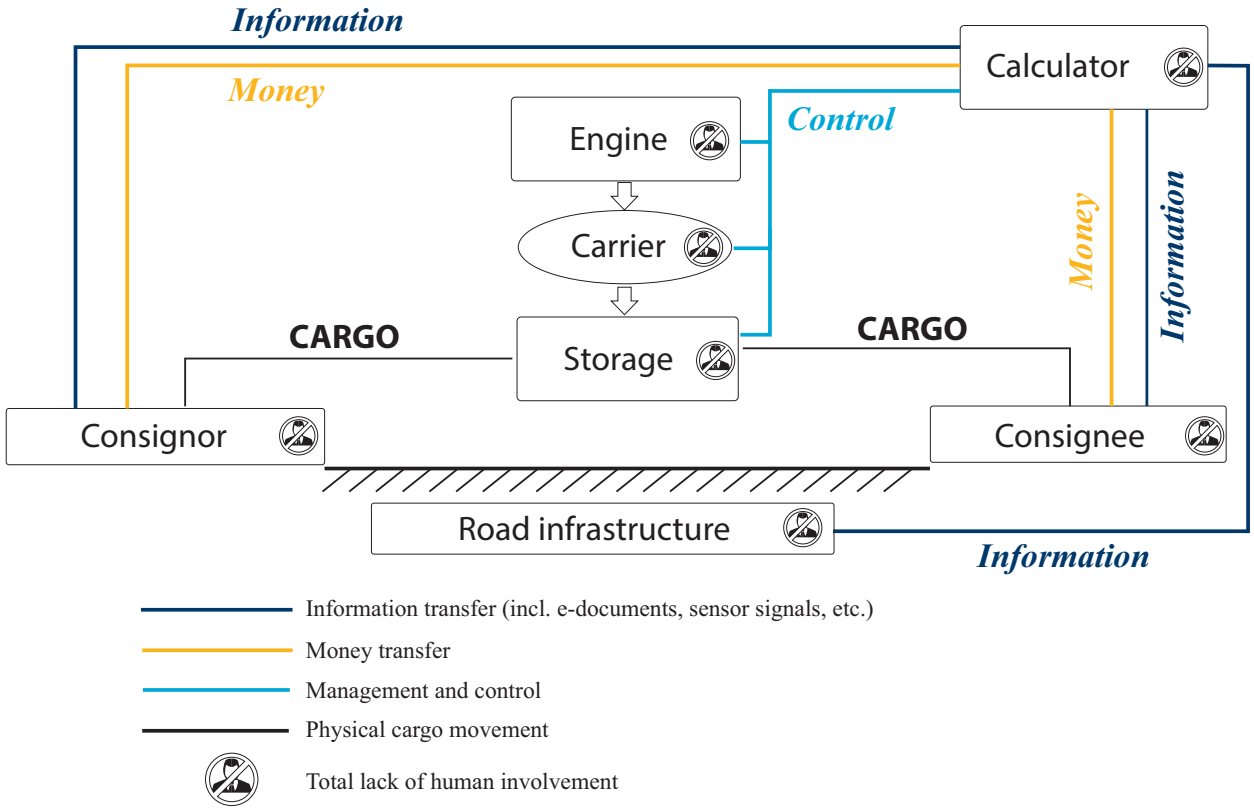
Humans create unpredictability, so their presence in any role (driver, consignor, consignee, etc.) is undesirable from the point of view of completely dehumanised transport. It is no coincidence that drones are most successfully introduced

Fig. 1. Structure of cargo handling system and development of its subsystems



Source: compiled by the author.

Fig. 2. Scheme of a completely deserted, dehumanised transport



Source: compiled by the author.

into the production process in places where human presence is minimal: mines, industrial sites, marshalling yards. The logic of the development of this technology suggests that the control functions should be transferred to the vehicle itself, and the coordination and forecasting functions to the road infrastructure, which should analyse road traffic, monitor weather conditions, control traffic lights, and so on.

3. Evolutionary scenario for the development of unmanned vehicles

Although unmanned vehicles are highly intelligent and rely on numerous sensors, computer vision systems and satellite navigation, they pose a danger to people and their property, as news reports have amply demonstrated. At the same time, there are no established legal models or operational regional unmanned systems in the legislation of different countries.

This presents a unique opportunity: the first country to introduce an effective system of regional unmanned transport will set the standard for unmanned transport around the world for decades to come. We see examples of this in past centuries: road gauge, power supply voltage, keyboard layout and much more. Today, there is no shortage of different models and prototypes of unmanned vehicles, but the regional door-to-door freight delivery system is not on show.

Many countries are working hard to take the lead in this race. Russia has adopted the Transport Strategy of the Russian Federation until 2030 with a forecast until 2035[3]. Projects are being developed under the National Technology Initiative: Marinet (maritime transport), Autonet (logistics for people and goods), Aeronet (unmanned aerial vehicles).

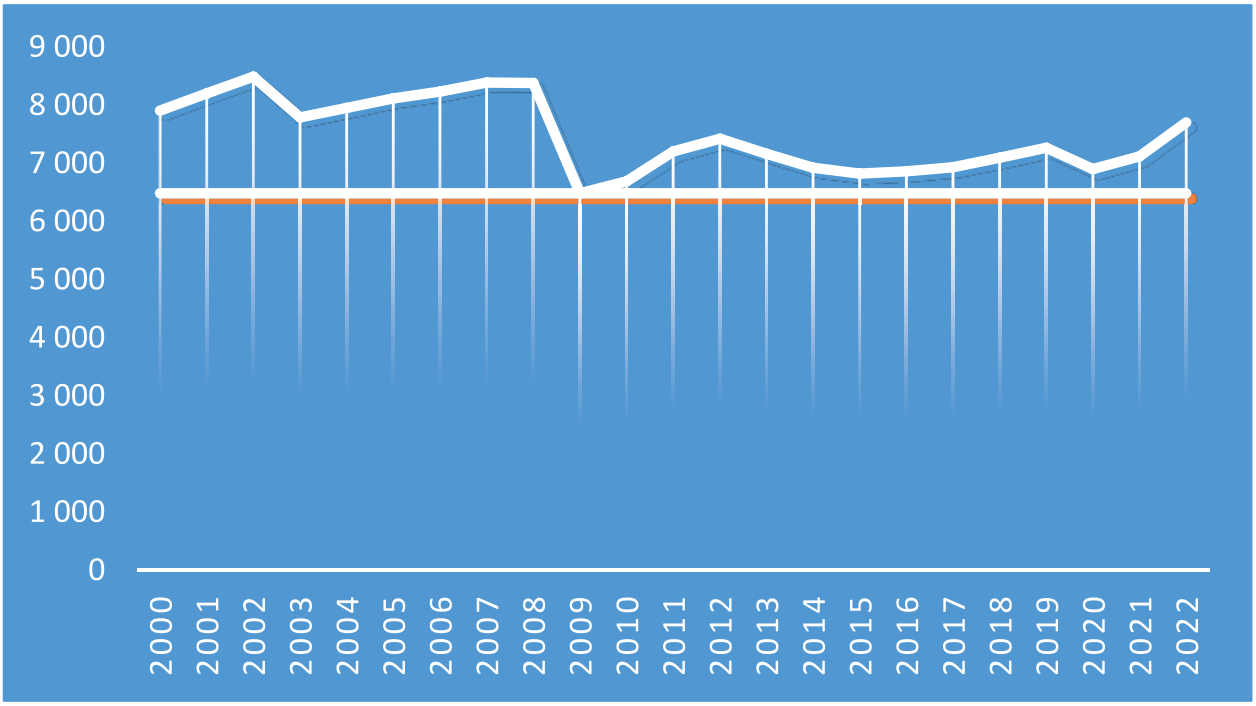
However, special requirements for transport infrastructure objects of unmanned vehicles are not regulated by law and apparently have not even been formulated yet.

The draft federal law 'On Highly Automated Vehicles and Amendments to Certain Legislative Acts of the Russian Federation' divides unmanned vehicles into two groups: vehicles in which a test driver is constantly present, and vehicles that are remotely controlled. In other words, we are not yet talking about the complete elimination of humans from the sphere of transport, but the level of technology described by the law will bring completely new risks [Begishev, 2021]:

– software unreliability, for which Tesla products, for example, are known today. In 2022, for example, a glitch caused a self-driving Tesla car to increase its speed to 198km/h instead of parking, resulting in the deaths of people[4];

[3] Decree of the Government of the Russian Federation dated 11/27/2021 No. 3363-r 'On approval of the Transport Strategy of the Russian Federation until 2030 with a forecast for the period up to 2035'. http://static.government.ru/media/files/7enYF2uL5kFZlOOpQhLl0nUT91RjCbeR.pdf.
[4] https://life.ru/p/1538680.

Fig. 3. Freight transport according to modes (excluding pipelines) (mln t)



Source: compiled by the author based on Rosstat data: https://rosstat.gov.ru/statistics/transport.

– information threats to intelligent transport. These include attempts to gain unauthorised access to the vehicle's systems, as well as sending false signals. In 2021, for example, it was discovered that car sensors may not recognise road signs correctly if they are slightly distorted[5].

Legal risks from the external environment are also increasing. For example, who will be responsible for the risks of emergency situations? What will be the consequences of legally significant actions performed between different unmanned and automated intelligent devices (e.g. entering a paid car park with automatic payment, receiving valuable cargo, etc.)?

The President of the Russian Federation, V.V. Putin, spoke on the subject. Putin said, 'From whom should we recover damages if, for example, an unmanned vehicle causes a traffic accident, and the authorities and management often reach a dead end... How to ensure liability for the actions and, in certain cases, for the inaction of robots and artificial intelligence algorithms?'[6]

Moreover, neither these legal questions nor fundamental ethical problems have yet been answered [Chen et al., 2023]. For example, the well-known 'trolley problem', formulated in 1967, has still not been solved: a speeding trolley can only move along two tracks on which people are chained (on one - five people, on the other - one). Which way should the driver choose in this situation? Today, the responsibility lies with the driver, but who will be held responsible for the actions of a completely inhuman vehicle? Many studies are devoted to this problem today, including those of theology, Protestant ethics [Németh, 2023], etc. However, some authors note that there is currently no alternative to the 'utilitarian principle of saving more lives' [Mayer et al., 2023].

As a result, traditional risk management strategies cannot be applied to autonomous vehicles because they require accurate and reliable estimates of the probability of choice outcomes and agreement on values [Resnik, Andrews, 2023].

Until all these issues are resolved, such transport cannot be used en masse [Jędrzejewska, 2023]. Real needs, of course, cannot expect a protracted solution to this theoretical problem and therefore rely on the usual algorithms for transferring responsibility to the manufacturer, owner, driver or operator..

Thus, in the state of California, where unmanned vehicles have the right to drive on public roads, the responsibility is assigned by law to the driver, who is obliged to take control of the vehicle at all times [Tsirit, Tatyanina, 2019]. German legislation establishes the mandatory presence of a driver at the wheel, who controls the movement of a highly automated vehicle, and each unmanned vehicle must have a black box installed to record the course of the journey and establish the

[5] https://www.securitylab.ru/news/487718.php.
[6] http://www.kremlin.ru/events/president/news/67099.

technical characteristics of a potential offence [Korobeev, Chuchaev, 2019]. In Russia, according to the federal bill 'On highly automated vehicles... '[7] responsibility will be assigned not only to the driver in the car, but also to the remote operator.

There seems to be only one radical solution to this problem - the separation and isolation of unmanned cargo transport in a separate system where there is no room for accidents. In the same way that oil and gas are transported today in closed loops along oil and gas pipelines, freight transport will most likely consist of isolated strings of identical transport units carrying a homogeneous cargo. Projects are already being developed that could serve as a basis for this: in the railway sector, there are plans to create separate tracks for passenger and freight transport [Ovchinnikov, Kulgin, 2021].

At the same time, it is necessary to realise that such an isolated transport system can serve only fully predictable cargo flows (in terms of volume, schedule, type, etc.). This in turn means that all human needs must be divided into stable (fully predictable) and unstable (unpredictable). The former will probably be served by unmanned vehicles, the latter will be served by traditional ones.

In our opinion, it is possible, as a first approximation, to estimate the ratio of stable and unpredictable needs based on the dynamics of freight transport by year (excluding pipeline transport) (Fig. 3).

Fig. 3 shows that, although the volume of goods transported by all modes of transport has changed continuously over the years, it has not fallen below the minimum volume of goods transported of 6485 million tonnes (which is approximately 87% of the volume of goods transported). It can be tentatively assumed that this ratio (13/87) over the period under consideration characterises the approximate relationship between the foreseeable and unforeseeable needs of final consumers, which in turn allows us to assess the prospects of traditional and unmanned modes of transport. It can be predicted that the transformation process will not be limited to the creation of an isolated system of unmanned freight transport. It will most likely lead to a fundamental change in consumer behaviour.

The demand for full predictability and rhythm of unmanned transport will be imposed on consignors and consignees. Freight with a constant volume will be transported according to schedule and at minimum prices. Freight with unpredictable volumes (e.g. due to fashion influences) is likely to be transported via traditional shipping lines and at higher rates. This means that the transport system will reward predictable human characteristics and indirectly 'punish' unpredictable ones (through higher transport tariffs).

As a result, there will inevitably be a reformatting of a person's needs and their whole personal life: they will become radically more 'predictable'. Spontaneity and chance will be slowly but surely driven by an iron roller into the immaterial sphere, where there is no material inertia and no resistance of the transport system.

Moreover, dehumanised transport will require sacrifices comparable to those of earlier technologies. Thus the advent of writing led to a weakening of memory (it is unlikely that any reader today will be able to recall and reproduce from memory 'the Rigveda', 'the Odyssey', or even an average story). The advent of the counting system has removed the need to count in the head. The keyboard weaned us from handwriting. Machine tools and tools weakened the strength of our hands, and optics contributed to visual dysfunction. Of course, some people retain and even develop these skills, but this is not widespread, and the skills themselves have been transformed from a survival tool into a hobby.

In this regard, we should expect a person to lose the ability to drive vehicles, the ability to navigate the terrain, and even the ability to anticipate their own needs.

If this scenario comes to pass, we will initially see a bifurcation of transport into unmanned and traditional transport, and after a certain period of time they will merge at a higher level of complexity. It is possible that in the near future there will be intelligent systems capable of predicting or directly programming even currently unpredictable needs.

4. Niche scenario for unmanned vehicle development

There is a non-zero probability that unmanned vehicles will not have a significant impact on the transport industry and will only serve some market niches. Let's consider the possible reasons for this scenario.

1. Unmanned transport as a regional or transcontinental system may not be economically competitive with traditional transport modes. This may be due to extremely high capital investment, higher transport costs, reduction of transport tariffs by traditional transport (dumping), etc.

2. To achieve dominance, unmanned vehicles must cover all stages: from the mine to the shop door. Otherwise, the stages that remain under human control will throw the entire transport chain into chaos. The result will be an alternation of emergency operations and downtime, with increased risks and costs. This means that unmanned transport should not even be national, but transcontinental. In other words, unmanned transport presupposes a globalised world economy.

However, world events in recent years may lead to a reversal of globalisation trends towards regionalisation. As a result, the world may be divided into economically isolated regions and the need for transcontinental transport will be minimal.

3. The global transport system is influenced by a myriad of factors: economic, demographic, political, natural and many others. This means that even the most isolated freight circuits are affected by an ever-changing external environment. This influence is virtually unpredictable (after all, man cannot control the entire universe) and can potentially paralyse unmanned traffic. In this case, even a series of small stops will be enough to change views on the means of delivery.

4. It is not yet clear how increasingly stringent environmental requirements will affect new forms of

[7] The draft Federal Law 'On Highly Automated Vehicles and on Amendments to Certain Legislative Acts of the Russian Federation', prepared by the Ministry of Transport of the Russian Federation, project ID 02/04/06-21/00116763 (not included in the State Duma of the Federal Assembly of the Russian Federation).

transport. In terms of carbon footprint, driverless vehicles are unlikely to differ significantly from traditional vehicles. At the same time, there is now a strong case to be made for moving away from modes of transport with high carbon footprints, such as rail over air. The ESG agenda is gradually becoming a mandatory practice, and many of the largest companies (e.g. Rusal, Novatek, Gazprom, Lukoil, etc.) have adopted 'corporate climate strategies aimed at reducing CO2 emissions by increasing the share of carbon-free energy sources and investing in compensatory afforestation' [Zhavoronkova, Agafonov, 2022]. It is possible that in the new round of the struggle to save the planet not only air transport, but also rail and road transport will be undesirable, and the most environmentally friendly will remain, for example, river transport. However, the instability of the external environment in water transport is much higher, which will cast doubt on the suitability of unmanned technologies there.

5. Such a development of additive technologies cannot be excluded when all consumer goods (including food) are produced close to the place of consumption from universal substrates. For example, bioprinting of meat and other prepared foods is no longer science fiction [Jeong et al., 2022; Tibrewal, 2023]. This could potentially lead to the transport of mainly basic substrates (proteins, fats, carbohydrates) from region to region, which can be easily handled by traditional means of transport.

In the scenarios mentioned above, unmanned transport will only serve a few relatively isolated niches: transport in mines, shunting locomotives in marshalling yards, delivery of parcels to consumers, etc. At the same time, where traditional and unmanned modes of transport meet, emergency situations will inevitably arise, as is already the case on public roads: unmanned vehicles have different speed characteristics, which leads to periodic congestion and traffic jams. Moreover, some authors consider it advisable to reduce the average speed of autonomous trucks, which will reduce costs and carbon dioxide emissions: according to some data, reducing the target speed from 90 to 70 km/h reduces fuel consumption and carbon dioxide emissions by 26% [Bray, Cebon, 2022].

5. Discussion and conclusion

In conditions of autonomy of the means of freight transport, the sensitivity of the transport system to disruptions will increase. The smallest disturbance can have unpredictable consequences for the regional or even continental economy. This requires the allocation of a separate, isolated freight transport subsystem. Furthermore, based on the unproven hypothesis that an increase in order in one place leads to a similar increase in chaos in another, an increase in order in the sphere of transport and people's vital needs will lead to chaos in other areas of society.

Unmanned transport can lead to a complete reformatting not only of the transport system, but also of human needs.

In the niche option, unmanned vehicles will only take place in isolated transport circuits.

References

Altshuller G.S. (1979). *TSIP - The theory of solving inventive problems.* Moscow, Soviet Radio. (In Russ.)

Begishev I.R. (2021). The legal regulation of unmanned means of transport. *Transport Law,* 3: 7-10. (In Russ.)

Zhavoronkova N.G., Agafonov V.B. (2022). The role of the national climate law in ensuring "Energy transition". *Actual Problems of Russian Law,* 2: 151-162. (In Russ.)

Korobeev A.I., Chuchaev A.I. (2019). Unmanned vehicles: New challenges to public security. *Lex russica,* 2(147): 9-28. (In Russ.)

Ovchinnikov D.V., Kulgin K.A. (2021). Aspects of design and calculation of a railway track intended for dedicated passenger lines. *Russian Railway Science Journal,* 80(6): 351-358. https://doi.org/10.21780/2223-9731-2021-80-6-351-358. (In Russ.)

Tsirit O., Tatyanina A. (2019). About some questions of criminal responsibility for accident with the participation of an unmanned vehicle. *Issues of Russian Justice,* 4: 461-472. (In Russ.)

Shpakovskiy N.A., Novitskaya E.L. (2011). *TSIP. Practice of targeted invention.* Moscow, Forum. (In Russ.)

Bray G., Cebon D. (2022). Operational speed strategy opportunities for autonomous trucking on highways. *Transportation Research,* 158(9): 75-94. DOI: 10.1016/j.tra.2022.01.014.

Jeong D., Wook J., Hong-Gu S., Show L., Bae H. (2022). Efficient myogenic / adipogenic transdifferentiation of bovine fibroblasts in a 3D bioprinting system for steak-type cultured meat production. *Advanced Science,* 9(31). DOI: 10.1002/advs.202202877.

Jędrzejewska E. (2023). Autonomous vehicles and the issue of liability for damage caused by the movement of such a vehicle. *Journal of Modern Science,* 51(2): 627-644. DOI: 10.13166/jms/168065.

Tibrewal K., Dandekar P., Jain R. (2023). Extrusion-based sustainable 3D bioprinting of meat & its analogues. *Bioprinting,* 29. https://doi.org/10.1016/j.bprint.2022.e00256.

Mayer M.M., Buchner A., Bell R. (2023). Humans, machines, and double standards? The moral evaluation of the actions of autonomous vehicles, anthropomorphized autonomous vehicles, and human drivers in road-accident dilemmas. *Frontiers in Psychology,* 13: 1052729. DOI: 10.3389/fpsyg.2022.1052729.

Chen N., Zu Y., Song J. (2023) Research on the influence and mechanism of human-vehicle moral matching on trust in autonomous vehicles. *Frontiers in Psychology,* 14: 1071872. DOI: 10.3389/fpsyg.2023.1071872.

Németh B. (2023). Coordinated control design for ethical maneuvering of autonomous vehicles. *Energies,* 16(10): 4254. https://doi.org/10.3390/en16104254.

Resnik D.B., Andrews S.L. (2023) A precautionary approach to autonomous vehicles. *AI Ethics Journal,* 27 March. https://doi.org/10.1007/s43681-023-00277-6.

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Formation and development of human capital and social-labor relations: The experience of Singapore

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Abstract

The article discusses Singapore's experience in the formation and development of human capital and social-labor relations. Singapore's successful implementation of policies in the areas of education, health care and the development of social and industrial relations was studied. Among the four major 'economic tigers' of East Asia, Singapore is the undisputed leader, as evidenced by key economic indices and ratings. Singapore has steadily improved its economic performance thanks to Lee Kuan Yew's forward-looking policies and rigorous implementation, and anticipating challenges on many fronts. The President of the Republic of Uzbekistan has identified six key areas of cooperation with Singapore in the near future, which are outlined in the article. There are great prospects for cooperation in the field of education, the development of information and telecommunications technologies, the financial and banking sectors, partnership in the areas of 'smart nation' and 'digital government' in the field of 'smart cities,' digital public services, fintech and artificial intelligence. In this way, Singapore has shown that investment in human capital can pay big dividends, and that nothing is impossible when it comes to technological breakthroughs in the Republic of Uzbekistan.

Keywords: human capital, investment, social-labor relations, tripartism, managerial skills, education, healthcare, preschool, school and higher education.

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新加坡在形成和发展人力资本以及社会和劳资关系方面的经验

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摘要

本文章介绍了新加坡在人力资本的形成和发展以及社会和劳资关系方面的经验：在教育、医疗保健以及发展社会和劳动关系领域成功实施国家战略。在"亚洲四小龙"中，新加坡无疑是佼佼者。主要经济指数和排名证实了这一领先地位。得益于李光耀高瞻远瞩的政策，新加坡的经济表现稳步提升。严格遵守这一政策有助于预见许多方面的挑战。乌兹别克斯坦共和国总统确定了近期与新加坡合作的六个关键领域，本文将对此进行介绍。在教育、信息和电信技术发展、金融和银行业方面、在智慧国家和数字政府、智慧城市、数字公共服务、金融科技和人工智能等领域的合作前景广阔。新加坡已经证明，人力资本投资可以带来丰厚的回报，乌兹别克斯坦共和国在技术突破方面也没有什么是不可能的。

关键词：人力资本、投资、社会和劳资关系、三方主义、管理技术、教育、医疗保健。

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Increasing the intellectual and spiritual potential of the youth, forming a new generation with deep knowledge, educated in the spirit of patriotism, national and universal values are related to the future of Uzbekistan are the most important at the current stage of reforms in the country.

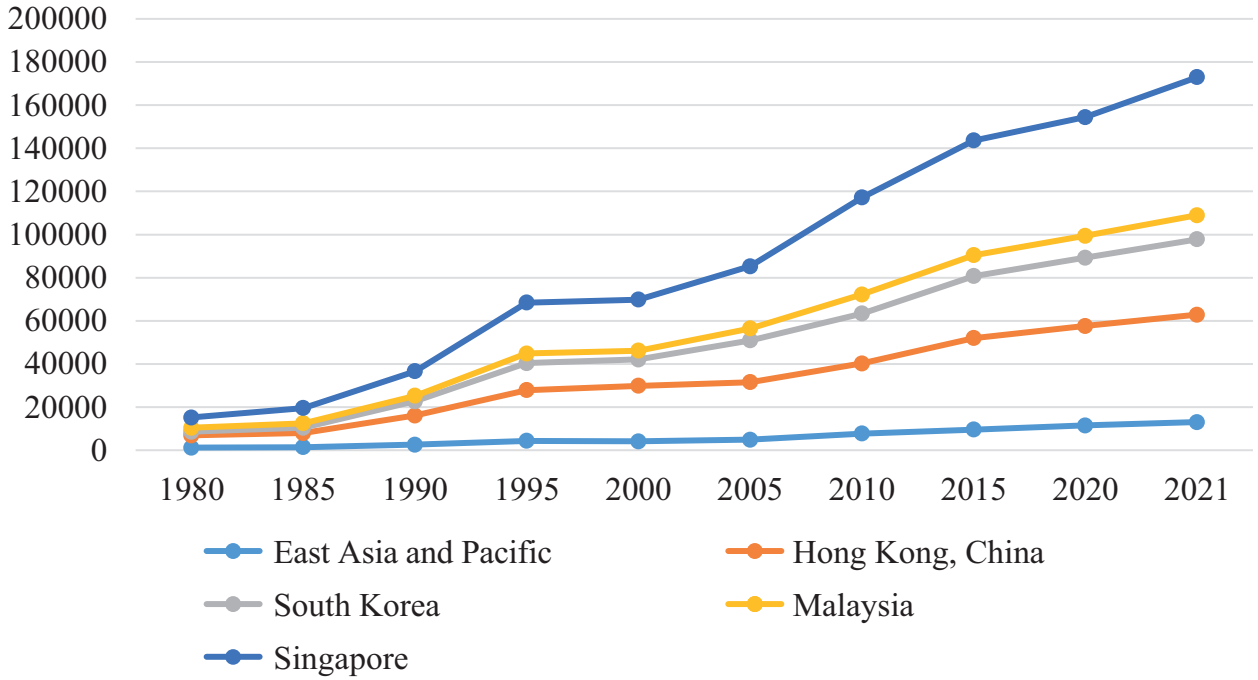
It is obvious that the accelerated development of Uzbekistan depends on the generation that has mastered modern knowledge and advanced technologies. It is highly qualified personnel, who are associated with the 'new renaissance'. In this respect, the state is sparing no effort or resources to ensure their harmonious development. It is no coincidence that the President of the Republic of Uzbekistan emphasises the importance of this issue, noting that the development of pre-school, school and higher education is 'a matter of life and death'[1]. In view of the above, it seems interesting to study the experience of Singapore, one of the world's leading countries and the economic centre of the Asia-Pacific region.

Since independence in 1965, Singapore's economy has transformed from a low-income economy to a developed high-income economy. During this period, the country's education policy has been aligned with national economic policy and human capital formation. Singapore has demonstrated that investment in human capital can yield greater returns in technological breakthroughs.

Many elements of the Singapore model are now widely accepted. Although many developing countries have attempted to follow similar strategies, few have been fully successful in achieving similar results. This study examines the policies, programmes and processes that Singapore has implemented from 1960 to the present to stay ahead of other countries.

The article identifies several factors that have contributed to Singapore's successful implementation of policies in the areas of education, health and the development of industrial relations. First, the collection and analysis of data to

Fig. 1. Dynamics of GDP per capita
in East Asian countries, 1980–2021



Источник: составлено автором на основе данных рейтинга глобальной конкурентоспособности, составляемого Всемирным банком: http://www3.weforum.org/docs/GCR2018/05FullReport/TheGlobalCompetitivenessReport2022.pdf: https://www.imd.org/wcc/world-competitiveness-center-rankings/world-competitiveness-ranking-2022/.

[1] Mirziyoyev Sh.M. (2022). Message from the President of the Republic of Uzbekistan to the Oliy Majlis and the people of Uzbekistan. 20th of December. https://president.uz/ru/lists/view/5774.

inform policy development. Second, effective leaders who fight corruption and set high standards for themselves and others. Third, Singapore has created a meritocratic and largely non-politicised bureaucracy that can strategise, develop forward-looking policies and implement them in a coordinated manner. Coordinated implementation is key to achieving results. Fourth, the national leadership maintained harmony in the multi-ethnic society and actively reduced tensions. Fifth, Singapore attracted immigrants, both skilled and unskilled. Sixth, the leadership mobilised domestic resources, which played a critical role in financing infrastructure, housing and other key investments. Finally, Singapore has never rested on its laurels; it has always been open to ideas, willing to learn, innovate and embrace new technologies.

Social and labour relations in Singapore can be understood and studied using Dunlop's model [Dunlop, 1993]. It consists of three actors (government, union and management) in the context of the environment, the mechanisms through which the actors interact, the outcomes of the cooperation (workplace rules) and the feedback mechanism (consequences for the actors and society). The Singapore model is also characterised by cooperative tripartism, with features such as (1) strong informal and formal communication networks, (2) the dominance of government as a policy, (3) a primary concern for economic growth, political stability and industrial peace, (4) a strong centralised trade union movement (there is only one trade union federation - the National Trade Union Congress), (5) a symbiotic relationship between government and trade unions, and (6) a non-confrontational approach to problem solving.

Singapore is the undisputed leader among East Asia's four major economic tigers. This is confirmed by key economic indices and rankings[2]. The country's GDP per capita growth has outpaced other Asian tigers since 1980 (Fig. 1). Singapore is highly competitive (ranked third in the International Institute for Management Development's World Competitiveness Index and second in the World Economic Forum's Global Competitiveness Index[3]). The country was ranked fifth among the most innovative economies in the world in the Global Innovation Index [Breuer, Pinkwart, 2018]. Singapore also ranks fifth in the Observatory of Economic Complexity's Economic Complexity Index. The country ranks second in the World Bank's Doing Business Index for ease of doing business, and has the highest online readiness score in the Global Information Technology Report. Singapore was ahead of other East Asian countries because it never rested on its laurels.

Since becoming an independent republic in August 1965, Singapore has steadily improved its economic performance through forward-looking policies and strict adherence to them, anticipating challenges on many fronts. To paraphrase Lee Kuan Yew, the man who made Singapore what it is today, relentless effort can achieve the impossible.

Under the leadership of Lee Kuan Yew, Singapore's government adopted a strategy of rapid industrialisation aimed at creating jobs for low-skilled workers and generating income from exports. As with other 'Asian Tigers', it began with the production of garments, shoes, toys and basic consumer electronics. The government has set its sights on rapidly diversifying and deepening industry to move up the income ladder. To achieve this goal, the small island economy needed to attract investment from transnational corporations (TNCs) and integrate local industry into their emerging global value chains. This was achieved by developing industrial zones supported by modern heavy and light infrastructure, reforming laws to end endemic labour disputes and, most importantly, creating an efficient bureaucracy to minimise transaction costs for business. Recognising that the quality of the workforce would be a key attraction for multinationals, the government laid the foundations early on for an education system that would provide the skills needed to support a modern industrial economy.

The quality of human capital, management skills and intangible capital have had a strong impact on Singapore's economic performance. Representatives of the scientific school 'Labour Economics and Human Capital' at the Tashkent State University of Economics argue that we live in 'the era of human capital in the sense that human capital is the most important form of intangible capital in the modern economy on a global scale, including in the Republic of Uzbekistan. The economic success of individuals, as well as entire economies, depends on how extensively and effectively people invest in themselves' [Abdurakhmanov, 2021].

It should be noted, however, that Uzbekistan has significant shortcomings in its education system. Enrolment in kindergartens was low, a crisis was brewing in school education, and young people graduating from universities were unprepared to compete in the labour market. The level of education in universities was unsatisfactory, but competition for admission to universities and institutes was in the double digits, while professors and teachers received low salaries, students and teachers were tired of forced labour, and the status and authority of teachers in society was unacceptably low.

Solving these problems required huge amounts of money and decisive action. Funds were and are being allocated, and education reform began at an accelerated pace. The head of state identified education as one of the priority areas for laying the foundations of a new Uzbekistan.

In general, a great deal of work has been done in the field of education. This has resulted in the creation of an effective system of comprehensive and continuous support for children from birth to adulthood, helping them to find a worthy place in life. The President of the Republic of Uzbekistan regularly holds meetings on the subject of education, at which the accumulated problems

[2] The search for the sources of Singapore's economic power, political system and leadership has been the subject of numerous academic studies. A keyword search by author identified 45,300 articles published between 1993 and 2016, including 200 academic articles on the Singapore model alone.
[3] https://www.globalinnovationindex.Org/gii-2022-report#.

Table 1
Uzbekistan human development index

Indicators	2020	2022	Dynamics from 2020 to 2022
Life expectancy at birth (years)	71.7	70.9	–0.8
Expected duration of study (years)	12.1	12.5	+0.4
Average duration of study (years)	11.8	11.9	+0.1
GNI per capita at PPP (USD)	7142	7917	+775
Human Development Index	0.72	0.727	+0.007
Human Development Index ranking	106	101	+5

Source: Compiled by the author on the basis of the data from https://hdr.undp.org/system/files/documents/global-report-document/hdr2021-22overviewrupdf.pdf.

are discussed in a critical spirit. For example, the issue of further improvement of 10,130 schools across the country was discussed - after all, the future of more than 6 million students and over 500,000 teachers, representatives of all strata of our society, every family, depends on his decision.

As a result of the ongoing reforms, the Republic of Uzbekistan is ranked 101 out of 191 countries in the Human Capital Index in 2022, with an index value of 0.727 (the maximum index value is 1,000), improving its ranking by five positions and the index value by 0.07 compared to 2020 (Table 1).

The comparative analysis shows that the only indicator negatively affecting the Human Development Index (hereafter HDI) for Uzbekistan is life expectancy at birth, which has fallen by 0.8 years compared with 2020. According to experts, the reason for this decline is the situation with the spread of COVID-19 and the weakness of the health system in the fight against this infection.

Singapore is the economic centre of the Asia-Pacific region. For many years, it has maintained its status as one of the world's largest and most developed economies, built on success in key industries such as electronics, chemicals, biotechnology, banking, logistics and transport.

With this in mind, the President of the Republic of Uzbekistan identified six key areas of cooperation with Singapore in the near future[4].

Firstly, 'the development of human capital and the training of highly qualified personnel for public administration'. An implementation agreement was reached with the School of Public Policy. Lee Kuan Yew Joint Programme for the education and training of civil servants in the fields of governance, urban planning, infrastructure development, digital transformation, innovation, education and health. An intensive retraining programme for civil servants will also be launched, based on the Academy of Public Administration of Uzbekistan, with the participation of leading Singaporean experts.

Secondly, the involvement of the Singaporean side in the privatisation processes in Uzbekistan. In this context, the prospects for implementing new projects in the framework of privatisation of large enterprises in Uzbekistan with the involvement of advanced experience, modern technologies and management of leading Singaporean companies have been identified. A joint investment fund for the transformation and restructuring of state-owned enterprises will be established, with the aim of further launching an IPO and attracting external investment.

Thirdly, attracting advanced green technologies and digital solutions is a top priority. Opportunities have been identified to leverage Singapore's achievements in digitalisation and the use of innovation and technology in 'green development'[5].

Fourthly, to attract Singapore to improve Uzbekistan's urban infrastructure and communications. Measures have been developed for cooperation in urban planning and construction, landscaping and public utilities. The first step in this direction is the establishment of a joint design and engineering centre in Uzbekistan for the implementation of infrastructure and industrial projects.

Fifthly, areas of cooperation have been developed, including the promotion of investment and the expansion of mutual trade through the promotion of joint projects with leading Singaporean companies.

[4] Uzbekistan - Singapore: New horizons for the development of multifaceted cooperation. https://president.uz/ru/lists/view/5825.
[5] Id.

In this regard, an Uzbek-Singaporean investment company will be established with an authorised capital of $500 million.

Sixthly, it is necessary to emphasise the exchange of experience in the field of ensuring public security, maintaining inter-ethnic harmony and combating radicalism.

In Singapore, the aforementioned School of Public Policy, named after Lee Kuan Yew at the National University of Singapore, is one of the world's leading higher education institutions. The school has long been at the top of the world rankings of higher education institutions and organises short-term training programmes for senior officials from abroad.

It is widely known that a well-thought-out human resources policy and the priority given to the training of qualified, competent and honest managers have played an important role in Singapore's economic and social success. The President of the Republic of Uzbekistan has paid special attention to these issues from the very beginning of his activity. Therefore, studying and applying Singapore's experience in the field of public administration training is of great importance.

In the context of expanding opportunities for bilateral partnership, we will look at the key milestones of cooperation between the countries and characterise the immediate prospects for interaction.

Uzbekistan is interested in attracting Singaporean capital and establishing production cooperation. An example of this is the partnership between the Uzeltehsanoat Association and the Singapore Semiconductor Industry Association. Hong Leong Asia plans to set up a production facility in Uzbekistan to supply precast concrete, cement and rigid packaging to the local and international markets. Pan-United Corporation Ltd will supply concrete innovations. Collaboration with Singaporean companies Wellchem Pharmaceuticals and Poli Medical will enable the opening of joint ventures for the processing of medicinal plants and the manufacture of medicines from them. Systems on Silicon Manufacturing Company Pte. Ltd. will start producing electronic chips for cars in Uzbekistan, and a joint venture with Continental Automotive Singapore will produce sensors and displays for transmissions.

There are broad prospects for cooperation in the field of education, development of information and telecommunication technologies, finance and banking. Partnership in the field of 'smart nation' and 'digital government' in the areas of 'smart cities', digital government services, fintech, artificial intelligence are priority areas for expanding cooperation between Uzbekistan and Singapore, which has been recognised as one of the world's best 'smart cities' for many years.

Table 2
Timeline of Singapore's education system from 1965 to the present

1960–1970 - survival phase	1970–1980 – phase of increasing efficiency	1980–1990 – capability phase	1990-2000 – phase of forming schools of thought, learning nation	2000–2010 – 'teach less, learn more' phase
1960 Bilingualism	1970 Universal secondary education Council for Vocational and Industrial Education	1987 English taught as first language in Singapore schools	1995/1999 International trends in mathematics and science education	2002 Comprehensive training programmes are established
1965 Universal primary education	1976 Technical education		1997 Launch of a master plan for the development of IT technologies in education	From 2003 to present Creation of innovative and digital companies
1965–1970 Secondary enrolment almost doubles	1979 Introduction of continuing education		By 2000 the content of education programmes reduced by 30.0%.	

Source: compiled by the author using data from https://www.straitstimes.com/singapore/education/the-education-system-over-the-years.

Digital transformation is another promising area for the two countries, especially in the field of e-government. Singapore's focus on digital transformation began in the 1980s with the creation of the National Computerisation Programme. Today, 99.0% of all government transactions are conducted digitally.

Singapore's experience shows that it is not the length of education (the number of years of schooling) that contributes most to individual productivity and GDP growth, but the quality of education, as measured by the test scores of school leavers in science and mathematics. While years of education are weakly correlated with growth in accumulated knowledge, knowledge capital, which reflects the quality of learning, is strongly associated with growth in both magnitude and importance. Teachers' skills largely determine the amount and quality of knowledge transferred to students.

After independence, Singapore inherited a 'mix' of schools divided along ethnic lines: English, Chinese, Malay and Tamil schools, each with its own language of instruction and curriculum [Poon, 2009; Simon, 2016; Kerr, 2020; Testa et al., 2022]. During the colonial period, the administration favoured English-medium schools, which provided upward mobility for the local population, but most students attended schools where English was not the language of instruction. The first priority for the newly created state was to integrate Singapore's schools into a single system and, in the interests of the country's future outward-looking development strategy, to expand the use of English as the medium of instruction so that the future workforce could communicate with foreign companies. Fig. 2 provides a chronology of the measures taken to achieve these goals and other important developments from 1965 to the present.

As always, Singapore's policymakers are closely monitoring and absorbing global trends. They are well aware that global competition is intensifying. As intangible capital and innovation will be the main drivers of productivity growth in the future, the quality of human resources, the excellence of Singapore's researchers and the skills of its managers in government agencies, companies and schools will determine whether Singapore can remain at the forefront of Asia's economies. Singapore's administrative strength makes it flexible, and its small size makes it less likely to make mistakes.

In Singapore, the average family spends USD 71,000 on primary and tertiary education, according to an HSBC report on the value of education [Kerr, Kerr, 2020]. According to an earlier World Bank report, private expenditure on education in Singapore was 1.2% of GDP. Every Singaporean child between the ages of 7 and 16 has an Edusave account into which the government contributes USD 200 per year if the child is enrolled in a full-time school programme, vocational programme or special education programme. This money is intended to cover the family's educational expenses. Each child can also have a post-secondary education account, and the government will reimburse any payments made into this account, up to a certain limit, until the child reaches the age of 18. Any funds in this account that are not used to pay for higher education are transferred to the individual's Central Provident Fund (CPF) account, Singapore's compulsory social security scheme. There are also awards and scholarships for successful work.

Research shows that increased investment in education boosts economic growth. The cumulative effect of improved education includes higher wages, workforce efficiency and gross domestic product.

By ensuring the provision of quality education, the government will be able to significantly improve the skills and competencies of the workforce in line with the needs of the economy over the long term. As part of the reforms and economic transformation undertaken by the country's leadership, Uzbekistan will need a skilled workforce in the medium term to achieve maximum productivity and continuous innovation. This is a trend in today's increasingly globalised economy that must be taken into account if tangible results are to be achieved.

According to international experts, effective policies in education, science and innovation can contribute not only to the personal development of individuals, but also to the development of regions, stimulating processes of social inclusion and integration. Meanwhile, recent market research in developed countries shows a growing gap between the skills people acquire through education and training and the skills required by the labour market. The main reasons for this mismatch are the transition to Industry 4.0, the widespread introduction of technological innovations and structural changes in the business environment. For example, a study by the World Economic Forum found that closing the skills gap could add USD 11.5 trillion to global GDP by 2028.

In his message, the President of the Republic of Uzbekistan proposed to the Oliy Majlis and the people of Uzbekistan to proclaim 2023 as the year of caring for people and quality education. 'It should be noted in particular that a social state means, first of all, the creation of equal opportunities for people to realise their potential and the necessary conditions for their decent life and the reduction of poverty. Therefore, we must first of all pay attention to supporting education - the most important investment in the new Uzbekistan'[6].

To this end, a new programme will be implemented from 2023. European educational standards will be introduced in one of the technical schools in each region, and over the next five years such a system will cover all colleges and technical schools. At the same time, support for talented young people will be expanded. Specialist engineering schools will be set up in collaboration with leading international organisations in the chemical, electrical, transport and energy sectors. This will create a system for training a new generation of engineers.

Considering the share of youth in the republic's population structure, improving the quality of education and human capital will become an important driver of economic growth and improvement in the quality of life.

[6] Shavkat Mirziyoyev (2020). https://president.uz/ru/lists/view/5774.

The development strategy of the new Uzbekistan for 2022-2026 outlines the main aspects of radically improving the quality of education. In particular, tasks have been outlined whose implementation will ensure an increase in the rate of enrolment in pre-school education from the current 67.0% to at least 80.0%, as well as raising the quality of education in the pre-school system to a new level, including through the training of more than 160,000 teachers. It is also necessary to completely overhaul it on the basis of advanced foreign experience and to implement new curricula and textbooks[7] in practice by 2026. It is also worth noting that systematic work is being carried out in the Republic to increase the level of enrolment in higher education to 50.0%. All these measures are undoubtedly the main conditions for improving the quality of education. The necessary efforts are being made to improve Uzbekistan's position in the Global Innovation Index and to be included in the top 50 countries in the ranking by 2030.

As global practice shows, and Singapore's experience in particular, it is possible to achieve these goals. This is mainly possible by increasing spending on human capital, investing in infrastructure, and studying and adapting the best practices of the top 50 countries in the Global Innovation Index. Singapore's Skills Future Programme, for example, helps all students, from undergraduates to seasoned professionals, identify the skills they need for their chosen careers. It also provides access to the necessary resources. By reaching out to all segments of the population, the programme encourages lifelong learning among Singaporeans.

As for Uzbekistan, the republic is implementing comprehensive measures for the active development of digital human capital and the digital economy, as well as the widespread introduction of modern information and communication technologies in all industries and sectors. The 'Digital Uzbekistan-2030' strategy has been adopted, which aims to ensure a successful transition to the digital economy, taking into account modern trends. According to the strategy, the network of information systems and software products for the automation of management, production and logistics processes at enterprises in the real sector of the economy is being dynamically expanded. Systematic work is also being carried out on the further development of the e-government system, the expansion of the market for software products and information technologies, the organisation of local IT and technology parks, and the training of qualified personnel[8].

Many new universities are opening, including in cooperation with foreign countries (branches of prestigious universities). The quotas for those wishing to enter higher education are increasing. As a result, the number of universities in the republic has increased by 2.5 times - to 198, and enrolment in higher education has increased from 9.0 to 38.0%.

Uzbekistan and Singapore have successful experience of interaction in education and science. Countries are establishing close links between educational institutions. A striking example of cooperation is the Management Development Institute of Singapore (MDIS), which opened in Tashkent in 2008. Over the years, the university has trained thousands of professionals in banking, business management, tourism and other industries.

The Tashkent Institute of Technology, Management and Communications (TMC), a branch of the TMC Academy in Singapore, will also open in 2021. Under the current agreement, the Institute contributes 1% of its total income to the Multi-Partner Trust Fund for Human Security in the Aral Sea Region. The second campus of the university was opened last year. This will allow the number of students to increase by 12.5 times (from 400 people in 2021 to 5,000 in 2022).

Cooperation in education is developing rapidly. Uzbekistan and Singapore are implementing a number of joint projects. For example, in recent years, the Singaporean company SixClouds has launched an interactive online English learning programme for 300 schools in the Republic of Karakalpakstan and 14 presidential schools in Uzbekistan. The A-Level educational programme, which is recognised in 130 countries, has been introduced in the presidential schools and is already showing results. Each student studies specific areas in depth according to their abilities, and their chances of getting into the best universities in the world are increasing. The Singaporean side is also actively helping to modernise the programmes of pre-school educational institutions in our country. For example, an agreement was signed with the Singaporean company Modern Montessori International to establish a pre-school educational institution in Tashkent.

In the next five years, the coverage of children in pre-school educational institutions will reach 80.0%, while another 600,000 places need to be created. The private sector has an important role to play here. There will also be a major effort to build new schools and expand existing ones. One hundred schools will be built at the expense of private investors, and in the next five years the number of such educational institutions will increase to one thousand.

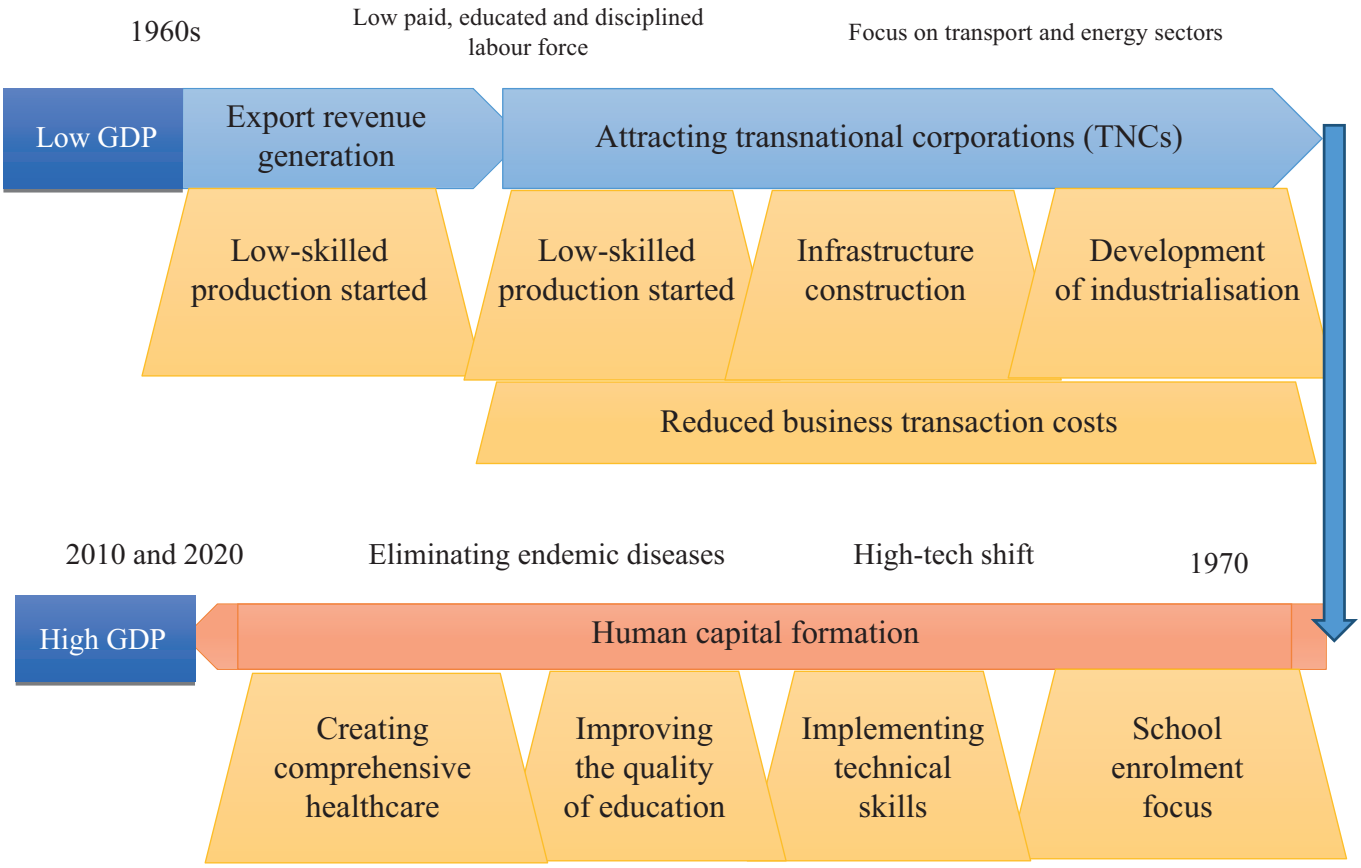
What positive results will the development of the private education system and the creation of equal opportunities for state and non-state educational institutions bring? First of all, there will be competition between them, which will open the way to the development of the sphere and improvement of the quality of education. Secondly, the number of children in classes will be reduced. Thirdly, corruption, which is deeply rooted in the education sector, will decrease. Fourthly, the number of knowledgeable, competent teachers will increase, as the need for qualified personnel in society will grow, wages will increase depending on the rating, and as a result, the status of the teaching profession will rise.

A branch of the Singapore Institute of Management Development's Service Quality Centre, which is highly regarded in Singapore and specialises in improving the skills

[7] Decree of the President of the Republic of Uzbekistan "On the development strategy of New Uzbekistan for 2022-2026" dated 28.01.2022 No. UP-60.

[8] Decree of the President of the Republic of Uzbekistan 'On approval of the strategy "Digital Uzbekistan-2030' and measures for its effective implementation' dated 10.05.2020 No. UP-6079.

Fig. 2. Elements of Singapore's development strategy



Source: compiled by the author.

of managers and middle managers in the service sector, will be established in the Republic. Established in 1990, the centre is currently the training and development arm of the Singapore Human Resources Development Agency and provides short-term intensive training (bootcamp training) to employees in various industries on behalf of the government and industry.

Singapore's higher education system is recognised as one of the most developed in the world. The study of Singapore's experience is necessary for Uzbekistan, as the republic's universities are in the stage of large-scale transformation. Domestic specialists are actively working on developing measures to implement Singapore's experience. An important partner in this area is one of Singapore's leading universities, TMC Academy. At present, the parties intend to expand the activities of the Academy's branch in Tashkent in two stages. In the first phase, two educational buildings will be constructed over the next two years at a total cost of up to $10 million. In the second stage, university buildings will be built in the regions of the republic, particularly in the Tashkent region. Work will be organised to train personnel in areas in demand on the Uzbek labour market (information technology, financial technology, cybersecurity).

In 2023, the funds allocated to preferential educational loans for university students will double, reaching a total of 1.7 trillion soums.

In 2022, 1.5 trillion soums were allocated for the development of science and innovation - almost 6 times more than in 2017. The salaries of scientists have also increased by 4.5 times. Thanks to the measures taken, 18 new scientific fields have been organised, such as nano and biotechnologies and digital geology. In 2023, 1.8 trillion soums will be allocated to science and innovation.

According to N.S. Ziyadullaev, the development of education has been elevated to the level of state policy in Uzbekistan over the past six years. A great deal of work is being done to raise the younger generation as physically strong people, creating conditions for the manifestation of skills and talents [Ziyadullaev, 2021].

Singapore's experience has shown how upgrading human capital can accelerate development and dramatically reduce poverty in a resource-constrained economy, and

this experience has been confirmed by other economies in East Asia. Can Singapore's models of quality education and health care be replicated in other middle- and lower-middle-income countries?

As noted above, some elements of these models were supported by conventional wisdom. Providing universal primary education, emphasising the quality of teacher training, focusing on teaching, especially in STEM subjects, collecting data for decision-making, strengthening school management, systematically assessing school and student performance, and controlling costs are integral to most countries' education strategies. Similarly, eradicating disease, focusing on prevention and primary care rather than acute care, and sharing the cost of health care between the population and the government are among the main goals of other countries. Many developing countries have made steady progress in building and improving their human capital, but few are fully satisfied with their performance, and strengthening their delivery capacity is a recognised priority.

This leads us to seven factors that have contributed to Singapore's success in implementing its education and health human capital strategies, factors that may be difficult to replicate elsewhere (Fig. 2).

Firstly, policy development requires the development of digital technologies that facilitate the collection and analysis of data and its use to formulate targeted policies.

References

Ziyadullaev N.S. (2021). *Transformation of national economies of post-Soviet states.* Moscow, Ekonomicheskoe obrazovanie. (In Russ.)

Abdurakhmanov K.Kh. (2021). Features of development of digital economy in Uzbekistan. In: *Innovative economy: Challenges, analysis and prospects for development.* 7 August.

Breuer W., Pinkwart A. (2018). Venture capital and private equity finance as key determinants of economic development. *Journal of Business Economics,* 88(3): 319-324. https://doi.org/10.1007/s11573-018-0892-x.

Dunlop J.T. (1993). *Industrial relations systems.* Boston, Mass, Harvard Business School Press.

Kerr W.R. (2020). The gift of global talent: Innovation policy and the economy. Cambridge, MA, *National Bureau of Economic Research,* Working Paper w25875. https://www.nber.org/system/files/working_papers/w25875/w25875.pdf.

Kerr S.P., Kerr W.R. (2020). Immigration policy levers for US innovation and start-ups. Cambridge, MA, *National Bureau of Economic Research,* Working Paper w27040. https://www.nber.org/system/files/working_papers/w27040/w27040.pdf.

Poon D. (2009). China's evolving industrial policy strategies and instruments: Lessons for development. Pretoria, *Trade and Industrial Policy Strategies,* Working Paper 2-2009. https://www.tips.org.za/research-archive/trade-and-industry/item/download/1108_d5a6a0704da527d4052d4085e811f4b2.

Simon J.P. (2016). *How to catch a unicorn: An exploration of the universe of tech companies with high market capitalization.* Brussels, ERC Joint Research Centre. https://data.europa.eu/doi/10.2791/893975.

Testa G., Compañó R., Correia A., Rückert E. (2022). *In search of EU unicorns - What do we know about them?* Luxembourg, Publications Office of the European Union. https://doi.org/10.2760/ 843368.

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Behavioral and cognitive factors in the formation of the heuristic model of the effective interpreter in investing in high-tech companies

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Abstract

The article presents a systematisation of the main factors of cognitive distortions and behavioural heuristics that make the switch to the effective interpreter model irreversible in portfolio investments, especially in high-tech companies. As the heuristic model of the effective interpreter can be perceived as generally increasing the risks in the system for all stakeholders at the current stage of the evolution of the investment system, the author focuses on the most negative manifestations of cognitive and behavioural factors in his description in the publication. However, this does not mean that it is possible or desirable to return to the rational investor model, as narrative and storytelling's components are too important in the context of 'new economy' industry formation and and fast business expansion by disruptive companies. To better interpret the business potential of companies, stakeholders, especially investors, increasingly need to work with narratives, storytelling, aspects of perception and business trust, rather than the numerical values and ratios of financial reporting and analytics. This is partly due to the fact that the intangible assets of companies in the S&P500 index have accounted for up to 90% of the total market capitalisation over the last two decades.

The author identifies the most significant cognitive and behavioral factors: the increase in the narrative component of equity value, the 'fake it till you make it' approach, the proliferation of cryptocurrencies as the asset with the largest narrative component of value, the boom in IPOs and SPACs in 2020-2021, buybacks as an unproductive signalling tool, the popularisation of chasing triple digit returns based on the survivor bias, the popularity of momentum strategies, the over-reliance on analyst recommendations and assessments, 'pump and dump' schemes, investment gamification and investor extroversion, anchoring and framing, the sunk cost fallacy, the lack of rigorous techniques for invalidating investment theses, and the perception of free money in investing over the past decade and a half. Awareness and tracking of at least the most significant behavioural and cognitive factors in the formation and further development of the heuristic model of the 'effective interpreter' will help to reduce risks in the financial and investment system of the 'new economy' and increase the sustainability of its long-term development.

Keywords: cognitive biases, behavioral heuristics, survivor bias, sunk cost fallacy, representativeness heuristic, market capitalization, stock market, portfolio investment, IPO, SPAC, innovation, narratives, irrational optimism, irrational exuberance, behavioral finance, growth companies, high-tech companies, new economy, cryptocurrencies, momentum strategies, investment thesis.

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高科技公司投资过程中 高效解释 启发法模型形成的行为和认知因素

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摘要
该文章系统阐述了认知扭曲和行为启发式的主要因素。它们在投资组合中，主要是在高科技公司，使转向"高效解释"模型变得不可逆转。由于在投资系统发展的现阶段，"高效解释"启发式模式可能会被认为普遍增加了系统中所有参与者的风险，作者重点阐述了认知和行为因素最消极的表现形式。然而，这并不意味着回归理性投资者模式是可能的或可取的，因为在"新经济"产业的形成和颠覆者公司的业务建设中，叙事和讲故事意义重大。为了更好地解读公司的商业潜力，参与者尤其是投资者，越来越需要使用叙事、讲故事、商业中的接受和信任问题，而不是财务报表和分析的数值和比率来。部分原因是，在过去二十年中，S&P500 指数公司的无形资产占总市值的比例高达 90%。
最重要的认知和行为因素包括：增加股东价值的叙事部分、"fake it till you make it" 方法、密码货币发展（这种资产的价值具有最大的叙事成分）、2020-2021 年的 IPO 和 SPAC 热潮、无益的信号工具 — 回购、普及基于倖存者偏差的即时增益法、战略动力流行、过度依赖分析师的建议和估计、"pump and dump"方法、投资游戏化、投资者外向性、沉锚效应和框架效应、沉没成本误区、取消投资论文的严格方法缺乏，以及对过去十五年投资中资金自由使用的看法。认识和跟踪至少是形成和进一步发展"高效解释"启发法模型的最重要的行为和认知因素，将有助于降低"新经济"金融和投资体系的风险，提高其长期发展的可持续性。
关键词： 认知扭曲、启发法、倖存者偏差、沉没成本误区、代表性启发法、市值、股票市场、组合投资、IPO、SPAC、创新、叙事、非理性乐观、非理性繁荣、行为金融学、成长型公司、高科技公司、新经济、密码货币、战略动力、投资论文。

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Introduction: the transition from the model of the rational investor to the model of the effective interpreter

Over the past three decades, behavioural and cognitive aspects of valuation have come to the fore and largely determine the fundamental performance and dynamics of companies. In the article [Ilkevich, 2022], which logically preceded this work, a comparative analysis of the ten main characteristics of the rational investor model and the effective interpreter model was carried out. It explained why the effective interpreter model with all its pros and cons, including a higher level of risk in the investment system, is a new reality in terms of the typical decision-making pattern in the investment industry, both at the level of retail investors and at the level of active and passive fund managers, as well as other types of institutional investors. In the context of this publication, it seems appropriate to consider and systematise the set of cognitive and behavioural factors that determine and consolidate the transition to a new heuristic model of investment decision-making.

Since the emerging realities of portfolio investment in high-tech companies are such that manipulative aspects and problems of objective perception based on evidence and critical thinking are becoming more pronounced, the focus in this article on the factors of cognitive biases and behavioural heuristics will be primarily on the negative aspects of the factors under consideration. This is not to say that the efficient interpreter model is so inherently flawed that it would in any way be desirable or realistic

to return to the 'good old' rational investor model, which worked quite reliably in the context of business valuation for 'old economy' sectors. This would not be a fully consistent conclusion after examining all aspects of the 'dark side' of the effective interpreter model. It seems that the transition to a new heuristic model is irreversible.

This article discusses a fundamentally different category of issues. The behavioural and cognitive landscape of the new economy sectors is so complex that interpretive aspects of decision making come to the fore. Increasing the efficiency of perceptions and interpretations (primarily related to the realism of ideas about the true potential of companies' business models and the distribution of probabilities of various business development scenarios) for stakeholders in the investment industry is a complex interdisciplinary scientific and practical task. Systematising the factors of cognitive biases and behavioural heuristics in the context of raising general awareness and self-reflection among investors is the first stage in solving this type of problem, as it improves awareness of a complex and multifactorial phenomenon.

The question of the possibility and feasibility of distinguishing between behavioural and cognitive factors needs to be addressed separately. In a sense, this question is similar to the dilemma of which came first - the egg or the chicken. Cognitive aspects (mainly heuristics) undoubtedly determine to some extent the individual and group behavioural dynamics of economic agents. At the same time, behavioural patterns influence and to a large extent determine the matrix of cognitive perception. Without claiming to have a definitive answer to this question, it must be stressed that, in the context of this study, behavioural and cognitive factors represent a single heading and a conglomerate of aspects. Through their combined action, they lead to the final consolidation of the model of an effective interpreter of the stock market in the context of the modern economy. It is worth noting that there are studies with their own empirical methods that insist on the productivity of distinguishing and differentiating behavioural and narrative expectations in investment decisions [Johnson, Tuckett, 2022]. The central controversial aspects of this issue were discussed by the author in a previous article [Ilkevich, 2022].

Central factors of cognitive biases and behavioural heuristics in the effective interpreter model

Let's now consider the conglomerate of the main factors that reinforce cognitive biases and behavioural heuristics in the model of an effective interpreter. Not all of the factors discussed below are completely new, but even some traditional factors have been given significant specificity and new dynamics in the context of investing in high-tech companies.

Investors held hostage by the narrative under the 'fake it till you make it' approach

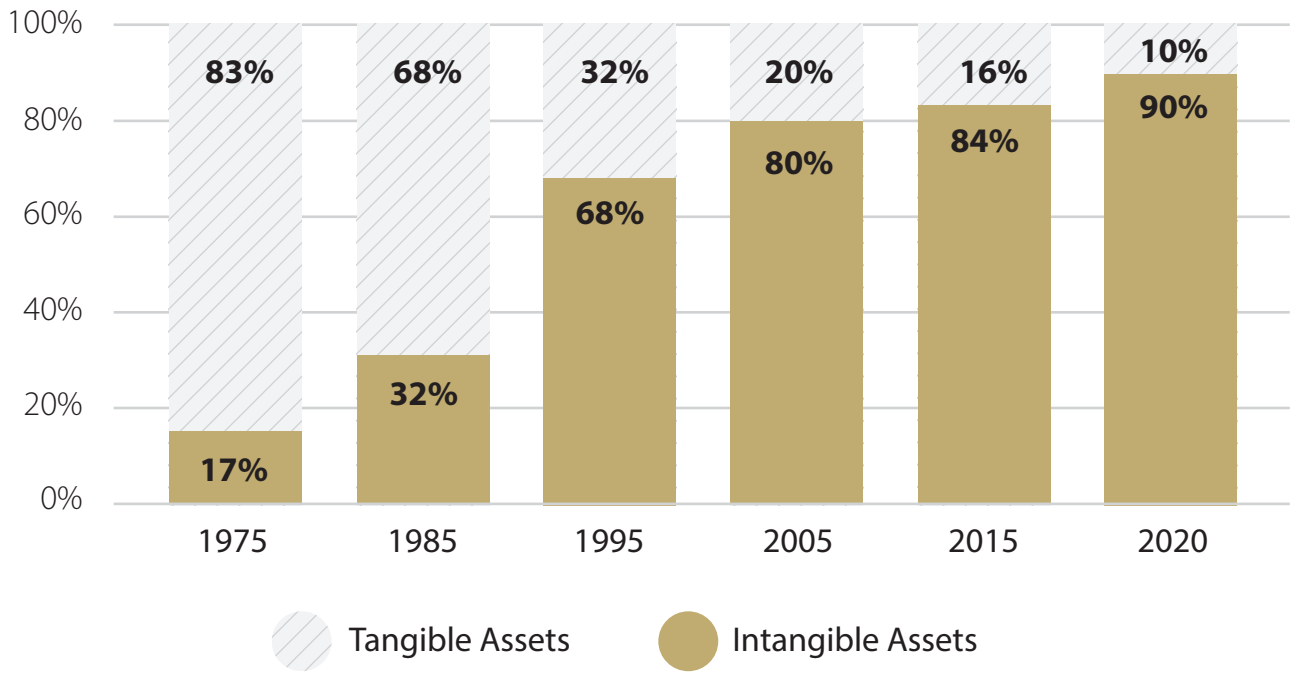
In high-tech sectors, the practical philosophy of 'fake it till you make it' has gained particular popularity, which primarily means the need for a company to appear to partners, customers and investors in the most promising and plausible state possible. In other words, to appear as if the company's resources, competencies, technologies, developments and minimum viable versions of the company's products and solutions already exist or are on their way. As a result, in today's stock market, all companies, but especially young start-ups, become hostage to the narrative and tend to promise what is at the top of the list in terms of feasibility. As a result, the 'fake it till you make it' approach becomes a kind of stock market philosophy of pragmatism, regardless of the true state of affairs, which requires companies to be as generous as possible in terms of promises, but not, of course, outright 'fraud'. Nevertheless, investors are being asked to put their money into those companies that are more the product of a narrative and a myth, in the neutral sense of the word 'myth', at the beginning of their activity, because the initial myth can really trigger the rapid development of a disruptor company.

However, it would be simplistic to see all narratives as just a manipulative and unreliable picture of the future. It's hard to argue that stock market narratives tend to embellish reality - it should always be taken into account. That's why for decades investors in 'growth companies' have lost out to investors in 'value companies', as the share prices of high-tech companies have traditionally been too far removed from fundamental indicators. It was and is, one might think, a kind of 'cognitive tax' on overly optimistic futurist investors.

Only in 2008-2021 was this not the case, but in 2022 it all came crashing down when the NASDAQ index fell by 30%.

Narratives are a 'necessary evil' because they act as a natural market coordination mechanism within the new economy ecosystem, especially when it comes to building a new or emerging industry and funding future champions of new sectors, and when a disruptive company is about to completely change the business landscape in the traditional sector. In this case, a few promises of a 'bright future' based on a visionary idea, and some trust in such promises, are particularly needed at the outset. It is almost impossible to structure and explain this area completely scientifically, as it is rather an art form in itself for investors to successfully determine who should be trusted with the presented picture of the future and a certain 'road map' for the implementation of a business model, and who should

Fig. 1. Ratio of the value of tangible and intangible assets
to the capitalisation of the S&P500 over the period 2000–2022



Source: https://www.oceantomo.com/intangible-asset-market-value-study/.

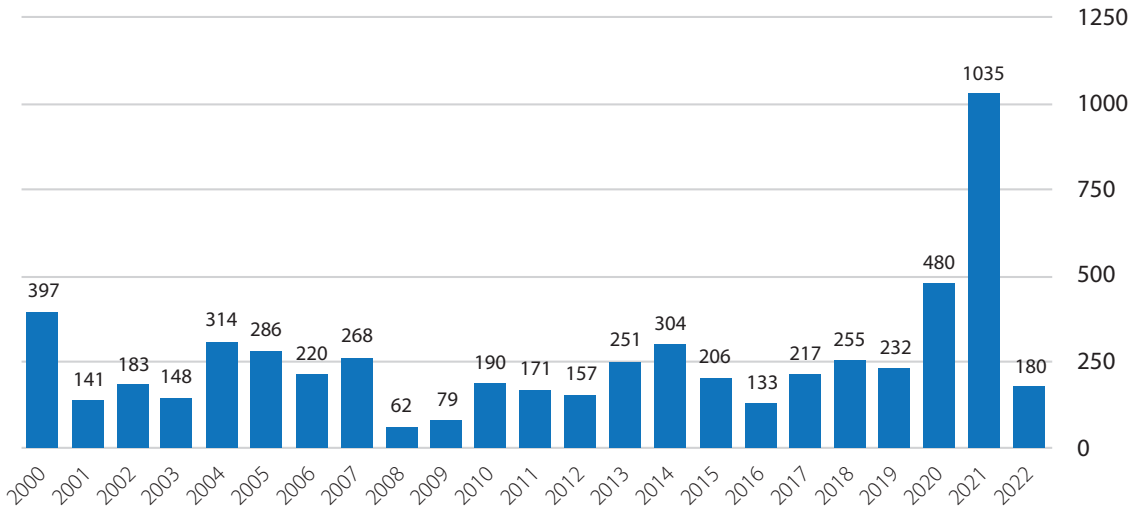
not. Despite the large subjective component of such decisions about trust, narrative and storytelling as phenomena have become an objective, significant and functioning mechanism for coordinating economic actors in the realities of the modern economy.

It is worth emphasising that 'fake it till you make it' is not just a business custom or an informal institution in terms of the breadth of the practice and the form in which it has become established. The narrative component of corporate value is de facto institutionalised, if only by the fact that companies without positive profitability or even significant revenues and cash flows are, in principle, allowed to go public, especially in North America. Thirty years ago, in the early 1990s, stock exchanges and underwriters required a company going public to have at least two or three years of positive profitability. Therefore, the most that could threaten investors in a future public company was incompletely reliable accounting. But then the primary measure of business success became assumptions and storytelling about future free cash flows, in other words a certain narrative component of value based on the plausibility of the investment thesis, which could be trusted or not.

Undoubtedly, this business valuation model has its very strong points - first and foremost, the fastest possible scaling of future giants of new industries. This is one of the reasons why American big tech has become so dominant in the global economy, while European companies and the European investment infrastructure have lagged behind, sticking to more conservative and traditional approaches to valuing a company. Strategically, the philosophy of liberalising the rules and speeding up the listing of high-tech companies from promising and revolutionised sectors has proved to be correct. Here, as they say, 'the score is on the scoreboard' - in the sense of which countries now have which global champion companies in various sectors of the 'new economy'. However, the downside is that the narrative component of value, which is the dominant part of the capitalisation of many high-tech companies, is likely to be undermined or even eliminated, as the value of listed (and already traded) high-tech companies, especially unprofitable ones, can in a sense be split into two components. They are objective (based on cash flows and profitability) and subjective-narrative (based on plausible promises of future cash flows and high business margins due to an innovative business model and intangible assets).

Using simpler and already established terminology, we can say that the intangible (immaterial) assets of companies (including intellectual property and reputation) are coming to the fore in investors' perceptions. They reach, according to estimates by

Fig. 2. Number of IPOs on the US stock exchanges in 2000–2022



Source: https://stockanalysis.com/ipos/statistics/.

some research organisations, 90% of the definition of capitalisation of the S&P500, and the share of tangible (material) assets in determining capitalisation has fallen to 10%, which is twice less than twenty years ago (Fig. 1). As the economy, on the whole, moved away from an industrial base and became more structurally focused on services and knowledge, there has been something of a 'creeping revolution' in the importance of the factors that now influence company valuations.

Whether it is possible to say that the situation with such a high importance of intangible assets in determining the value of a company has now gone too far or, conversely, that this is just a normal situation ('the new normal') in the modern innovative and transforming landscape of the economy is a very debatable question. However, there are a number of factors that could help to perpetuate the current state of affairs. They include further digitalisation, a further increase in the number of internet users and the introduction of 5G, as well as the general potential of the technologies of the Fourth Industrial Revolution.

An important and interesting question is also whether there is a long-term equilibrium value for the share of intangible assets that would still be very innovative but at the same time ensure the sustainability of the investment system. Let's say 82 or 85% in the context of the S&P 500, and in the context of the more industrial and export-oriented German economy, the value for the DAX30 index could be 70%, to illustrate. Incidentally, the same research company, OCEAN TOMO, makes the following assessment for the European equity market: the trend towards the increasing importance of intangible assets continues for the S&P Europe 350 index, albeit to a lesser extent, with an increase from 71% in 2015 to 74% in 2020[1].

IPO and SPAC boom in 2020-2021 as aggressive trading narratives

The IPO boom of recent years can also be interpreted in the context of the 'fake it till you make it' trend as a kind of particularly aggressive and massive 'narrative trading'. Fig. 2 shows the number of annual IPOs on the US stock market from 2000 to 2022. Obviously, 2020 and especially 2021 have become a shock year in terms of the volume of new companies going public, which can also be interpreted as an indicator of irrational abundance in the investment system, when new companies try to go public in time and not be late for a kind of 'festival of abundance'. The IPO boom began in June 2020. There was a sharp increase in transactions on a monthly basis, coinciding with the flow of 'helicopter' money into the economy and the rapid strengthening of the metanarrative about the generally unique prospects of high-tech companies, especially in the digital, biotech and alternative energy sectors, in what was then thought to be an indefinitely long pandemic era. In 2020-2021, the whole pipeline of SPAC deals, which were used to accelerate many IPOs, including the most dubious and even fraudulent, as in the case of Nikola, also attracted special attention. SPACs are shell companies that have no operations, business model or business plan other than to acquire a private company with the money raised in an IPO, allowing the private company to go public quickly. A recent study found that IPOs through SPACs are particularly likely to lead to lower share prices for companies that use this controversial accelerated placement vehicle [Klausner et al, 2022].

By way of comparison, the Russian IPO market is, to put it bluntly, not very active in terms of the number of transactions. Moreover, over the past decade and a half, there has been a decline in the placement of new

[1] https://www.oceantomo.com/intangible-asset-market-value-study/.

companies (Chart 3). This is a separate major problem of financing and business development in Russia. Of the 'new economy' companies, only three have gone public in the last three years: Ozon (24.11.2020), Positive Technologies (17.12.2021), Whoosh (14.12.2022). One 'new economy' company a year is very few. The structural, innovative restructuring of the Russian economy may take a long time, partly due to the underdeveloped investment infrastructure.

It would not be an exaggeration to say that many IPOs in recent years have become not just a game of chance for investors, but a phenomenon akin to a lottery. Moreover, a recent study on the spillover effects of the popularity of gambling on the stock market in different regions of the world quantitatively confirms this comparison [Chen et al., 2021]. In fact, we can say that there are not only successful metaphors and allegories, but also a correlation between the popularity of lotteries and the most risky stocks. A study of spillover effects found that when the general attitude towards gambling in a particular region or community is highly positive, investor demand for 'lottery' (high-risk) stocks increases, and these stocks generate characteristic positive short-term excess returns. Managers of such companies are more likely to split shares at the IPO, then conduct so-called stock splits to increase exposure to a wider range of retail investors, or, as is often the case, dilute shares to meet increased demand for low-cost lottery shares. As a result, IPOs with such measures are more profitable on the first day of placement [Chen et al., 2021]. This, one might assume, will greatly reduce expected future profitability.

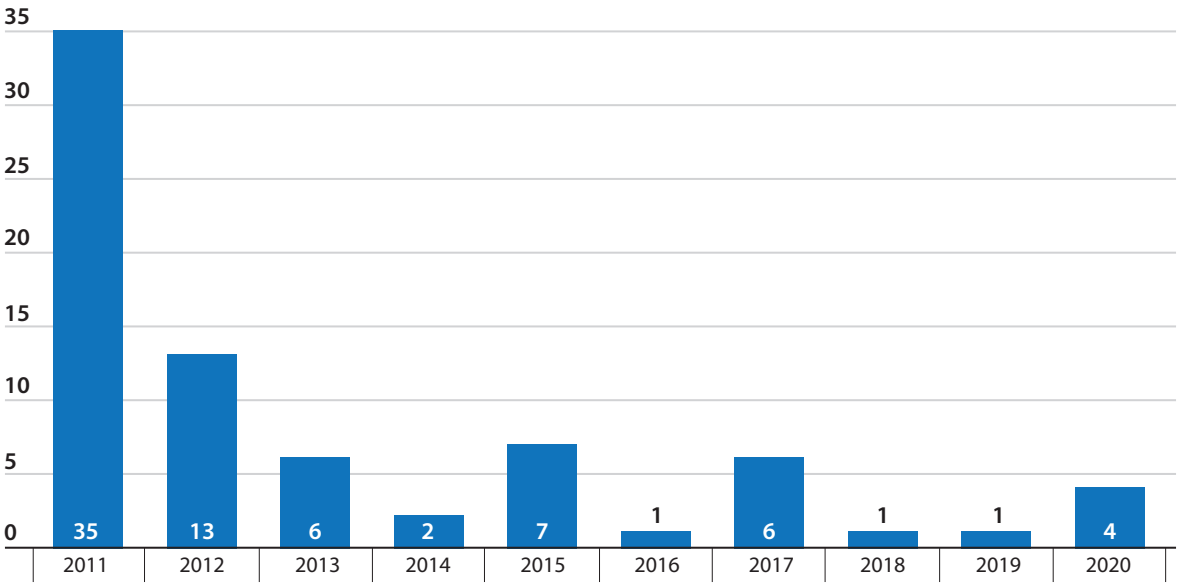
Russian IPOs have become particularly notorious in recent years. To understand why, just look at the stock charts (even to February 2022) of many of the companies that have recently entered the equity market: VK, Ozon, Fix Price and a host of others.

Buybacks as an unproductive signalling tool to increase the narrative component of shareholder value

The narrative component in the value of high-tech companies has also been strengthened in recent years by the so-called buybacks (share repurchases by companies), which became an important factor in the 'acceleration' of the share value of many companies in 2018-2022, especially the high-tech giants. As shown in Fig. 4, over the past twenty years, with the exception of the very difficult crisis year of 2009, share buybacks by companies have exceeded the total volume of dividend payments. The ability to buy back record amounts of shares has been underpinned by record profits for the tech giants. Buybacks have largely become an end in themselves, as the market (especially in the US) highly values their signalling role [Kurt, 2018]. It goes without saying that management has to demonstrate a willingness to buy back its shares in the belief that they will only go up in price. In other words, from the point of view of signalling effects in relation to their business, companies act on the principle of 'you need such a cow yourself'.

In deep market downturns, this practice often makes sense (based on decades of statistics), as it can be the most effective investment of the free cash flows of fundamentally very undervalued companies. Moreover, in such situations, there is often a case to be made for using borrowed funds for such purposes (subject to the financial stability of the company). However, when aggressive buybacks occur at market peaks, this game

Fig. 3. Number of IPOs on the *Moscow Exchange* in 2011–2020



Source: https:// conomy.ru/analysis/articles/213.

of 'doubling down' on a business can go too far at some point. Instead of business development, demonstrative and signalling motives come to the fore. Thus, following unproductive motives, considerations and practices, the company spends a disproportionate amount of resources on buying its own shares at price levels at which a rational investor would no longer buy (at least to further increase an issuer in its portfolio). The result is an additional aggravating factor within the general philosophy of 'fake it till you make it' logic, but for an established company.

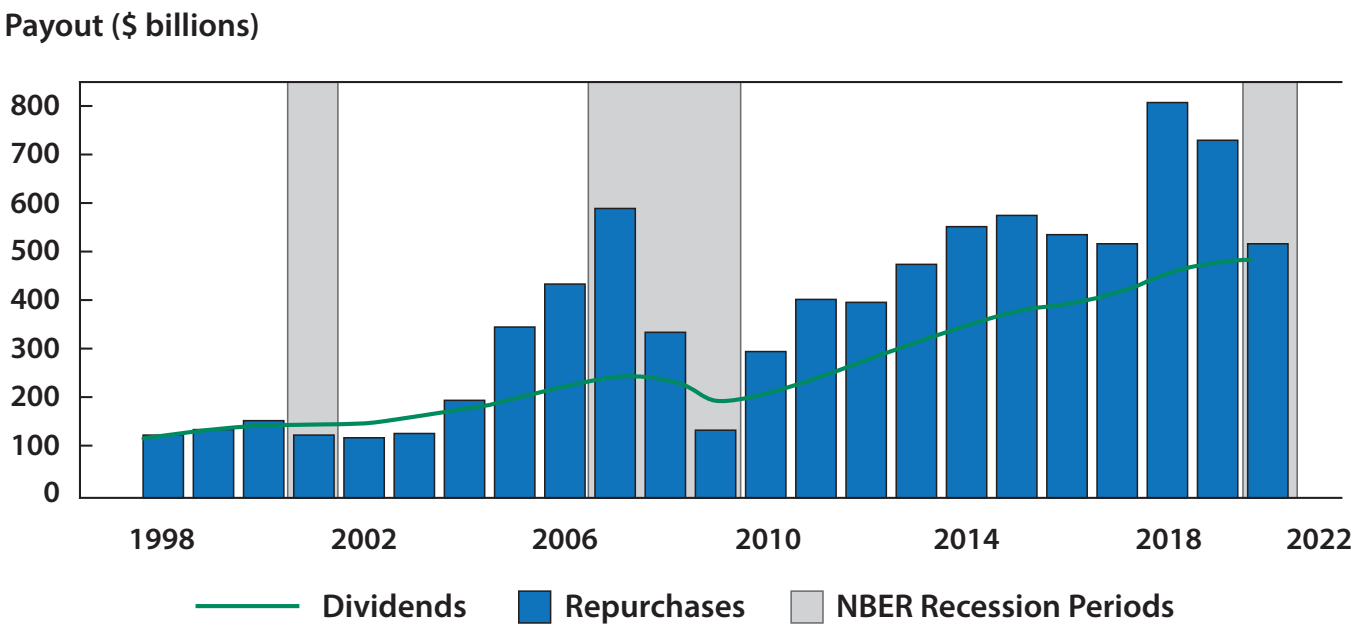
In particular, this type of practice can be considered in the context of the cognitive bias known as the 'endowment effect', whereby economic agents tend to value their asset slightly higher, more valuable, than if they did not already have it and were only thinking about acquiring it. The human psyche is characterised by a defence mechanism in relation to a previously made decision in the context of choosing between alternatives. In the same way, companies with an aggressive buyback policy find themselves in a situation where they have to come up with as many justifications as possible to buy back shares instead of developing promising areas and businesses. Such practices are approved by certain cohorts of investor enthusiasts (as they lead to a 'pumping' of the company), but such short-termism can be costly for the company in terms of business quality and strategy. Therefore, an important regulatory and institutional task arises - to redirect the country's corporate resources towards innovation and sustainable development, limiting the rental practice of share buybacks [Palladino, Lazonick, 2021]. With the growth of executive stock option compensation plans, the link between increased open market share repurchase activity and compensation may not be coincidental. Research shows that managers, as corporate insiders, can use share buybacks for personal gain [Palladino, 2020].

Popularisation of cryptocurrency trading as the asset class with the largest narrative in the cost

Cryptocurrencies themselves are perhaps the purest form of narrative value of a financial asset in the modern financial system [Azqueta-Gavaldón, 2020]. As a hypothesis, it is logical to assume that cryptocurrencies have important similarities with so-called beta stocks with a high influence of market sentiment. Such a comparison often comes to mind for analysts, practitioners and researchers. Indeed, a recent study found that bitcoin's returns are broadly similar to those of high-sentiment beta stocks [Jo et al., 2020]. It is also reasonable to assume that investors in high-tech companies as a cohort overlap and are highly correlated with the cohort of crypto investors. At least one study has found that a significant proportion of crypto investors are tech-savvy and active users of the digital economy with a propensity for high risk and gambling, which in turn points to the potential risks of excessive psychological involvement in the crypto market [Steinmetz, 2023].

One of the reasons why all this is happening is that investors in high-tech stocks and cryptocurrencies are using funds to buy both types (classes) of assets, figuratively speaking, out of the same pocket. If even one asset class falls significantly, this type of investor

Fig. 4. S&P500 share buybacks and dividends in 1998–2020



Source: [Chen, Obizaeva, 2022].

becomes poorer and therefore less willing to buy into the asset class that has not yet fallen. Moreover, there is a strong temptation to sell the 'expensive' asset class that has not fallen at a 'high' price, reduce the position in it and buy the collapsed 'cheap' asset at 'low' prices (relative to recent experience). Here we can assume a significant anchoring effect in the perception of which asset classes are expensive and which are cheap in the current paradigm, as well as a cognitive distortion due to recent experience (recency bias). The same thing happens when one of the two asset classes under discussion - high-tech stocks or cryptocurrencies - goes up in price. In this case, investors feel richer - and are more likely to buy an asset class that has not yet risen in price.

As a result, there is some hybridisation in the logic of investors' perceptions between the two asset classes - equities and cryptocurrencies. One study examined the relationship between the cryptocurrency market and the Dow Jones Industrial Average [Zhang et al., 2018]. The authors focused on the top 20 cryptocurrencies from 2013 to 2018 and constructed a composite cryptocurrency index (CCI). The results showed that the Composite Cryptocurrency Index and, significantly, even the Dow Jones Industrial Average were correlated with each other. It could also be argued that a common problem for investors in both cryptocurrencies and high-sentiment stocks is the representativeness heuristic, which gives disproportionate weight to recent experience compared to long-term averages when analysing the prospects of scenarios and their probability distributions. However, such a hypothesis needs to be examined and confirmed separately.

Popularisation of the 'search for X' based on the survivor's mistake

To a large extent, the phenomenon of 'chasing Xs' is the desire of investors to make a quick buck by finding stocks that will multiply in value in a relatively short period of time when market participants significantly overestimate the company's potential in a positive direction. Thanks to disruptive innovation, it relies not only on the representativeness heuristic mentioned above, but also on another type of retrospective cognitive bias - survivor bias. The investment industry (both brokers, active and passive fund managers and analysts) deliberately exaggerate the survival of companies with disruptive and breakthrough innovations in order to attract attention and funds. Due to the excessive mythologisation of the winners of previous technological breakthroughs, a retrospective analysis of the emergence of the current leaders of high-tech markets and sectors often rejects scenario analysis. It favours pseudo-determinism and embraces the principle that 'history is written by the winners' (i.e. ignoring the possibility that other companies could become the current established high-tech leaders). This approach may be partly appropriate for establishing the organisational culture of companies within the framework of the ideology of a 'great' and/or 'unique' company, but when it penetrates the minds of investors and managers, there is a decrease in the critical perception of reality and an excessive reliance on faith in the company.

Thus, the desire to 'make X' (as often expressed by investors in tech companies and cryptocurrencies) and the survivor's fallacy are important components of the narrative and mythologised perception of tech companies. Research in this regard shows that when investors are aware of the level of risk, they can manage the situation more effectively and make more profits than when they are not aware of the risk [Nguyen et al., 2019]. Therefore, self-reflection in the context of understanding one's own susceptibility to survivor error when constructing an investment thesis, as well as when building an investment position in a particular issuer, is critical for equity market participants, especially in relation to disruptor companies.

Sunk cost errors and lack of techniques for unwinding an investment thesis

'Chasing Xs' and the survivor's mistake are not so bad. Irrational, mystical, intuitive perception leads many investors to disorganised decision-making and a lack of a structured approach to assessing the business prospects of high-tech companies.

One of the most common types of cognitive error is an approach that can be described as 'breaking the mark'. An investor who has bought into a high-risk company will often take a 60-70-80% loss on his investment position and then hope for a recovery in the share price. But when that recovery does occur, it is quite likely to be a classic example of a turnaround company (according to Peter Lynch), where the company has been able to overcome the difficulties of growth and back up the initial positive narrative with the real evolution of its business model. In such cases, it is statistically better for the investor to hold the position. However, an investor who has been tormented by a long 'sitting out' of a deep negative position is often simply happy to have the opportunity to at least recoup his investment after all the anxiety and disappointment. The chance to break even is perceived subjectively and post-traumatically as a kind of gift of fate and relief from suffering, and the shares of the company become toxic and psychologically traumatic for the investor, despite the restoration of the price level.

An even more common manifestation is the averaging of a position, not because of the strengthening of any fundamental or even technical signals of the original investment thesis, but simply because of a significant fall in the company's share price itself. In such cases, the investor becomes a hostage to anchoring and viewing

the situation through the prism of recent events (recency bias). The same Lynch has a famous joke: if you bought shares of a company for 10 thousand dollars at 30 dollars each, and a little later your neighbour bought shares of the same company for 30 thousand dollars at only 3 dollars, but then the shares of the company are still the same, let's go to the near-zero mark - which of you two has more losses? The problem, Lynch jokes, is that not all retail investors can answer this question immediately...

Research shows that even for professional managers, frequent investment feedback and reports do not help to reduce the effect of sunk costs. Only a high frequency of feedback combined with high affective commitment can suppress the desire to continue an unprofitable investment project [Chen et al., 2020]. Notably, strong evidence of this type of fallacy was found in subjects with high cognitive ability, who did not reduce the sunk cost bias [Haita-Falah, 2017]. This is a very interesting and revealing result. It confirms Warren Buffett's famous statement in an interview that he would rather entrust the management of funds to a manager with an IQ of 140 (provided that he is reflective, critical, reasonably doubtful and cautious in his decisions, a person who is able to stop in time and admit his mistakes) than to a fanatical and categorical manager with an IQ of 180 in his decisions. This is because a manager of the second psychological type will, sooner or later, definitely run his fund into the ground.

The popularity of impulse (momentum) and swing strategies

A special feature of the high-tech sector is that momentum strategies are based not only on long-term statistical observations, but also on the expectation of a continuation of the company's rapid growth. The principle of extrapolation of past success is particularly strong in the minds of investors, fuelled by the installation of so-called faith in the company. This, in turn, leads to particularly dramatic gaps between expectations and extrapolations in current share prices and their fundamental value.

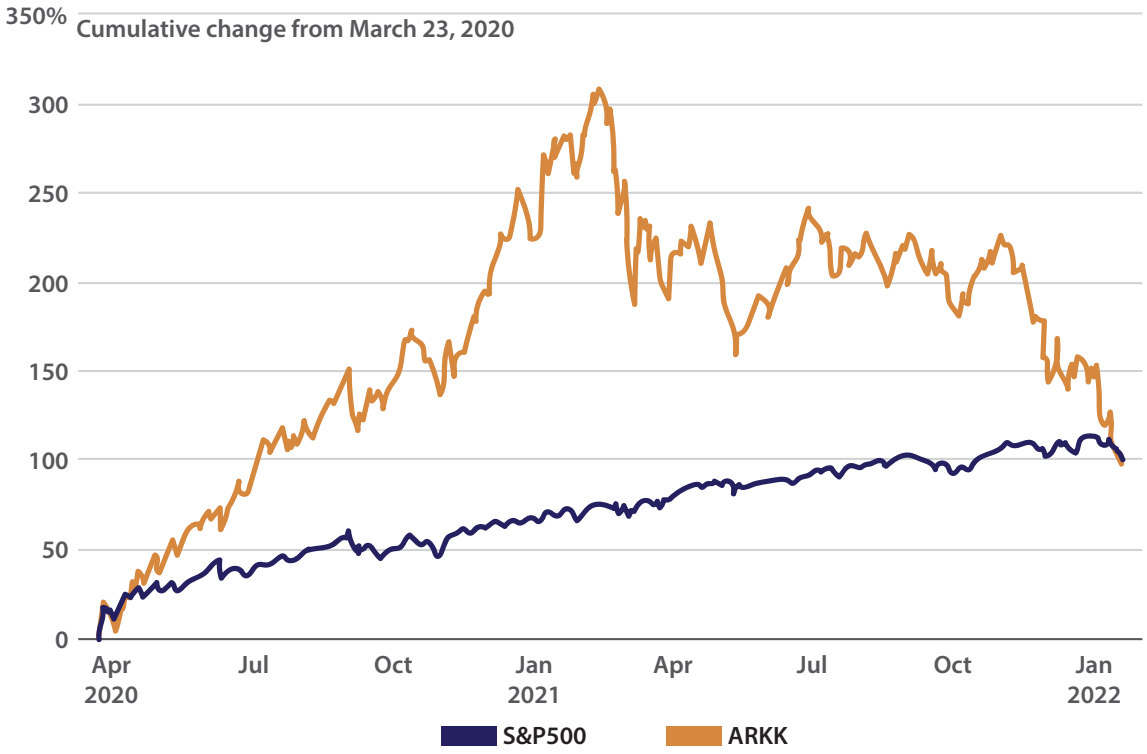
From a technical perspective (reading and interpreting price charts), following the 'trend is your friend' principle as a general investment approach is understandable and generally productive in reducing risk compared to counter-trend trading approaches, especially for less experienced retail investors. Although it is worth noting in the context of the general principle that there is no single method for recognising a trend as broken, the subjective factor is quite strong here: what and how each investor saw for themselves on the chart. This is a separate major epistemological problem in deciding what a trend is in a given situation. In itself, following the 'trend is your friend' principle means that the investor is simply forced to take a position, if not on local tops that confirm the trend, then on weak corrections at a price level close to the top. When investing in high-tech companies, this carries additional risks as investors often get into overheated stocks with a larger gap between current valuations and fundamentals. All of this, as research shows, leads to the herd effect also creating some institutional demand for overpriced securities [Demirer, Zhang, 2019]. In addition, as far as momentum strategies in tech stocks are concerned, it is advisable to re-engage with the cryptocurrency market, where this type of strategy has become particularly popular [Grobys, Sapkota, 2019].

Swing strategies (swing trading) are also unproductive when investing in high-tech companies. Most significant price movements are not accompanied by publicly available information. What other information do investors use to establish certain 'fair' prices around which they can expect fluctuations and make money from periodic partial or complete 'loading' and 'unloading' of an investment position in the issuer? Research shows that investors rely more on anchoring and framing [Brady, Premti, 2019]. In other words, many investors' trading approaches explicitly and implicitly use swing approaches.

Traditionally (and rightly), swing trading approaches are generally considered to be healthy (including by increasing market liquidity as speculators with swing strategies complement market makers), especially when such approaches are based on the use of options to control the risk of investors' positions [Thomsett, 2013]. However, when valuing high-tech companies, investors lack the necessary anchor in terms of a more or less accurate understanding of the 'fair' value of the company in order to trade the cyclical short and medium-term fluctuations in the share price. The inability to predict periods of market consolidation leads to large losses for investors. Broad assumptions do not allow an objective assessment of a company's value. Under these conditions, the anchoring and framing effect in investors' perceptions naturally increases: when a company's share price has fallen by 40-50-60 percent or more, it starts to look very interesting to many investors, even though the 'fair' value may still be much lower. This is a significant difference from traditional sectors, where for a company with a proven business model, more understandable earnings and cash flows, one can speak with relative accuracy about market under- or overvaluation, despite the increasingly common value traps) for value investors in today's more dynamic business landscape.

Due to the even more dynamic industrial landscape of the 'new economy', market participants have a natural tendency to reconsider their positions more often, as the competitive disposition changes many times faster than in traditional 'old' industries. High-tech companies are characterised by higher volatility [Kudryavtsev, 2018]. However, the problem is that the reliability of investors' interpretations and decisions is significantly reduced.

Fig. 5. Cumulative change in S&P500 and ARK Innovation (ARKK) from April 2020 to January 2022



Source: https://markets.businessinsider.com/news/stocks/stock-market-analysis-sp500-cathie-wood-ark-tech-selloff-rotation-2022-1#-1.

Over-reliance on analyst recommendations and estimates

In the absence of an objective centre of gravity for the value of high-tech stocks, consensus estimates are perceived as the best available targets. Even a concept such as narrative authority has emerged [Leins, 2022; Stolowy et al., 2022], which has its 'dark side', as the lack of an informed view by many investors of the 'fair' value of companies with a high narrative component leads to an exaggeration of the degree of expertise of analysts. For example, if the average expectation of Alibaba's share price in a year's time, based on the opinions of 25 experts, is USD 330, and the lower estimate of the five most sceptical experts is USD 240 (as in 2020, the parameters of this example are close to real events), then investors get the false impression that it is virtually impossible for the share price to fall below USD 180. After all, it is impossible for such a large number of experts to be so wrong at the same time. This logic is somewhat more applicable to traditional 'old economy' sectors, but when it comes to valuing the business of high-tech companies, experts are likely to become hostages to framing and herd behaviour. In the case of Alibaba, the share price fell to USD 65 in 2022, which was simply inconceivable on the basis of analysts' forecasts.

A number of studies [Corredor et al., 2014] have shown that the prevailing market mood, the so-called market sentiment, also influences analysts' forecasts (which are erroneously perceived as a completely objective and mathematically verified assessment of a company), especially for those stocks that are difficult to value. Both cognitive biases (distortions) and strategic behaviour have been found in analysts' forecasts [Karamanou, 2011], whereby analysts flexibly and adaptively adjust their opinions to the dynamically changing consensus forecasts of their peers. This, in turn, means that while international best practices for regulating public analyst forecasts may reduce analysts' optimistic bias somewhat, cognitive biases and behavioural factors (in particular herd and strategic behaviour, perception of consensus pressure) significantly bias analysts' estimates towards an exaggerated stock price growth outlook. Even if, as a distant allegory, we can compare analysts here

to members of a party who come to a party meeting with fairly autonomous and critical ideas on an issue, but during the meeting vote for a certain unified party line, what is called 'hesitating together', with the party line. Research has uncovered a wide range of cognitive phenomena in analysts' forecasting, and it is time to talk about the need for a separate science – 'analyticology'. One characteristic, for example, is that security prices tend to cluster in rounded price increments. The results show that the prices of technology stocks cluster at levels significantly higher than those of non-technology stocks, especially during periods of rising positive sentiment and high investor expectations in certain industries and sectors. The causal relationship here arises precisely because investors tend to cluster price values, not vice versa [Blau, 2019]. However, weak forecasters tend to be overconfident in the sense that they make extreme forecasts, and their confidence intervals are less likely to include the possible achievement of price levels [Deaves et al., 2019].

A recent paper examines the stock market's irrational reaction to analyst recommendation revisions as a function of the level of investor sentiment prior to the publication of analyst reports. Analyst revisions have a more pronounced effect on downgrades, which is related to the sentiment effect. Investors tend to react less to upgrade (downgrade) news when their prior beliefs are pessimistic (optimistic), indicating that they are overconfident [Kim et al., 2021].

'Pump and dump' schemes

'Pump and dump' schemes, which can be translated into Russian as 'pump and dump' or 'acceleration and drain' schemes, are largely a derivative phenomenon of the factors already discussed: the strengthening of the narrative component of stock prices, the popularity of impulse (momentum) strategies, and excessive faith in analysts' recommendations or their collective consensus. However, there is a reason why it is advisable to identify pump-and-dump cycles as a separate behavioural factor in the formation of an effective interpretive model: the relatively high degree of coordination of market participants' actions. To compare this to an orchestra in terms of the degree of synchronisation is perhaps unnecessary, but here too there is a 'first violin' (a market participant who creates a narrative that is super positive for the company).

It is also characteristic that many of the investors in such an asset assume that there will be a dump at some point, but hope to react before others. Pump and dump schemes continue to be the bane of equity markets, particularly markets and exchanges where small- and mid-cap companies are traded. The proliferation of schemes in these markets affects market integrity by discouraging investment and listing [Austin, 2021].

Launch of Exchange Traded Funds (ETFs) for high-tech companies

Since 2020, there has been a sharp increase in the inflow of funds into exchange-traded funds (ETFs) composed exclusively of shares of high-tech companies, including certain sectors - IT, biotech, space launches. This has led to greater opportunities for manipulation. The particular danger is that these types of funds have further weakened the vigilance of retail investors and can be expected to have reinforced the combined effects of a number of cognitive biases, notably the representativeness heuristic, the survivorship bias and, of course, the reliance on experts. In addition, manipulative narratives about the 'bright future' of individual industries and sectors have intensified throughout the market and near-market infrastructure (analysts, forecasters).

Perhaps the most striking and widespread example in terms of direct and indirect consequences for the entire investment industry is the ARK Innovation fund, which has become a kind of pyramid or Ponzi scheme. ARK was a disaster for new investors. The incredible growth rates of some of its stocks were too hard to resist; inexperienced investors predicted similar growth rates far into the future. If, for example, a fund invests USD 3 billion in the shares of a company with revenues of USD 100 million, and the share price rises by a factor of 3 to 10, this is a 'caliph for an hour' situation and a 'last fool's calculation' for those who buy shares at an accelerated price. There is an aggressive and cynical abuse of the rhetoric of innovation, progress and technological revolution with deliberately manipulative targets in a distorted system of incentives and interests (including moral hazard).

ETFs like ARK Innovation have essentially become serial pump and dump cycles. Fig. 5 illustrates this very clearly by comparing the situation at the time of the Covid collapse in the spring of 2020 and the subsequent rush into tech companies. By January 2022, the 'drain' that followed the 'overclocking' had put everything back in its place. This is what happens when fund companies have an average intangible share of capitalisation of more than 98%.

It is important to note that in the face of growing problems, techniques have emerged that seek to reduce the importance of cognitive biases in portfolios. Human Factors (H-Factor) is an actuarial portfolio tool developed by New York-based asset management firm New Age Alpha (newagealpha.com) that aims to reduce the risk of human behaviour in stock selection. H-Factor does not attempt to find high returns by using traditional methods such as generic smart beta and factor funds. Instead, H-Factor quantifies and avoids the risk of human bias in stock selection. The model uses as probabilistic values two parameters that we know for certain about the listed company: the current share price and the company's profitability as measured by published financial

results. Based on these two inputs, we can calculate the probability that a company will generate growth based on its share price, given that it has done so over the last 16 reporting periods. Even in high-tech industries, portfolios built to maximise the utility of the H-factor successfully reduce downside risk and preserve shareholder wealth, as opposed to cases such as the ARK fund, which selects speculative stocks with no track record, prone to high volatility and drawdowns.

'Robinhooders' and 'Reddits' as a trend for the gamification of investing

Pump and dump cycles intersect with the general trend towards the gamification of investing (or rather speculation). There is an ongoing debate in the research community about whether or not additive apps such as Robinhood and Reddit constitute gamification [Brown, 2020]. However, some manifestations of gamification do resemble gaming behaviour - individually and even collectively. Reddit users behave in ways reminiscent of quests in multiplayer online games. 'Reddits' as an investment 'quest' 'dispersed' from a rational position unpromising shares. For example, the offline computer game store Game stop [Rudegeair et al., 2021], whose business model could not withstand competition from online distribution [Ponczek, 2020], and their virtual opponent, in a sense the 'boss' of the final level of the game, were investment and hedge funds that 'shorted' Game stop with a large position.

The ease of investing through brokers on platform solutions with a simplified interface has led to investors taking on too much risk. Research claims that the success of the Robinhood app is due to the continuous expansion of the user base through various interface design techniques. This leads to the implementation of platform capitalism, which extracts rents from different revenue streams, with higher rents coming from more frequent and riskier trading behaviour. According to some researchers, the narrative of the democratisation of finance that occurs through the widespread use of mobile technologies thus obscures the capitalist logic and predatory practices that underlie financial technologies [Tan, 2021].

Investing in high-tech companies as a psycho-cognitive trap for extroverts

In an abstract and speculative way, one could assume that a number of the factors already mentioned and others (the same collective gamification of investing) lead to a particular vulnerability of extroverts when investing in high-tech companies. Indeed, several studies have been carried out in this direction in recent years. As a result, more extraverted people pay higher prices for financial assets and buy more financial assets when assets are overvalued than less extraverted people [Oehler et al., 2018]. Extroverted investors are risk-averse, so they are more likely than introverted ones to allocate money to risky assets and to use mental shortcuts and simplified heuristics when making investment decisions [Ishfaq et al., 2020].

Perception of free use of money in the investment area

The creation of cognitive distortions over the last decade and a half (2007-2022) has been facilitated by a particular 'macroeconomic climate' of low interest rates and the growth of retail investing (including through mobile applications). Even the so-called leverage (borrowed funds for a margin position) of leading international brokers (e.g. Interactive Brokers) over the last decade has only cost investors 2-4% per year, not to mention the fact that many financial derivatives (e.g. futures) have free 'wired' shoulders in their structure.

How do low interest rates affect investor behaviour? Research shows that when interest rates are low, people become more risk-seeking. Low interest rates lead to a significant increase in the reallocation of portfolios into risky assets across different population groups [Lian et al., 2019].

Of course, the almost 'free' money also directly increased the calculated values of the 'fair' capitalisation of companies through the NPV formulas of estimated future cash flows. This, in turn, influenced both analysts' valuations and the formation of mass investor psychology. There has even been an inversion between the real economy and the stock market, especially in the US. Over the past decade, especially in 2017-2018 and 2020-2022, low economic growth and employment problems acted as a kind of marker for investors that the Federal Reserve would keep interest rates low or cut them, so bad news from the economy led to higher valuations of companies, especially big tech and high-tech start-ups. The stock market began to play less of a proactive role as a leading indicator of the economy (following the principle that 'markets live by expectations') and began to play a more reactive role: revaluing companies, especially high-tech companies, in inverse proportion to the state of production and employment dynamics in the economy as a whole.

Conclusion

The article has highlighted and to some extent specified the main aspects of the influence of cognitive and behavioural factors on the overall formation of a model of an effective interpreter. However, this publication does not claim to be a complete representation of all aspects (especially given their changing nature) that together form the current paradigm for assessing the business of high-tech companies. The central thesis is that awareness and tracking of at least the key behavioural and cognitive factors of the heuristic model of an effective interpreter will help to reduce risks in the financial and investment

system of the new economy and increase the sustainability of its development. Speculation as a component of the economic cycle mechanism stimulates investment activity, therefore, it is not entirely bad as long as it is not carried out excessively through manipulative actions that end up causing panic among investors [Taskinsoy, 2021]. The current level of distortion and manipulation appears to be high and unproductive, so the number one task for all stakeholders in the financial and investment system is to raise awareness and consciousness (what is called 'awareness' in international approaches, methods and guidelines) in the systemic, holistic presentation, and at the same time with good detailing of specific cognitive-behavioural issues.

It should also be borne in mind that, at the level of the financial and investment system as a whole, the period of capital inflows into the high-tech sector can be replaced by a fairly long and even multi-year period of outflows. In this respect, 2022 has become just that, although it is difficult to predict exactly how long the current wave of outflows will last. The lack of dividend growth for the vast majority of companies, together with the reduced balance in the portfolios of the majority of private investors, will lead to greater destruction of the value of their investments in the event of many years of market stagnation. This poses a major threat to public welfare, as the depletion of retail savings will coincide with difficult times for pension systems in many countries around the world, as well as the general problem of the erosion of the middle class. Thus, there may be an effect of overlapping crisis phenomena in several segments of the financial system at the same time, affecting the long-term ability of 'new economy' companies to attract capital.

The factors identified in the article are also relevant for describing the risks associated with the formation of a national investment culture in Russia. An opportunistic or irrational national investment culture for large cohorts of retail investors can become a breeding ground for self-perpetuation and the reproduction of cognitive and behavioural distortions. This assumption may seem too general or speculative, but a clear illustration of the accumulating problems with the 'investment mentality' is the structure of investments, especially in foreign stocks, by Russian retail investors, which is characterised by taking the highest risks. This indicates a low awareness of what kind of game investors are actually playing and according to what rules. Taking all this into account, even in the period before February 2022, the Central Bank of the Russian Federation constantly threatened to restrict retail investors' access to foreign shares. Moreover, in the current dramatically changed conditions it simply cancelled foreign shares for unqualified investors, which seems to be a suboptimal approach even taking into account the extraordinary situation with infrastructure risks in the attitude of Russian brokers towards investors. It would be possible to leave investors the opportunity to buy foreign shares in the amount of at least 20-30% of the portfolio value, guided more by long-term considerations of developing the awareness of market participants and not by total paternalistic protection of them from mistakes. If high-risk Russian investors turn to crypto exchanges rather than the NASDAQ, it is not yet known who will benefit. This is a separate, multi-dimensional issue.

References

Ilkevich S.V. (2022). Heuristic model of "effective interpreter" in portfolio investment in high-tech companies. *Strategic Decisions and Risk Management*, 13(2): 116-128. https://doi.org/10.17747/2618-947X-2022-2-116-128. (In Russ.)

Austin J. (2021). Stock markets play 'Whack a mole' with pump and dump schemes (draft). *UC Davis Business Law Journal,* Forthcoming. https://ssrn.com/abstract=3972431 or http://dx.doi.org/10.2139/ssrn.3972431.

Azqueta-Gavaldón A. (2020). Causal inference between cryptocurrency narratives and prices: Evidence from a complex dynamic ecosystem. *Physica A: Statistical Mechanics and its Applications,* 537: 122574. https://doi.org/10.1016/j.physa.2019.122574 or https://www.sciencedirect.com/science/article/pii/S0378437119314736.

Blau B.M. (2019). Price clustering and investor sentiment. *Journal of Behavioral Finance,* 20(1): 19-30. DOI: 10.1080/15427560.2018.1431887.

Brady K., Premti A. (2019). How do investors determine stock prices after large price shocks? *Journal of Behavioral Finance,* 20(3): 354-368. DOI: 10.1080/15427560.2018.1511563.

Brown A. (2020). Robinhood is not gamifying markets. It's democratizing them. *Bloomberg,* 18 December. https://www.bloomberg.com/opinion/articles/2020-12-17/robinhood-is-democratizing-markets-not-making-them-a-game.

Chen A., Obizaeva O. (2022). *Stock Buyback Motivations and Consequences: A Literature Review.* CFA Institute Research Foundation. https://books.google.ru/books?id=bclgEAAAQBAJ&dq=buybacks+and+stock+prices&lr=&hl=-ru&source=gbs_navlinks_s.

Chen D.-F., Chen P.-K., Chung S.-H., Cheng K.-C., Wu C.-H. (2020). The influence of performance feedback frequency and affective commitment on the sunk cost effect. *Managerial and Decision Economics,* 41: 873-882. https://doi.org/10.1002/mde.3144.

Chen Y., Kumar A., Zhang C. (2021). Searching for gambles: Gambling sentiment and stock market outcomes. *Journal of Financial and Quantitative Analysis,* 56(6): 2010-2038. DOI: 10.1017/S0022109020000496.

Corredor P., Ferrer E., Santamaria R. (2014). Is cognitive bias really present in analyst forecasts? The role of investor sentiment. *International Business Review,* 23(4): 824-837. https://doi.org/10.1016/j.ibusrev.2014.01.001.

Deaves R., Lei J., Schröder M. (2019). Forecaster overconfidence and market survey performance. *Journal of Behavioral Finance,* 20(2): 173-194. DOI: 10.1080/15427560.2018.1505727.

Demirer R., Zhang H. (2019). Industry herding and the profitability of momentum strategies during market crises. *Journal of Behavioral Finance,* 20(2): 195-212. DOI: 10.1080/15427560.2018.1505728.

Grobys K., Sapkota N. (2019). Cryptocurrencies and momentum. *Economics Letters,* 180: 6-10. https://doi.org/10.1016/j.econlet.2019.03.028 or https://www.sciencedirect.com/science/article/pii/S0165176519301077.

Haita-Falah C. (2017). Sunk-cost fallacy and cognitive ability in individual decision-making. *Journal of Economic Psychology,* 58: 44-59. https://doi.org/10.1016/j.joep.2016.12.001.

Ishfaq M., Nazir M.S., Qamar M.A.J., Usman M. (2020). Cognitive bias and the extraversion personality shaping the behavior of investors. *Frontiers in Psychology,* 11. https://www.frontiersin.org/article/10.3389/fpsyg.2020.556506. DOI: 10.3389/fpsyg.2020.556506.

Jo H., Park H., Shefrin H. (2020). Bitcoin and sentiment. *Journal of Futures Markets,* 40: 1861-879. https://doi.org/10.1002/fut.22156.

Johnson S.G.B., Tuckett D. (2022). Narrative expectations in financial forecasting. *Journal of Behavioral Decision Making,* 35(1): e2245. https://doi.org/10.1002/bdm.2245.

Karamanou I. (2011). On the determinants of optimism in financial analyst earnings forecasts: The effect of the market's ability to adjust for the bias. *Abacus,* 47: 1-26.

Kim K., Ryu D., Yu J. (2021). Do sentiment trades explain investor overconfidence around analyst recommendation revisions? *Research in International Business and Finance,* 56. https://doi.org/10.1016/j.ribaf.2020.101376.

Klausner M.D., Ohlrogge M., Ruan E. (2022). A sober look at SPACs (December 20, 2021). *Yale Journal on Regulation,* 39(1). https://ssrn.com/abstract=3720919 or http://dx.doi.org/10.2139/ssrn.3720919.

Kudryavtsev A. (2018). The availability heuristic and reversals following large stock price changes. *Journal of Behavioral Finance,* 19(2): 159-176. DOI: 10.1080/15427560.2017.1374276.

Kurt A.C. (2018). Managing EPS and signaling undervaluation as a motivation for repurchases: The case of accelerated share repurchases. *Review of Accounting and Finance,* 17(4): 453-481. https://www.emerald.com/insight/content/doi/10.1108/RAF-05-2017- 0102/full/html.

Leins S. (2022). Narrative authority: Rethinking speculation and the construction of economic expertise. *Ethnos,* 87(2): 347-364. DOI: 10.1080/00141844.2020.1765832.

Lian C., Ma Y., Wang C. (2019). Low interest rates and risk-taking: Evidence from individual investment decisions. *The Review of Financial Studies,* 32(6): 2107-2148. https://doi.org/10.1093/rfs/hhy111.

Nguyen L., Gallery G., Newton C. (2019). The joint influence of financial risk perception and risk tolerance on individual investment decision-making. *Accounting and Finance,* 59: 747-771. DOI: 10.1111/acfi.12295.

Oehler A., Wendt S., Wedlich F., Horn M. (2018). Investors' personality influences investment decisions: Experimental evidence on extraversion and neuroticism. *Journal of Behavioral Finance,* 19(1): 30-48. DOI: 10.1080/15427560.2017.1366495.

Palladino L. (2020). Do corporate insiders use stock buybacks for personal gain? *International Review of Applied Economics,* 34(2): 152-174. DOI: 10.1080/02692171.2019.1707787.

Palladino L., Lazonick W. (2021). Regulating stock buybacks: The $ 6.3 trillion question. *Roosevelt Institute Working Paper,* May. https://rooseveltinstitute.org/wp-content/uploads/2021/04/RI_Stock-Buybacks_Working-Paper_202105.pdf.

Ponczek S. (2020). Reddit's stock threads become a must-read on Wall Street. *Bloomberg,* 15 September. https://www.bloomberg.com/news/articles/2020-09-15/big-investors-are-dying-to-know-what-the-little-guys-are-doing.

Rudegeair P., Grind K., Farrell M. (2021). Robinhood's reckoning: Facing life after GameStop. *The Wall Street Journal,* 5 February. https://www.wsj.com/articles/robinhoods-reckoning-can-it-survive-the-gamestop-bubble-11612547759.

Steinmetz F. (2023). The interrelations of cryptocurrency and gambling: Results from a representative survey. *Computers in Human Behavior,* 138: 107437. https://doi.org/10.1016/j.chb.2022.107437 or https://www.sciencedirect.com/science/article/pii/S074756322200259X.

Stolowy H., Paugam L., Gendron Y. (2022). Competing for narrative authority in capital markets: Activist short sellers vs. financial analysts. *Accounting, Organizations and Society,* 100: 101334. https://doi.org/10.1016/j.aos.2022.101334.

Tan G.K.S. (2021). Democratizing finance with Robinhood: Financial infrastructure, interface design and platform capitalism. *Environment and Planning A: Economy and Space,* 53(8): 1862-1878. DOI: 10.1177/0308518X211042378.

Taskinsoy J. (2021). *The famous new bubbles of the 21st century: Cases of irrational exuberance.* https://ssrn.com/abstract=3845422 or http://dx.doi.org/10.2139/ssrn.3845422.

Thomsett M.C. (2013). Dangerous waters: Risk inherent in comprehensive swing-based strategies. In: *Options for Swing Trading.* New York, Palgrave Macmillan. https://doi.org/10.1057/9781137344113_4.

Zhang W., Wang P., Li X., Shen D. (2018). The inefficiency of cryptocurrency and its cross-correlation with Dow Jones Industrial Average. *Physica A: Statistical Mechanics and Its Applications*, 510(92): 658-670. https://doi.org/10.1016/j.physa.2018.07.032.

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The impact of innovation on the costs incurred by transport companies

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Abstract

This article analyses the impact of innovation on the costs of transport companies. In order to carry out the research, the types of innovation in the transport industry and the innovation strategies of transport companies are considered. The case method has been identified as the research method. The analysis concludes that innovation has an impact on both operational performance and shareholder value. Firstly, the value of companies is influenced by innovations related to the purchase of new equipment, the improvement of production indicators and the increase in the quality of services/goods offered.

The main objectives of digital technologies are to improve the control of operational processes, to enhance customer interaction and to reduce costs. Together with the purchase of new equipment, this can be seen as one of the ways of increasing the value of the company.

Keywords: innovation, innovation activity, transport, new technologies, efficiency.

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创新对运输企业价值的影响

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摘要

本文章探讨了创新对运输企业价值的影响。为了开展这项研究，作者分析了运输业公司的创新类型和运输公司的创新战略。案例研究法被确定为研究方法。分析结果表明，创新对运营绩效和公司价值都有影响。企业的价值主要受到与购置新设备、提高生产绩效和所提供服务/产品的质量有关的创新的影响。

数字技术的主要目的是加强对业务流程的控制，改善与客户的互动，降低成本。加上购买新设备，这些方面都可以被视为提高企业价值的途径之一。

关键词： 创新、创新活动、运输、新技术、效率。

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Introduction

The development of innovation in the transport industry is one of the key factors influencing not only the industry directly, but also related industries: industrial production, trade and the living standards.

The transport industry is at the forefront of innovation and technological development[1]. Thanks to the introduction of new technologies, cars and trains can move without human intervention, special sensors and artificial intelligence (AI) collect information on road conditions and quickly dispatch repair teams; intelligent algorithms are involved in traffic management, capable of redirecting flows online to reduce travel time and congestion [Verhoef et al., 2021].

According to Accenture Consulting and the World Economic Forum, the transport industry will be a major beneficiary of the digitalisation of the economy and the introduction of new technologies: the potential for economic growth exceeds USD 1.5 trillion by 2025, and the positive impact on society could reach USD 2.4 trillion in terms of improved quality of life and labour productivity[2].

For countries with large territories, including Russia, the speed of introduction of new technologies in the transport industry is becoming a key issue of competitiveness in the global economy.

According to a study by Strategy Partners, the transport and logistics sector is ahead of other sectors of the Russian economy in terms of readiness for digital transformation. More than half of the companies surveyed in the sector have already started implementing digital transformation strategies, and 80% of companies are partially or fully moving to new business models based on digital technologies[3]. New technologies open up a wide range of areas for industry development [Baumann, Kritikos, 2016]:

- improvment of logistics based on data;
- creation of a safe and regulated transport environment;
- automatic analysis and prediction of the technical condition of vehicles;
- optimisation of the supply chain [Daim et al., 2021].

Researchers cite artificial intelligence, predictive analytics systems, the Internet of Things, etc. as the most promising technologies for implementation. [Martin, Nguyen-Thi, 2015; Ehls et al., 2020].

Research firm Smart Nations predicts that the AI market in the global transport and logistics industry will grow to USD 3.5 billion by 2023, and Statista predicts it will grow to USD 10.3 billion by 2030[4]. According to Accenture experts, 65% of logistics and transport companies are already using or testing AI-based[5] solutions. Using AI, the model can incorporate data on traffic, weather, waiting times, loading and unloading speeds at specific locations and with specific suppliers, as well as the impact of specific company personnel and customers on delivery speed.

Another example of technology is the use of a predictive analytics system [Murata et al., 2021; Ng, Sanchez-Aragon, 2022]. The traditional approach to route planning is based on a limited number of factors that are largely static and do not take into account current changes (e.g. route length and average speed) [Malek et al., 2020; Edeh, Acedo, 2021]. Based on real-time data, such a model will be able to build an optimal route and calculate the optimal delivery time with much higher accuracy, which means simultaneously reducing costs and delivery times and increasing customer satisfaction with quality service [Ji et al., 2019; Motta, Peitz, 2021].

Another opportunity for optimisation is the use of data and analytics to predict vehicle maintenance [Olaf, Hanser, 2018; Kim, Kang, 2022]. Automatic collection of data on the condition of the machine reduces unanticipated costs, and information on actual operation (routes, road conditions, type and weight of cargo) is used to plan maintenance in a timely manner, predict component costs, and maintain a sufficient number of working machines in the fleet.

Internet of Things technologies ensure the monitoring of the condition of goods during sea container transport. Until now, it has been possible to track the movement of goods by sea only in limited areas: during loading at the port and after delivery of the cargo to the consignee. During sea transport, breakage of seals and containers and even theft of cargo occurred [Alvarez et al., 2015].

The development of the Russian transport sector is characterised by high capital intensity, which explains the growing share of companies with state participation in the transport market and the existence of natural monopolies. The high degree of monopolisation of the Russian transport market hinders the introduction of innovations. However, according to the definitions of the federal statistical authorities, these enterprises belong to the category of innovation-active ones[6].

It is important to note that this sector in Russia is currently characterised by a low level of innovation activity compared to industry; the vast majority of transport companies invest in innovation activities[7].

The closest industries with similar indicators were construction and agriculture. At the same time, according to Rosstat, noticeable innovation activity in the transport industry was recorded only in 2019. Then, the level of innovation activity was 2.8%[8].

[1] Roads of the future: how the transport and logistics market is changing right now (2021). RBC. https://trends.rbc.ru/trends/industry/60eff42e9a79478d357c6566.

[2] Digital Health Technology Vision 2020 (2020). Accenture. https://www. accenture.com/_acnmedia/PDF-133/Accenture-Digital-Health-Tech-Vision-2020.pdf#zoom=40.

[3] Global Banks 2021 Outlook (2020). S&P Global. https://www.spglobal. com/_assets/documents/ratings/research/100047456.pdf.

[4] Singapore. National Artificial Intelligence Strategy (2019). Smart Nations. https://www.smartnation.gov.sg/docs/default-source/default-doc- ument-library/national-ai-strategy.pdf?sfvrsn=2c3bd8e9_4#:~:text= The%20National%20AI%20Strategy%20is%20a%20living%20docu- ment%20to%20place,to%20our%20citizens%20and%20businesses.
How Industry 4.0 and digitization improves manufacturing responsiveness, quality, and efficiency (2021). ISA. https://blog.isa.org/indus- try-40-digitization-improve-manufacturing-responsiveness-quality- efficiency-iot.

[5] Digital Health Technology Vision 2020… https://www. accenture.com/_acnmedia/PDF-133/Accenture-Digital-Health-Tech- Vision-2020.pdf#zoom=40.

[6] Order of Rosstat of 27 December 2019 No. 818 'On approval of the methodology for calculating the indicator "Level of innovative activity of organisation"'. http://srv-consplus/cons/cgi/online.cgi?req=doc&ts=7SzQObTaziHixrlE&cacheid=530A4FC39904BA8CFE526982A184E4B7&mode=splus&rnd=0.08568365793935362&base=LAW&n=344264 - CO1ROb TQ09Q01xf.

[7] Federal State Statistics Service (Rosstat). Science, innovation and technology. https://rosstat.gov.ru/statistics/science.

[8] Id.

In this respect, the study of the innovative development of transport companies and its impact on increasing their value is relevant.

1. Research methodology

The methodology used in this study is inductive, characterised by the description of the empirical information collected and the interpretation of the results obtained. This raises the problem of selecting the objects to be studied. In order to obtain data, a case analysis method was chosen, namely an analysis of innovative activities using the example of large companies. The choice of this approach is justified by its universality and the possibility of using an integrated approach to the problem at hand.

The article studies three domestic companies: Aeroflot PJSC, TransContainer PJSC and State Transport Leasing Company JSC, which are active in the field of transport and logistics. The choice of companies is based on their significant market share (all three companies are classified as large and have a large market share in their respective segments), as well as the opportunities for innovation due to the presence of large financial flows.

The choice of large companies is determined by the adequacy of resources for introducing innovations and the segmentation of the transport market: Aeroflot JSC specialises mainly in passenger air transport, TransContainer JSC in rail freight transport, and State Transport Leasing Company JSC in vehicle leasing. A study based on a sample of these companies will allow us to draw conclusions about general trends in the transport industry, as well as to highlight the characteristics of individual transport segments: aviation, rail transport and transport leasing services.

2. Data collection

Data collection was carried out in four stages. In the first stage, a general assessment of innovative activity in the industry was carried out based on the analysis of open data: consolidated studies on the industry, as well as official documents, primarily the Passport for the Digital Transformation Strategy of the Transport Industry of the Russian Federation. This is necessary to identify the main types of innovations that experts consider to be the most important and effective. This will make it possible to compare how they operate and to assess how much progress they make in the proposed areas.

In the second stage, the financial statements of these companies for the year 2021 were analysed, as well as other official documents. This identified the main performance indicators of the enterprises, problems and difficulties in carrying out their activities, development prospects and information on the innovative activities carried out and the enterprises' plans to improve indicators and performance results through innovation. A brief description of the review of the enterprises' activities is given below.

In the third stage, a mixed format remote interview was conducted with 15 employees from each company on the implementation of innovation, the complexity of innovation activities and the identification of factors influencing innovation activities.

In the fourth stage, the same respondents were asked about the potential impact of the innovations developed in these companies on the main financial indicators such as turnover and profit. The lists of innovations for each company were obtained by analysing the companies' annual reports and the information available on official websites.

3. Research findings

3.1. Types of innovation in transport companies and an overview of innovation activities in the transport sector

The analysis based on open sources of information (strategic development documents of the Russian Federation, publications of specialist media, data from statistical agencies, reports of Aeroflot OJSC, TransContainer OJSC, State Transport Leasing Company OJSC, as well as consulting companies) shows the interest of the business community in various categories of innovations, as reflected in Table 1.

The global environmental agenda sets the trend for the development of mobility devices powered by alternative fuels [Pinsonneault, Choi, 2022]. Thus, the Transport Strategy of the Russian Federation until 2030 with a forecast for the period until 2035 (Transport Strategy) provides for reducing the negative impact on the environment through the development of electric transport[9].

Autonomous control technologies occupy a special place in the development of transport. A pilot project to test unmanned taxis is currently underway in Russia[10]. The Line Ministry is implementing a number of projects to introduce unmanned vehicles. According to the Russian Ministry of Transport, by 2030 the use of drones will increase the speed of delivery of goods and passengers by 25% and reduce the accident rate by 20%[11].

The companies discussed in this study contribute to the implementation of government policy by implementing measures to renew parks with energy-efficient equipment - electric transport, which ensures a reduction of harmful emissions into the atmosphere and a reduction of noise and vibration levels in megacities. According to the passport of Aeroflot PJSC's innovative development programme, the company has been conducting research in the field of using drones for aircraft maintenance since 2017. JSC State Transport Leasing Company implements state policy in the field of development of autonomous means of transport in the following areas: unmanned vehicle transport, unmanned navigation, unmanned aircraft[12].

[9] Transport strategy of the Russian Federation until 2030 with a forecast until 2035. http://static.government.ru/media/files/7enYF2uL5kFZlOOpQhLl0nUT91RjCbeR.pdf.
[10] The government has allowed Yandex to launch driverless taxis in Moscow (2022). RBC. https://www.rbc.ru/business/17/03/2022/623331689a79475ba96d9404 .
[11] Passport of the strategy of digital transformation of the transport industry of the Russian Federation. https://mintrans.gov.ru/activities/297/documents.
[12] Transport in detail. Unmanned technologies on land, sea and in the air. STLC. https://www.gtlk.ru/press_room/drone/.

Table 1
Types of innovation in transport companies

Order	Innovation category	Modes of transport
1	Electric transport	Road transport, municipal passenger transport
2	Unmanned vehicles	All modes of transport
3	High-speed transport systems	All modes of transport
4	Immersive technologies (VR, AR)	All modes of transport
5	Smart contracts	All modes of transport
6	Biometric technologies	All modes of transport
7	Traffic Management Technologies	Motor vehicles
8	Predictive analytics	All modes of transport
9	Electric vertical take-off and landing technologies	Air transport
10	Automated fleet maintenance (AMOS)	Air transport
11	Hydrogen fuel cell trains	Rail transport
12	Smart port	Sea/river transport

Source: compiled by the authors based on the study of media materials and annual reports of PJSC Aeroflot, PJSC TransContainer, JSC State Transport Leasing Company.

With sanctions restricting the supply of components for the production of drones, domestic manufacturers will fall significantly behind the leading countries in the autonomous transport market. According to J'son & Partners Consulting, the global structure of the drone market in 2035 will be represented by China (33%), the US (26%) and European countries (21%)[13].

Another promising direction is the development of Intelligent Transport Systems (ITS), which aim to optimise and redistribute transport flows, transmit key production indicators online and thus increase the efficiency of business management and reduce business costs.

Transport companies use virtual reality (VR, AR) to train employees in the aviation and rail industries.

With regard to the overview of the innovation activity market [Zezulka et al., 2016; Pinsonneault, Choi, 2022; Razzak et al., 2022], the transport and logistics industry is currently entering a phase of transition to innovation in the course of its activities [Innovation activity indicators..., 2022]. This was triggered by the COVID-19 pandemic, which led to a sharp decline in the market and disruption of supply chains. Falling profits have forced operators to pay more attention to innovation: around 80% of companies are moving to new business models linked to digital technologies and using innovations of various kinds[14].

Since 2019, the transport sector has been characterised by a noticeable increase in innovative activity. Other statistical indicators are shown in Table 2.

The share of costs of innovation activities in the total volume of transported goods was 2.6% in 2019 and 2% in 2020. At the same time, the volume of innovative goods, works or services created by transport companies amounted to 47.7 billion roubles and 125.5 billion roubles in 2019 and 2020, respectively. Growth in the share of innovative goods, works or services in the total volume of the companies' products, 0.5% in 2019 and 1.2% in 2020, is also indicative of the industry's turn to innovative activity[15].

It is worth noting that the main activity involved was purchasing machinery and other equipment needed to carry out their activities. This was the case for 39.8 % of enterprises engaged in innovation. Research and development carried out by enterprises to improve the quality of their products, reduce costs and generally update production processes came second (30.2 %). The third (26.5%) most common type of innovative activity of transport enterprises was the acquisition or independent development and implementation of computer programs and databases necessary to improve enterprise control in terms of ensuring transparency of operational processes, identifying weaknesses and growth points [Lin et al. , 2016; Tidd, Bessant, 2018].

Table 2
Statistical information on the innovative activity of transport companies

Indicators	2019	2020
Level of innovation activity	2.8	4
Share of innovation activity costs in the total volume of goods shipped (%)	2.6	2
Volume of innovative goods, works or services created by transport enterprises (billion roubles)	47.7	125.5
Share of innovative goods, works or services in the total volume of the enterprises' products (%)	0.5	1.2

Source: compiled by the authors on the basis of Rosstat data.

[13] Global self-driving car market, 2020–2035. J'son & Partners Consulting. https://tadviser.com/index.php/Article:Self-driving_cars_(global_market)#Json_.26_Partners_study.
[14] Roads of the future... (2021). RBC. https://trends.rbc.ru/trends/industry/60eff42e9a79478d357c6566.
[15] Federal State Statistics Service (Rosstat). https://rosstat.gov.ru/statistics/science.

The comparative share of the main types of innovative activities of transport enterprises and those providing services as part of their main activity is shown in Table 3.

Table 3
Comparison of innovation shares in transport and services (%)

	Transport industry	Companies providing services
Research and development	30.2	33.9
Acquisition of machinery and equipment	39.8	44
Marketing and branding	1.6	3.9
Staff training and retraining	9.6	13.7
Engineering design	1.1	1.5
Engineering services	7.2	7
Development and purchase of computer programs and databases	26.5	35.5
Acquisition of rights to the results of intellectual activity	9.6	8.4
Planning, developing and implementing new ways of doing business, organising workplaces and external relations	3.5	5.1
Other types of innovation activity	20.1	16.4

Source: Compiled by the authors on the basis of Rosstat data.

The main types of innovation used in transport and service enterprises are shown in Table 4.

Table 4
Main types of innovation used by transport and service companies (%)

	Transport industry	Companies providing services
Product innovation	57.9	65.9
Process innovation	71.7	67.7
Methods of producing and developing goods and services	18.4	18.6
Methods of logistics, supply and distribution	23.5	11.3
Information processing and transmission methods	45.7	38.5
Business practices, corporate governance	32.1	26.3
Business relations and external relations practices	16.4	14.1
Methods of labour management	25.3	19.6
Marketing methods for the promotion, provision and pricing of goods and services	14,5	12,3

Source: Compiled by the authors on the basis of Rosstat data.

Product and process innovations were used by 57.9 % and 71.7 % respectively of enterprises engaged in innovation activity in transport. These figures can be explained by the fact that the main types of services provided by transport enterprises cannot be changed conceptually. Instead, they focus on improving operational performance and the quality of services provided. Most of these innovations are related to changes in methods of processing and transmitting information (45.7%), as well as to new methods of doing business, corporate governance, accounting and financial reporting (32.1%).

Clearly, access to logistics infrastructure and the management of resources and components are linked to the provision of transport services. Therefore, 23.5% of the innovations introduced were related to improving logistics and distribution methods.

The problem of improving the quality of the human capital used is one of the main tasks in innovation, and the professional development of employees is an important factor determining the success of innovation. This problem is particularly pronounced in cases where the work of the company involves the operation of complex equipment or other objects. In this regard, innovations related to the labour resources of transport companies are quite obvious and are combined with the following material devoted to the analysis of the innovative activity of PJSC Aeroflot, PJSC TransContainer and JSC State Transport Leasing Company.

An analysis of the organisational structure shows that only 0.5% of companies in the sector have an R&D department . In general, the existing business model of such enterprises does not imply a close connection with the fundamental development of new types of material base for their activities or other forms of self-sufficiency with new technologies. The total number of people employed in these departments in 2020 was 2817. This is also reflected in the frequency of research and development activities. In 2020, 26.9% of enterprises regularly develop the innovative solutions they need and 73.1% of enterprises regularly address this issue[16].

The total cost of innovation activities of transport companies in 2020 amounted to 203.7 billion roubles. The lion's share of these costs came from own resources (193.4 billion roubles, or 95%), the rest from subsidies (2.8%) or targeted payments from the federal or regional budgets. Only 5.1% of enterprises received financial support from the government. The share of credits and loans for innovation in total costs seems to be quite low - only 0.4%. This suggests that, for the most part, transport enterprises are not financially starved and have sufficient resources to implement innovation initiatives.

165.3 billion roubles were spent on product innovation and 38.3 billion roubles on process innovation[17]. Despite the importance of process innovations and the fact that they are used one and a half times more than product innovations, a large share of the costs of the latter is understandable. Transport enterprises deal with complex equipment, especially in air transport, so that the purchase of more

[16] Id.
[17] Id.

Table 5
Frequency and cost of innovation use by transport companies

	Frequency of using innovation activity (%)	Cost of expences (million roubles)
Research and development	30.2	9 685.1
Acquisition of machinery and equipment	39.8	184 342
Marketing and branding	1.6	29.4
Staff training and retraining	9.6	1 072.5
Engineering design	1.1	25.1
Engineering services	7.2	1 698
Development and purchase of computer programs and databases	26.5	1 808.2
Acquisition of rights to the results of intellectual activity	9.6	108.7
Planning, developing and implementing new ways of doing business, organising workplaces and external relations	3.5	49.7
Other types of innovation activity	20.1	4 929.9

Source: Compiled by the authors on the basis of Rosstat data.

advanced similar objects as well as components for them is more expensive than investing in other types of innovations. This also explains the high share of transport in total innovation costs for the services sector. It accounts for 22.3% of total innovation expenditure by services enterprises[18]. Expenditure on innovation by type of economic activity and frequency of use is shown in Table 5.

It is interesting to note that transport companies are leading the way in environmental innovation. 16.9% of companies in the sector are currently innovating or have already completed projects to implement environmental innovations. This mainly concerns reducing pollution (84.3% of organisations), saving energy costs and switching to energy efficient technologies (35.7% of organisations), reducing carbon footprint and replacing raw materials with safer or less hazardous analogues (21.4% each). The main objective of environmental innovation is to ensure compliance with modern technical regulations (92.9% of companies). Many large transport companies are international in scope and it is important for them to implement environmental initiatives as part of the growing attention to the green agenda and the tightening of production standards in this area. Many companies (82.7%) voluntarily follow environmental principles[19].

At the same time, the lack of dedicated departments in the structure of transport companies forces them to seek outside help when introducing innovations. Payments to contractors account for 78.9% of all costs incurred by transport companies in implementing innovations. Certain categories of innovation activities are not actually carried out by the enterprises themselves. In the case of marketing and brand creation, 99.8% of the costs are paid to third parties; in the case of the training and re-training of staff, it amounts to 96.3 %; the cost of developing and acquiring computer programs and databases is 86.2%[20].

The total volume of innovative goods and services produced by transport companies in 2020 amounted to 125.6 billion roubles against 47.5 billion roubles in 2019[21]. This indicates an active process of introducing innovations and a gradual increase in their share of the total volume of products manufactured. It should be noted that the share of completely new or significantly modified products dramatically exceeds

[18] Id.
[19] Id.
[20] Id.
[21] Federal State Statistics Service (Rosstat). https://rosstat.gov.ru/statistics/science.

the volume of improved products. Thus, in monetary terms, the share of the former amounted to 98.1 billion roubles, and the share of the latter was 27.4 billion roubles. This indicates a sharp increase in interest in innovation and some practical successes in this regard. At the same time, the share of innovative products in the total volume did not exceed 1.2%, which, of course, does not give the right to talk about a radical transition of the industry to innovation.

Domestic transport companies did not present any conceptually new goods or services on the global market. It seems that the industry is in the phase of getting to know each other and taking the first serious steps in the application of innovative technologies. This can be partly explained by the current economic situation in which many transport companies, especially leading ones, find themselves cut off from foreign technologies or components.

However, it is worth noting that 30% of the innovative products of enterprises were created using intellectual property belonging to Russian economic and scientific entities. Most of the innovative products of transport companies are consumed within the country. In 2020, only 5% of the volume of innovative products was exported (the total amount of exports amounted to 6.2 billion roubles)[22]. At the same time, the main export destinations were non-CIS countries, which accounted for 99.5% of exported innovative products[23].

On the basis of the data presented, we can conclude that the situation in the Russian transport market can be described as unfavourable from the point of view of the introduction of innovations; innovation activity in the transport industry is insignificant.

This is mainly due to the fact that transport companies provide services and do not produce but operate innovations. At the same time, they are the ones who create the demand for innovation in the transport market and make significant investments in improving the material and technical base. For this reason, they are classified as being active in innovation.

As far as the dynamics of research in the field of innovative activity of transport companies is concerned, the process of introducing innovation started quite a long time ago, but the relatively noticeable results of this activity appeared only in 2020. Despite the small comparative indicators of the share of innovative products in their total volume, as well as the share of expenses for innovation activities in the cost structure of enterprises, the annual dynamics gives reasons to assume an increasing role of the innovative component in the activities of enterprises of the transport sector.

All of this speaks to the industry's high potential for innovation, as well as the need to increase the level of sustainability of companies to the current market conditions of the transport market, which is characterised by a high level of monopolisation.

3.2. The impact of innovative activity on the performance indicators of Aeroflot PJSC, TransContainer PJSC, JSC GTLK State Transport Leasing Company

Let us turn to the analysis of the innovative activity of Aeroflot PJSC, TransContainer PJSC, JSC GTLK State Transport Leasing Company. Data on market shares, productivity levels, passenger traffic, throughput and some other indicators are used to determine the impact of the innovations applied. The study uses data from the companies' annual reports. It also draws on the results of a survey of employees in the companies surveyed.

Aeroflot PJSC's most significant product innovation[24] was the launch of Russia's first low-cost carrier, Pobeda Airlines, in 2014. In 2014, Pobeda's share in the Aeroflot Group's total passenger traffic was only 0.4%, and in 2021 the airline carried 14.4 million passengers, or 31.5% of

Table 6
The impact of 'Pobeda Airlines' on financial indicators

Year	Passengers carried by Pobeda Airlines (million people)	Total number of passengers carried by the Group (million people)	Ratio of Pobeda Airlines passenger traffic to the Group's total passenger traffic (%)
2017	4.6	50.1	9.2
2018	7.2	55.7	12.9
2019	10.3	60.7	17
2020	9.1	30.2	30.1
2021	14.4	45.8	31.4

Source: compiled by the authors on the basis of Aeroflot PJSC's 2021 report.

[22] Id.
[23] Id.
[24] Aeroflot joined the Digital Transport and Logistics Association (2019). https://www.aerof lot.ru/ru-ru/news/61473.

Table 7
PJSC 'Aeroflot' innovation performance indicators

Indicator	2018	2019	2020	2021
Labour productivity (million km/person)	4.551	4.907	2.478	3.779
Passenger traffic (billion pkm)	143.2	156.3	68	100.1
Year-on-year cost reduction (%)	0.27	0.15	0.37	0.63
Flight punctuality (%)	89.9	94.8	96	93.8
Customer loyalty index (%)	72	73	*	74.6
Flight safety level (%)	99.974	98.932	99.965	99.973
Return on investment in innovation (%)	0.17	0.17	0.17	0.1**

* In 2020, the loyalty index was not evaluated.
** The indicator set at the mandatory level was reduced in accordance with the company's appeal to the Ministry of Transport and the Ministry of Economic Development of the Russian Federation.

Source: Compiled by the authors on the basis of Aeroflot PJSC reports for 2019 and 2021: https://rspp.ru/upload/uf/252/AFLT-ar19-ru__1_.pdf; https://ir.aeroflot.ru/fileadmin/user_upload/files/rus/common_info/gosa_doc_2022/Aeroflot_AR21_RUS_book_v2_0706_1740.pdf.

the Group's total passenger traffic. The impact of Pobeda Airlines on the Group's passenger traffic is shown in Table 6.

The launch of a new service for domestic consumers not only attracted customers from competitors, but also changed consumer preferences: 12% of passengers did not use air travel before Pobeda Airlines. The key elements of Pobeda Airlines' business model are:

1) efficient flight operations and routes that reduce economic and time costs;
2) high labour productivity, ensured by modern technologies and introduced innovations (in 2021 there were 7,113 passengers per company employee);
3) low level of transaction costs - the CASK, reflecting the cost per seat-kilometre, amounted to 2.3 rubles in 2021;
4) stimulation of the market, namely the offer of low prices for air transport (12% of customers before the appearance of Pobeda used only ground transport);
5) high demand, especially seasonal. However, due to the company's high market share, the average seat load factor on flights was 94%, reaching 96% in the peak months of the summer season;
6) operating an efficient fleet with high seat capacity.

Aeroflot PJSC clearly considers this innovation to be one of the most important. The results of a survey of Aeroflot PJSC employees show that about 78% of all key innovations implemented within the Group are tested or primarily implemented during the work of Pobeda Airlines.

According to the Passport of Aeroflot's Innovative Development Programme[25], the key areas for increasing the efficiency of innovation activities are as follows:

1) increase in labour productivity (million km/person);
2) increase in the efficiency of production and/or business processes, expressed in terms of passenger turnover (billion pkm);
3) reduction of costs, unit costs of production and service provision;
4) improvement in the quality (consumer characteristics) of the products manufactured and services provided, which includes flight punctuality, consumer loyalty index and flight safety levels;
5) economic efficiency of investment in innovation, measured as the ratio of R&D costs and other costs according to the established list to sales;
6) growth in non-resource export volumes, expressed as the share of local air transport revenue in the company's total revenue;
7) increase in energy efficiency and environmental friendliness of production, understood as a reduction in fuel and lubricant consumption compared to the previous year.

Given the sharp decline in the airline industry in general and the performance of Aeroflot PJSC in particular in 2020 due to the COVID-19 pandemic, it is difficult to draw conclusions about the effectiveness of innovation activities based on these indicators. Meanwhile, the speed

[25] Passport to the innovative development programme of PJSC Aeroflot. https://www.aeroflot.ru/media/aflfiles/media/strategy/pasport_2022.pdf.

Table 8
Existing IT systems in PJSC 'Aeroflot'

B2C	B2B	B2P
Aeroflot website, including mobile web check-in	Corporate loyalty programme	Maintenance management system
Mobile application	Agent loyalty programme	CrewTablet (SITA)
Customer loyalty management system	Investor website	Contact centre voice platform
Big data	Electronic aircraft customs declaration	SAP ERP Enterprise management system
E-commerce platform	Corporate system tax monitoring	Sirax Revenue accounting system
Unified payment solution		Electronic document management system and electronic digital signatures
Internet and inflight entertainment systems		Manager Monitor; EFB (Electronic Flight Briefcase)
		Base airport resource management system

Source: Compiled by the authors on the basis of Aeroflot PJSC reports for 2019 and 2021: https://ir.aeroflot.ru/fileadmin/user_upload/files/rus/common_info/gosa_doc_2022/Aeroflot_AR21_RUS_book_v2_0706_1740.pdf.

of their recovery can be used as a measure of success in this direction. On the basis of the company's official publications, the following conclusions can be drawn about the success of Aeroflot PJSC's innovative activities (Table 7).

Based on the information in Table 7, it can be seen that with a 50% reduction in labour productivity and passenger turnover in 2020 compared to 2019, the rate of recovery in 2021 shows the same result compared to 2020.

A similar situation is observed when comparing the dynamics of decline and recovery in other indicators, although to a lesser extent. For example, the cost of aviation fuel increased significantly in 2021 compared to 2020. Aeroflot PJSC's expenses for this cost indicator increased by 58.9%[26]. A similar situation is observed when comparing the dynamics of decline and recovery in other indicators, although to a lesser extent. For example, the cost of aviation fuel increased significantly in 2021 compared to 2020. Aeroflot PJSC's expenses for this cost indicator[27] increased by 58.9%.

Aeroflot PJSC is actively implementing digital technologies. According to the company's 2021 annual report, 100% of business processes are fully automated, making the Group one of the four most digitised airlines in the world. The development of digital technologies is a priority direction of the company's innovative development. Existing IT systems are shown in Table 8.

Aeroflot PJSC's IT systems, which are currently under development, will ensure stable growth of the company after 2020 and create an incentive for further development (Table 9). This is confirmed by the assessments of experts from the Ministry of Transport of the Russian Federation, who evaluated these innovations from the point of view of their impact on the value of the company.

According to the data presented, the current and promising types of innovation aim to solve the current problems related to increasing the efficiency of innovation activities. They are the only way out of the situation of restrictions and prospects for the company's growth.

The total cost of innovation for the Aeroflot Group in connection with the implementation of innovative projects and activities and research, development and technological work (R&D) in 2021 will amount to 117,641,096 million rubles, which is 103.16% higher than the actual figures for 2020[28]. A significant factor that had a noticeable impact on the Group's financial results in 2021 was the decrease

[26] https://ir.aeroflot.ru/ru/novosti/article/57983/.
[27] Annual report for 2021. https://ir.aeroflot.ru/fileadmin/user_upload/files/rus/common_info/gosa_doc_2022/Aeroflot_AR21_RUS_book_v2_0706_1740.pdf.
[28] Passport of the innovative development program of PJSC Aeroflot for 2021. https://www.aeroflot.ru/media/aflfiles/media/strategy/pasport_2022.pdf.

Table 9
Key innovations under development or already partially implemented in PJSC 'Aeroflot'

Types of key innovations	Innovation performance indicator that is influenced by the factors
Conducting training on complex flight simulators with scenario simulation depending on the individual skills of the flight crew using artificial intelligence technologies.	Level of flight safety Labour productivity Cost reduction Reduction in fuel consumption
Digitisation of freight sales. Predictive quotas and pricing of freight transport	Cost reduction Labour productivity
Introduction of biometric passenger identification at the airport for domestic flights and voice biometrics for customer authentication	Improving the quality (consumer characteristics) of products manufactured and services provided Level of flight safety
Development and use of intelligent bots with AI in chats on the website, instant messengers and online services	Improving the quality (consumer characteristics) of the products and services produced
Creation of a single portal for pilots and an electronic pilot profile	Level of flight safety Labour productivity
Development of a hardware and software complex for the use of IoT (Internet of Things) technology to automatically determine the location of containers	Return on investment in innovation Cost reduction compared to the previous year
Implementation of a fuel efficiency system to analyse in-flight fuel consumption	Cost reduction compared to the previous year
Corporate loyalty programme	Improving the quality (consumer characteristics) of the products and services produced
Production NDC environment	Cost reduction compared to previous year
Application of RFID technology in the business processes of PJSC Aeroflot	Return on investment in innovation Cost reduction Labour productivity

Source: Compiled by the authors on the basis of Aeroflot PJSC reports for 2019 and 2021: https://rspp.ru/upload/uf/252/AFLT-ar19-ru__1_.pdf; https://ir.aeroflot.ru/fileadmin/user_upload/files/rus/common_info/gosa_doc_2022/Aeroflot_AR21_RUS_book_v2_0706_1740.pdf.

in passenger traffic associated with the industry's operating conditions during the COVID-19 pandemic.

TransContainer PJSC, based on the strategic development programme, will implement measures to digitalise its business, which will allow it to increase its level to 80% by 2030[29]. The company plans to introduce a fully automated Customer Journey Map (a product development methodology based on a detailed analysis of customer needs and actual customer interactions with the company's products), end-to-end product-centric processes, a new digital order fulfilment fleet management system, and a unified service centre for the Delo Centre group of companies. These measures will reduce the cost of support functions by 27%[30]. The proposed implementation of the efficiency programme will make it possible to purchase rolling stock at a reduced price, which will gradually reduce CAPEX (capital expenditure costs). The total benefit of such a programme is expected to be around 30 billion roubles by 2030. This digitalisation is expected to reduce the speed of development of new innovations from 6-12 to 2-6 months, increase the level of automation of business processes by up to 60% and the availability of data for online analysis by up to 90% by 2025[31]. It is clear that these measures, if fully implemented, will have an impact on the company's operating results and, consequently, on the value of the company.

The company's key performance indicators, including innovation activities, are[32]:

1) net income;
2) EBITDA;
3) share of profitable transport by rail;
4) rail container transport volumes;
5) container handling volumes and some others.

[29] Strategic Development Programme of TransContainer PJSC. https://trcont.com/the-company/strategy.
[30] Annual report of TransContainer PJSC for the year 2021. https://www.e-disclosure.ru/portal/files.aspx?id=11194&type=2&attempt=2.
[31] Id.
[32] Id.

Table 10
Changes in key operating performance of PJSC 'Transcontainer'

Operating performance	2021	2020	2019
Volume of containers handled by rail (thousand TEUs)	2634	2405	2050
Volume of containers handled (thousand TEUs)	1435	1423	1320
Empty run rate of containers (%)	14	17	17.2
Share of profitable revenue traffic in total traffic (%)	84.4	80.4	81.7

Source: compiled by the authors based on the report of TransContainer PJSC for 2021: https://trcont.com/investor-relations/reporting/financial-reports-under-ifrs1.

In connection with the development of rail transport flows, TransContainer PJSC pays attention to improving the efficiency of its activities. In particular, the company is focusing on the development of IT systems that will allow it to reduce operating costs, increase the speed of loading and unloading containers by optimising warehouse operations, and deepen planning and cargo management. TransContainer PJSC has a long history of introducing innovations - on 2 November 2017, a presentation of the new information system 'Intelligent Container Terminal' (ICT) took place. The use of ICT enabled a reduction of 0.1 days in wagon downtime during freight operations, a reduction of 0.1 days in wagon turnover, a reduction of 2 days in container downtime, a reduction of 0.2 days in container turnover and minimisation of unproductive journeys during loading and unloading at the site. This in turn led to a reduction in electricity and fuel consumption, the cost of maintaining the gas unit and the cost of repairing the container site[33].

Digital solutions accompany the entire chain of the company's services. IT solutions currently specialise in the development of digital sales channels and CRM systems and the implementation of green logistics projects; the development of a BPM system for monitoring and optimising processes and the introduction of technologies for intelligent container terminals and artificial intelligence; the creation of cross-holding services and a unified corporate data warehouse for the Group, the implementation of infrastructure projects and the development of supporting corporate systems.

In 2021, TransContainer PJSC underwent a reorganisation of its sales department. As part of the reorganisation, a customer service department has been created, whose main task is to provide one-stop support for customer orders under feasibility study contracts at all stages of transport, with the assignment of a personal manager. The main aim of the changes is to improve the quality of service by improving communication with the customer. One of the results of the

Table 11
Key innovations under development or already partially applied in PJSC 'Trancontainer'

Types of key innovations	Innovation performance indicator that is influenced by the factors
TransContainer Academy	Increasing productivity
Implementation and standardisation of TOS	Improving the efficiency of production and/or business processes
Digital twin for the route network	Improving the quality (consumer characteristics) of manufactured products
Customer Journey Map and end-to-end product-centric processes	Improving efficiency of production and/or business processes Improving the quality (consumer characteristics) of manufactured products
Развитие iSales и каналов продаж, внедрение системы iTrans	Improving the quality (consumer characteristics) of manufactured products
Digital platform for co-executors	Improving the quality (consumer characteristics) of manufactured products Reducing costs, unit cost saving
Creation of cross-holding macro services	Improving efficiency of production and/or business processes Reducing costs, unit cost saving
Technology for covering container sites by laying terminal stone	Reducing costs, unit cost saving

Source: Compiled by the authors based on the report of TransContainer PJSC for 2021: https://trcont.com/investor-relations/reporting/financial-reports-under-ifrs1.

[33] Transcontainer introduced a new information system. https://trcont.com/press-centre/press-releases/-/asset_publisher/3m9B8CrlzS4s/content/-transkontejner-prezentoval-novuu-informacionnuu-sistemu-intellektual-nyj-kontejnernyj-terminal-.

Table 12
Changes in the key operating indicators of JSC 'GTLK'

Operating performance	2021	2020	2019
Leasing portfolio (billion roubles)	1355	1293	1102
Volume of investments in new business (billion roubles)	136	196	218
Volume of the leasing portfolio by the balance of the contract value reimbursement (billion rubles)	980	898	679
Expenses as a percentage of gross income (%)	29	35	40
Problem rate of the leasing portfolio (%)	0.5	0.8	0.9

Source: compiled by the authors on the basis of the report of JSC GTLK State Transport Leasing Company for 2021: https://trcont.com/investor-relations/reporting/financial-reports-under-ifrs1.

changes was a 3.5-fold increase in multimodal transport in the company's portfolio.

These examples demonstrate the extensive involvement of TransContainer PJSC in the process of innovative transformation, which is already having an impact on the company's key operating results (Table 10).

As shown in Table 10, innovations make it possible to increase the profitability of transport, reduce the amount of unused capacity and use containers more efficiently. TransContainer PJSC is focused on the further development of innovation activities and plans to develop and implement the types of innovations presented in Table 11 in the future.

According to the annual report of JSC GTLK State Transport Leasing Company for 2021, the company has set itself the strategic goal of digital transformation and increasing the operational efficiency of the company, including through the active implementation of innovations[34].

The main performance criteria are:

1) the increase in the net lease portfolio;
2) the volume of increasing investment in new business;
3) the increase in the leasing portfolio in terms of the balance of the compensation of the contract value;
4) the ratio of expenses to gross income;
5) the level of leasing portfolio problems and some others.

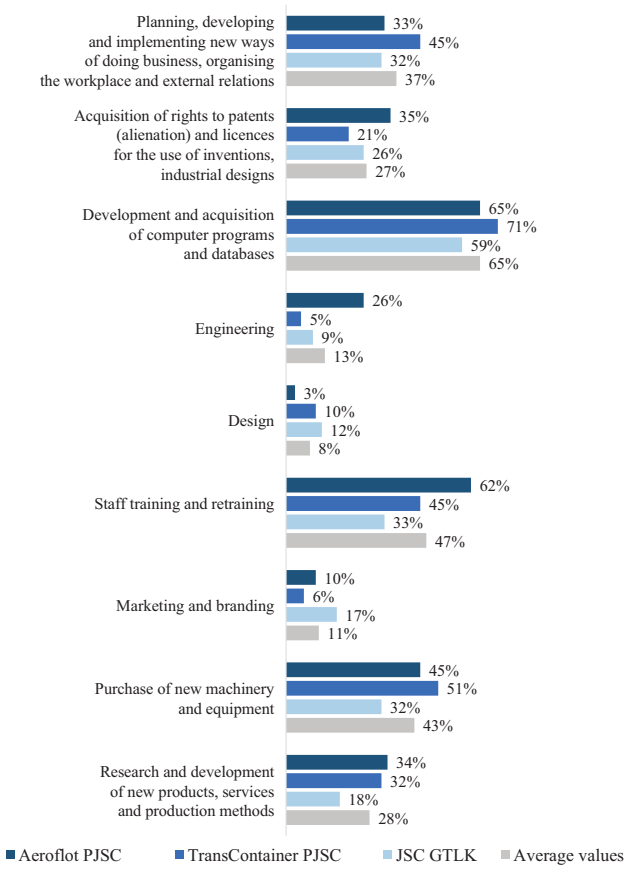
Table 13
Key innovations in JSC 'GTLK' under development or already partially implemented

Types of key innovations	Innovation performance indicator that is influenced by the factors
'Digital rooms' and 'digital passports'	Improving the quality (consumer properties) of manufactured products
Procurement management system	Improving the efficiency of production and/or business processes
Data showcase to ensure fiscal control in fiscal monitoring format	Improving the efficiency of production and/or business processes
Mobile application for the reception and transmission of equipment	Reducing costs, lowering unit costs Improving the quality (consumer properties) of manufactured products
Automation system for management and personnel selection based on the '1C: Salary and Personnel Management' software product	Increasing productivity
System for collecting and analysing operational data from aircraft	Improving the quality (consumer properties) of manufactured products
Use of big data to obtain information on technical reserves	Improving the efficiency of production and/or business processes
Business accelerator of the State Transport Leasing Company on the platform for the development of business innovations GenerationS	Increasing productivity Improving the efficiency of production and/or business processes
Application of blockchain technologies for protection of data received from transport companies	Cost reduction, unit cost reduction Improving the efficiency of production and/or business processes

Source: compiled by the authors on the basis of the report of JSC GTLK State Transport Leasing Company for 2021: https://trcont.com/investor-relations/reporting/financial-reports-under-ifrs1.

[34] Annual report of JSC GTLK for the year 2021. https://www.gtlk.ru/upload/iblock/818/nho6x4mxft7xyr8p8jmapo0lucfjx3u9/AR_2021_GTLK.pdf.

Fig. 1. Distribution of the answers to the question, 'What types of innovation are being implemented in your company?' (% of respondents)



Source: developed by the authors.

JSC GTLK State Transport Leasing Company focuses on the purchase of energy-efficient transport, primarily cars, which leads to a reduction in variable costs. The purchased domestic equipment runs on an alternative to traditional fuel, namely gas or electric traction. These vehicles are also equipped with a driver fatigue monitoring system, which should reduce accidents and vehicle breakdowns. The equipment used for passenger transport is equipped with electronic means of payment, which makes it possible not to lose part of the fare and generally leads to a 'whitewashing' of the market. The physical abilities of passengers are also taken into account. For example, most of these vehicles are low-floor, which allows people with reduced mobility to travel comfortably. In addition to reducing direct costs, innovation can also reduce operational risks and indirectly increase profitability.

At the end of 2019, JSC GTLK State Transport Leasing Company launched a programme for the leasing of digital assets, primarily for domestic development. The total volume of investments in this area is expected to reach 8.6 billion roubles by 2024.[35] JSC GTLK introduces a large volume of innovations, pursuing the main goal - to become a pioneer in the digital transformation of the transport industry in the Russian Federation[36]. This is already having an impact on the company's performance indicators (Table 12).

As mentioned above, JSC GTLK continues to actively introduce innovations in various fields of activity. The main innovations, which should be or have been partially implemented in the company, are listed in Table 13.

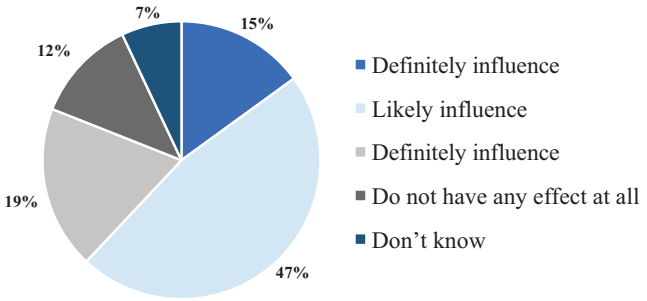
After reviewing the officially published information on the results of innovation activities of these enterprises, we turn to the results of a survey of employees in these enterprises to identify the internal characteristics of innovation implementation.

The first question aimed to identify the categories of innovations introduced by the responding enterprises (Figure 1).

As shown in Fig. 1, the main areas of innovation activity were the development of specialised computer programs, training and retraining of personnel, and the purchase of new equipment. This is generally in line with the industry indicators presented above. All enterprises show an interest in digital transformation and the transition to equipment that allows them to carry out their commercial activities more effectively.

The second question was to identify the overall impact of introduced innovations on the operational activities of enterprises. In this case, it seems obvious that successfully implemented innovations should have a positive impact on those operational indicators that are considered key in business (Fig. 2). Given that the operational indicators are not the same in the companies used for the analysis, the overall impact of innovation on them was assessed without highlighting specific parameters.

Fig. 2. Distribution of the answers to the question, 'Do the innovations implemented have an impact on the improvement of operational indicators?' (% of respondents)



Source: developed by the authors.

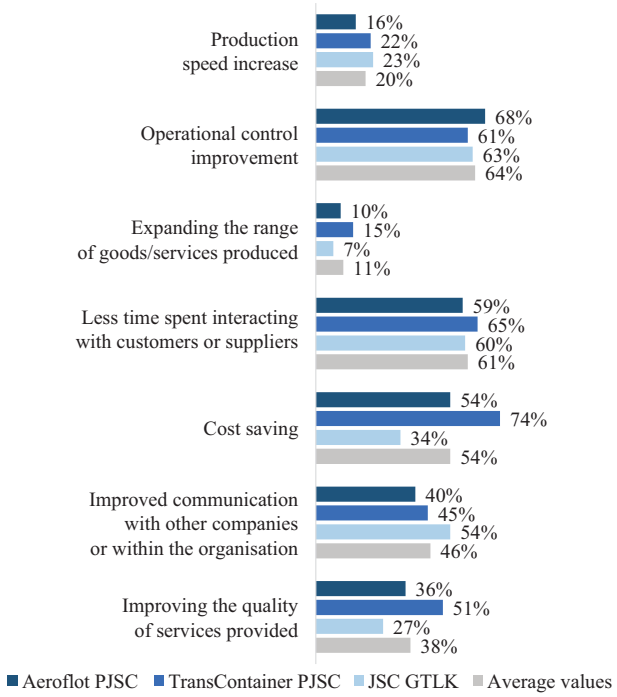
The survey showed that almost half of the respondents noted the impact of innovation on improving operational performance, which in turn is directly related to production activities, suggesting an improvement in the financial parameters of doing business.

[35] Id.

[36] Head of the State Transport Leasing Company – RBC, 'When supplying equipment abroad, we are not squeezed anywhere'. https://www.rbc.ru/business/02/09/2021/612f31219a7947ac10a86b66.

The third question was designed to identify a specific effect without reference to operational indicators. For the purposes of the study, it is important to understand exactly what improvements in what area of activity were noted by the respondents (Fig. 3).

Fig. 3. Distribution of the answers to the question, 'In your opinion, what is the main impact of the innovations that have been implemented?' (% of respondents)

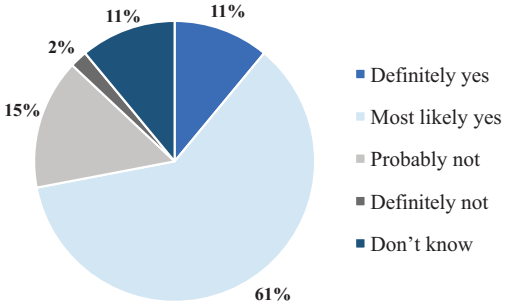


Source: developed by the authors.

The innovations introduced have had the greatest impact on improving control of operational processes, reducing time spent interacting with customers and reducing costs. The first two indicators make it possible to take business decisions more quickly and speed up production in the company. The third indicator directly proves a reduction in the company's expenses.

The fourth question revealed the relationship between the innovations introduced and the value of the company (Figure 4). Respondents were asked to give a general assessment of the potential importance of innovation for company value.

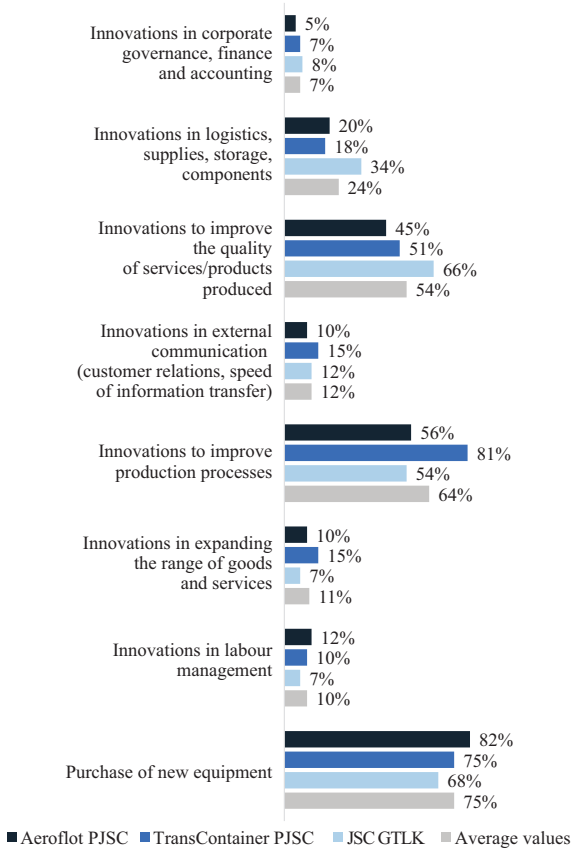
Fig. 4. Distribution of the answers to the question, 'Do you think that the implemented innovations have an impact on the value of your company?' (% of respondents)



Source: developed by the authors.

The vast majority of respondents answered that innovation had an impact on the value of the companies in which they operated. A total of 72% of respondents see value in innovation, affecting not only specific elements of a company's activities, but also its investment attractiveness in the eyes of investors, which is reflected in the value of the company.

Fig. 5. Distribution of the answers to the question, 'Which innovations do you think are most likely to influence the value of the company?' (% of respondents)



Source: developed by the authors.

The fifth question aimed to identify areas of innovation activity that, according to respondents, should primarily influence the value of the company. The survey results are shown in Fig. 5.

As the survey shows, respondents consider innovations related to the purchase of new equipment, which help to improve production indicators and the quality of services/products, to be the most important for the value of the company. For the transport and logistics sector, where companies' main assets are rolling stock, new equipment is obviously a priority area for innovation. In addition, the purchase of less energy-intensive and more efficient equipment can significantly improve production performance. As shown above, the purchase of new aircraft with a certain seating configuration, combined with the right management decisions, has had a significant impact on the financial and other indicators of Aeroflot PJSC in the creation of Pobeda Airlines. Obviously, the identified areas of innovative development are complex and interrelated.

4. Conclusions and recommendations

Innovation has an impact on both operational performance and firm value. Firstly, company value is influenced by innovations related to the acquisition of new equipment, the improvement of production indicators and the increase in the quality of the services/products offered. Value innovations predominate in the companies surveyed. Incremental innovations are less actively implemented, despite their objective importance. This can be explained by their high cost, which is a limiting factor for development in the current conditions. Digital technologies are mainly aimed at increasing control over operational processes, improving interaction with customers and reducing costs. Together with the acquisition of new equipment, these areas can be considered as one of the ways to increase the value of the company.

References

Indicators of innovation activity: statistical collection (2022). Moscow, NRU HSE. (In Russ.)

Alvarez R., Bravo-Ortega C., Zahler A. (2015). Innovation and productivity in services: Evidence from Chile. *Emerging Markets Finance & Trade,* 51(3): 593-611. https://doi.org/10.1080/1540496X.2015.1026696.

Baumann J., Kritikos A.S. (2016). The link between R&D, innovation and productivity: Are micro firms different? Bonn, Institute for the Study of Labor, *IZA*, Discussion Paper 9734.

Daim T., Bukhari E., Bakry D., VanHuis J., Yalcin H., Wang X. (2021). Forecasting technology trends through the gap between science and technology: The case of software as an E-commerce service. *Foresight and STI Governance,* 15(2): 12-24. DOI: 10.17323/2500-2597.2021.2.12.24.

Edeh J.N., Acedo F.J. (2021). External supports, innovation efforts and productivity: Estimation of a CDM model for small firms in developing countries. *Technological Forecasting and Social Change,* 173: 121189. https://doi.org/10.1016/j.techfore.2021.121189.

Ehls D., Polier S., Herstatt C. (2020). Reviewing the field of external knowledge search for innovation: Theoretical underpinnings and future (re-)search directions. *Journal of Product Innovation Management,* 37(5): 405-430. https://doi.org/10.1111/jpim.12549.

Ji S., Mauer D.C., Zhang Y. (2019). Managerial entrenchment and capital structure: The effect of diversification. *Journal of Corporate Finance*, 65(C): 101505. https://doi.org/10.1016/j.jcorpfin.2019.101505.

Kim J.-S., Kang J. (2022). Exploring the top-priority innovation types and their reasons. *Foresight and STI Governance,* 16(3): 6-16. DOI: 10.17323/2500-2597.2022.3.6.1.

Lin C.L., Lin H.L., Lin E.S. (2016). Is there a complementarity relationship between product and process innovation on productivity in Taiwanese manufacturing firms? *Hitotsubashi Journal of Economics,* 57: 139-173.

Malek S., Sarin S., Haon C. (2020). Extrinsic rewards, intrinsic motivation, and new product development performance. *Journal of Product Innovation Management,* 37(6): 528-551. https://doi.org/10.1111/jpim.12554.

Martin L., Nguyen-Thi T.U. (2015). The relationship between innovation and productivity based on R&D and ICT use: An empirical analysis of firms in Luxembourg. *Revue économique,* 66: 1105-1130.

Motta M., Peitz M. (2021). Big tech mergers. *Information Economics and Policy,* 54: 100868. https://doi.org/10.1016/j.infoecopol.2020.100868.

Ng D., Sanchez-Aragon L.F. (2022). Putting the cart (antecedents) before the horse (absorptive capacity): The role of competitive antecedents to the absorptive capacity innovation process. *Journal of Knowledge Management,* 26(9): 2306-2332. https://doi.org/10.1108/JKM-07.

Murata H., Nakamura K., Shirahada K. (2021). Knowledge co-creation roadmapping for future industrial visions: Case study on smart infrastructure. *Foresight and STI Governance,* 15(2), 52-64. DOI: 10.17323/2500-2597.2021.2.52.64.

Olaf J.M., Hanser E. (2018). Manufacturing in times of digital business and Industry 4.0 - The Industrial Internet of Things not only changes the world of manufacturing. *Advances in Manufacturing Engineering and Materials,* 33(1): 11-17. https://doi.org/10.1007/978-3-319-99353-9_2.

Pinsonneault A., Choi I. (2022). Digital-enabled strategic agility: It's time we examine the sensing of weak signals. *European Journal of Information Systems,* ahead-of-print. https://doi.org/10.1080/0960085X.2022.2027824.

Razzak M.R., Al-Riyami S., Palalic R. (2022). Organizational meta capabilities in the digital transformation era. *Foresight and STI Governance,* 16(4): 24-31. DOI: 10.17323/2500 2597.2022.4.24.31.

Tidd J., Bessant J. (2018). Innovation management challenges: From fads to fundamentals. *International Journal of Innovation Management,* 22(5): 1840007-1-13. https://doi.org/10.1142/S1363919618400078.

Verhoef P.C., Broekhuizen T., Bart Y., Bhattacharya A., Dong J.Q., Fabian N., Haenlein M. (2021). Digital transformation: A multidisciplinary reflection and research agenda. *Journal of Business Research,* 122(1): 889-901. https://doi.org/10.1016/j.jbusres.2019.09.022.

Zezulka F., Marcon P., Vesely I., Sajdl O. (2016). Industry 4.0 - An introduction in the phenomenon. *IFAC-PapersOnLine,* 49(25), 8-12. https://doi.org/10.1016/j.ifacol.2016.12.002.

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Assessment of cyclical and stochastic wind flow to ensure power system reliability

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Abstract

This article highlights current issues related to the problem of variability of wind power generation, which is becoming increasingly important as wind power's contribution to the overall energy balance of many countries grows. Various aspects of wind flow volatility, including its random and deterministic components, are considered. The random component is associated with unpredictable changes in wind speed and direction, while the deterministic component is due to known patterns, such as daily and seasonal variations. The article proposes different methods for levelling the stochasticity of wind power flows. This is important for the stability and reliability of the power system, as it reduces the likelihood blackouts and ensures a more even distribution of load. The article also gives examples of the economic and environmental impact of using the proposed methods.

Keywords: renewable energy sources, wind energy forecast, stochasticity, wind power plant, quantile forecast, statistical test.

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确保电力系统可靠性的风流周期性和随机性评估

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摘要

本文章重点介绍了当前与风电场发电变异性问题有关的问题。鉴于风能在许多国家的总体能源结构中所占比例越来越大，这一点正变得越来越重要。作者考虑了风流波动的各个方面，包括其随机和确定成分。随机成分是由于风速和风向的不可预测变化造成的，而确定成分则是由于已知模式造成的，如昼夜和季节变化。本文章提出了来平抑风流能量的随机性的多种方法。这对确保电力系统的稳定性和可靠性非常重要，因为通过提供更均匀的负荷分配，降低了停电的可能性。本文章还说明了使用拟议方法的经济和环境影响例子。

关键词：可再生能源、风能预测、随机性、风力发电厂、分位数预测、统计检测。

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Reliable operation of the energy system is the most important task for the normal functioning of all economic sectors and human life, which is ensured by a constant balance between electricity production and consumption.

In order to maintain a constant balance between electricity production and consumption, it is necessary to have an appropriate range of flexible tools to regulate the imbalance: hot reserve thermal power, flexible power plants, demand management, etc.

With increasing uncertainty in the power system, the demand for flexibile tools increases, which is associated with high costs for the power system.

One of the main factors in the growth of uncertainty is the increase in the amount of variable generation - wind and solar power plants.

The variability of wind speed and the energy produced limits its use in the electricity system to some extent. Therefore, many scientists are working on approaches to predict the output of wind power plants in order to know the arrival of wind energy in advance [Kamran, 2023]. As the forecast horizon lengthens, the forecast error increases.

In order to accurately model the arrival of wind energy, taking into account the stochasticity in the areas for which there is insufficient initial statistical information, it is necessary to determine the distribution of wind speeds over time by gradation and height [Zubakin, Kovshov, 2015].

The variability of the earth's surface roughness requires wind monitoring for at least one year prior to the construction of a wind farm in order to assess the main statistical parameters of the wind flow in the area where the station is located. At the same time, the accumulated data from one year of wind monitoring must be extrapolated for the entire expected operation time of the wind farm using various MCP (measurement - correlation - prediction) methods.

However, despite the stochastic nature of wind power generation, there are several ways to reduce the negative effects of variability in its output.

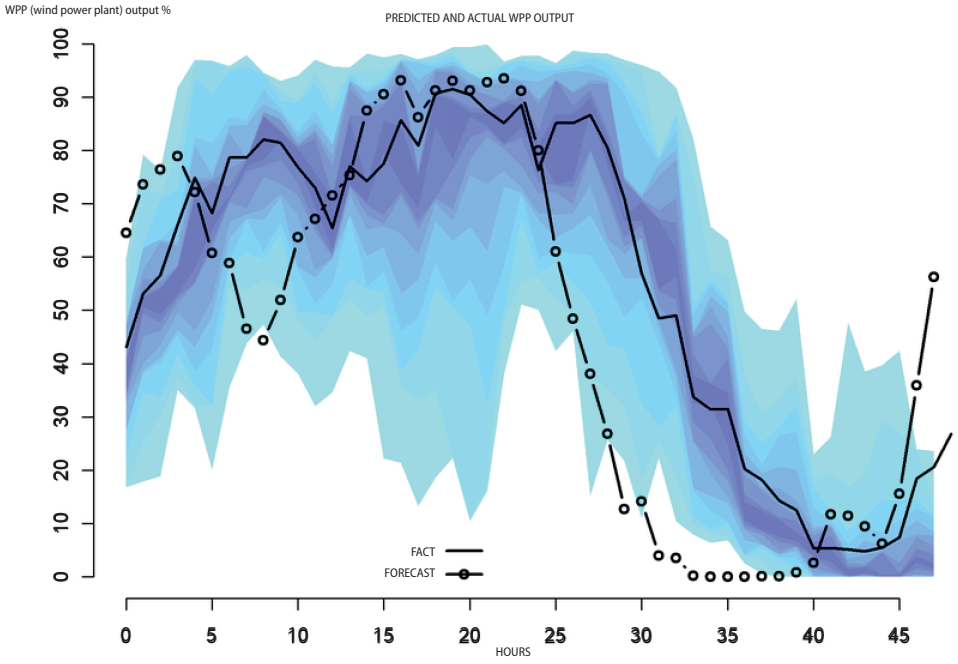
Thus, when assessing the behaviour of the wind flow at different time intervals, it is also necessary to take into account the probabilistic behaviour of the wind, which can be represented in the form of a quantile forecast [Bossavy et al., 2010] (Fig. 1).

If there is an unbiased forecast of the WPP production, the system operator can rely on the quantile forecasts (P05, P95) to plan the optimal reserve, which can significantly reduce its size. Thus, the system operator can use the lower value of the quantile forecast (P01, P05) as the guaranteed capacity of the WPP in the future.

Another effective management of the stochastic nature of WPPs is the integration of several WPPs into a virtual power plant, which leads to a reduction of the forecast error [Shuvalov et al., 2022]. At the same time, in aggregated WPPs, the quantile forecast has a smaller range, which is associated with a decrease in the dispersion of the total output of several WPPs.

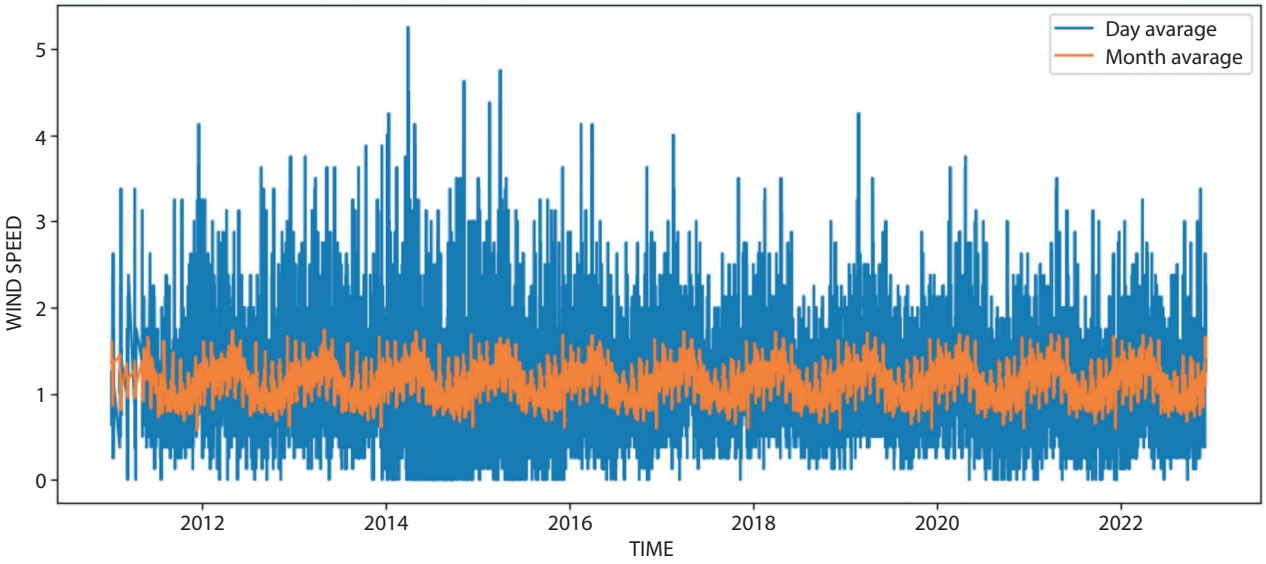
Contrary to popular belief, the long-term average energy density of the wind flow, distributed by month and by direction, presents a cyclical picture. Stochasticity increases at smaller time intervals (hours, minutes) and is manifested in the variability of a given local event (calm, low/medium wind, storm). This variability is due to the

Fig. 1. Actual and forecast values with consideration of uncertainty



Source: downloaded from the forecasting system.

Fig. 2. Time series of wind speed at the VDNKh weather station, 2012–2022



Source: downloaded from the forecasting system.

unstable and uneven movement of the wind flow layers caused by turbulent eddies, whose theoretical expression is predominantly random.

Thus, by analysing the autocorrelation component of the wind speed time series at the VDNKh (All-Union Exhibition of Achievements of National Economy) weather station, it is possible to determine the cyclicity in the data. The wind speed has a significant cyclicity with a period of about 24 hours. This is due to changes in air temperature during the day. There is also a cyclicity with a period of about 1 year (Fig. 2), which may be related to changes in climatic conditions. In order to assess the stationarity of the time series, the Dickey-Fuller statistical test was carried out. Consequently, the statistical value of the test was less than the p-value, which indicates that the time series is non-stationary. A time series has a time-varying mean and variance.

When considering models from the point of view of cyclicity, the main modelled indicator is the frequency of wind speeds $F(v)$, which shows what proportion of the time during the period under consideration the wind blew at one speed or another. The annual wind frequency is often approximated, especially in foreign practice, by the Weibull distribution or its modified version - the Weibull-Goodrich distribution:

$$F(v) = k\frac{v^{k-1}}{A^k}e^{-\left(\frac{v}{A}\right)^k},$$

where k – shape parameter (depends on the area, generally $k = 2$), A – scale parameter (depends on average wind speed, $A \sim 1.13$ v).

The Weibull-Goodrich distribution is the most universal and generally accepted method for modelling wind speeds. Many developments in the zoning of potential wind energy resources in Russia and individual regions have been made using this approach.

However, knowledge of the distribution law and the presence of high average wind speeds do not guarantee its effective use. In the case of wind energy, knowledge of the possible duration of lulls is of great importance. The probabilistic assessment serves as the main criterion for the efficiency of wind energy use. The structural characteristics of the wind regime can be considered as weakly dependent on the general level of intensity, i.e. in areas with significant wind intensity long lulls can be observed, making the use of wind ineffective. A calm is a period of so-called inactive wind speeds, which cannot be used for energy production. This characteristic, a necessary part of the wind energy cadastre, is considered to be one of the most important in assessing the prospects for wind energy use.

Therefore, assessing the cyclicity and stochasticity of the wind flow is important to ensure the reliability and efficiency of wind energy systems.

In conclusion, due to the dependence of wind power variability directly proportional to probabilities and periodicity, the use of methods to counteract the negative effects of wind power production probabilities and correctly identify the periodic components of wind speed time series can improve forecast accuracy using quantile wind power forecasting and WPP aggregation into virtual power plants. In the short term, reducing the reserve capacity required for the electricity grid could help to avoid the construction of new peaking power plants in the future.

In order to implement proposals to reduce generation stochasticity, further research is required using real data from several power plants to obtain a quantitative assessment.

References

Zubakin V.A., Kovshov N.M. (2015). Methods and models for analyzing the volatility of RES generation, taking into account cyclicity and stochasticity. *Strategic Decisions and Risk Management,* 4(91): 86-98. https://cyberleninka.ru/article/n/metody-i-modeli-analiza-volatilnosti-vyrabotki-viz-s-uchetom-tsiklichnosti-i-stohastichnosti.

Shuvalov N., Karasevich V., Velichko A. (2022). Improving the accuracy of forecasting renewable energy generation using neural network algorithms of a virtual power plant. In: *Materials of the D.I. Mendeleev International Scientific and Practical Conference:* Collection of articles, 1.

Bossavy A., Girard R., Kariniotakis G. (2010). Forecasting uncertainty related to ramps of wind power production. *European Wind Energy Conference and Exhibition,* Warsaw, Poland.

Kamran M. (2023). Fundamentals of smart grid systems. *Academic Press,* 365-392. https://doi.org/10.1016/B978-0-323-99560-3.00007-7. https://www.sciencedirect.com/science/article/pii/B9780323995603000077.

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