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The digital shadow and twin feasibility representation model for the radically new products competitiveness

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Abstract. The study examines the use of multidimensional scenario modeling (MSM) for the development and production of fundamentally new products, taking into account the variability of consumer requirements and market conditions. The focus is on the integration of end-to-end digital technologies, an approach to creating a dual digital product, and product lifecycle management based on IT systems. The purpose of the research is to develop a new methodology for the formation of the technical and economic appearance of a product based on end-to-end digital technologies and digital twins, which makes it possible to model life cycle scenarios and choose optimal solutions with minimal costs. The study uses methods of literature analysis, benchmarking and comparative evaluation of statistical data to study the competitiveness of radically new products using the concepts of digital twin and digital shadow. Special attention is paid to the analysis of the regulatory framework and classes of digital twin models, which makes it possible to assess the technological feasibility, market potential and cost-effectiveness of innovative solutions. An integrated approach provides a systematization of the factors influencing the positioning of new products in the context of digital transformation. The features, including economic ones, of digital product models, as well as the regulatory framework of the subject area are considered. The classification of types of models and types of digital analogues of the product is given. The problem of the research lies in the fact that the traditional parametric approach to determining the technical and economic characteristics of new products, based on the linear improvement of analogues, is outdated in the context of digitalization and does not provide the creation of radically innovative solutions. The authors analyze the advantages of how the use of MSM contributes to the optimal choice of materials, technologies and components, as well as how it helps to achieve a balance between cost, quality and functionality of products. Special attention is paid to the possibilities of preliminary testing and adaptation of the product being developed in accordance with the changing requirements and preferences of consumers in order to increase competitive advantages. The results of the research are the concept of designing radically new products initiated either by the customer or by the manufacturer seeking to strengthen competitive positions; the concept of the technical and economic appearance of the product, formed on the basis of market analysis and including functional, component and economic models; the approach of using digital twins, allowing to optimize the product lifecycle through multivariate modeling, reducing costs and speeding up development; the key factors of the competitiveness of such a product have also been identified, which are determined by the integration of the image and the digital twin, taking into account global trends and customer requirements. The economic effects of using digital product models at different stages of the life cycle are described. A product competitiveness model is proposed that takes into account the level of digital maturity and the intensity of use of digital representations. A functional efficiency model is proposed that takes into account the effect of digital product modeling and its impact on economic efficiency. The study offers an economic and mathematical toolkit for calculating the competitiveness of radically new products through the integration of DTP and multivariate analysis, which expands the theory of innovation management in the digital economy.

Keywords: digital product twin, multivariate modeling, innovation, product lifecycle management

Authors' contribution. The authors have made an equal contribution to the development of the structure and content, conducting research and preparing the text of the article.

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Формирование технико-экономического облика и принцип построения цифрового двойника с целью повышения конкурентоспособности радикально новой продукции

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Аннотация. Рассмотрено использование многомерного сценарного моделирования (MSM) для разработки и производства принципиально новых продуктов с учетом изменчивости требований потребителей и конъюнктуры рынка. Основное внимание уделено интеграции сквозных цифровых технологий, подходу к созданию двойного цифрового продукта и управлению жизненным циклом продукта на основе ИТ-систем. Цель исследования — разработка новой методики формирования технико-экономического облика продукта на основе сквозных цифровых технологий и цифровых двойников

(DTP), позволяющей моделировать сценарии жизненного цикла (ЖЦ) и выбирать оптимальные решения с минимальными затратами. Применены метод анализа литературных источников, бенчмаркинг и сравнительная оценка статистических данных для изучения конкурентоспособности радикально новых продуктов с использованием концепций цифрового двойника и цифровой тени. Особое внимание уделено анализу нормативно-правовой базы и классов моделей цифровых двойников, что позволяет оценить технологическую осуществимость, рыночный потенциал и экономическую эффективность инновационных решений. Комплексный подход обеспечивает систематизацию факторов, влияющих на позиционирование новых продуктов в условиях цифровой трансформации. Рассмотрены особенности, в т.ч. экономические, моделей цифровых продуктов и нормативная база предметной области. Дана классификация типов моделей и типов цифровых аналогов изделия. Проблема исследования заключается в том, что традиционный параметрический подход к определению технико-экономических характеристик новых продуктов, основанный на линейном улучшении аналогов, устарел в условиях цифровизации и не обеспечивает создания радикально инновационных решений. Авторы работы проанализировали преимущества того, как использование MSM способствует оптимальному выбору материалов, технологий и комплектующих, а также помогает достичь баланса между стоимостью, качеством и функциональностью продукции. Особое внимание уделено возможностям предварительного тестирования и адаптации разрабатываемого продукта в соответствии с меняющимися требованиями и предпочтениями потребителей с целью повышения конкурентных преимуществ. Результаты исследования: концепция проектирования радикально новых продуктов, инициируемых либо заказчиком, либо производителем, стремящимся усилить конкурентные позиции; концепция технико-экономического облика продукта, формируемого на основе анализа рынка и включающего функциональные, компонентные и экономические модели; подход применения цифровых двойников, позволяющих оптимизировать жизненный цикл продукта за счет многовариантного моделирования, снижая затраты и ускоряя разработку. Выявлены ключевые факторы конкурентоспособности такого продукта, которые определяются интеграцией облика и цифрового двойника с учетом глобальных трендов и требований заказчика. Описаны экономические эффекты от использования цифровых моделей продуктов на разных этапах ЖЦ. Предложена модель конкурентоспособности продукта, учитывающая уровень цифровой зрелости и интенсивность использования цифровых представлений продуктов. Предложена функциональная модель эффективности, учитывающая влияние цифрового процесса на результат. Исследование предлагает экономико-математический инструментарий для расчета конкурентоспособности радикально новых продуктов через интеграцию DTP и многовариантного анализа, что расширяет теорию управления инновациями в цифровой экономике.

Ключевые слова: цифровой продукт-двойник, многомерное моделирование, принципиально новые продукты, управление жизненным циклом продукта

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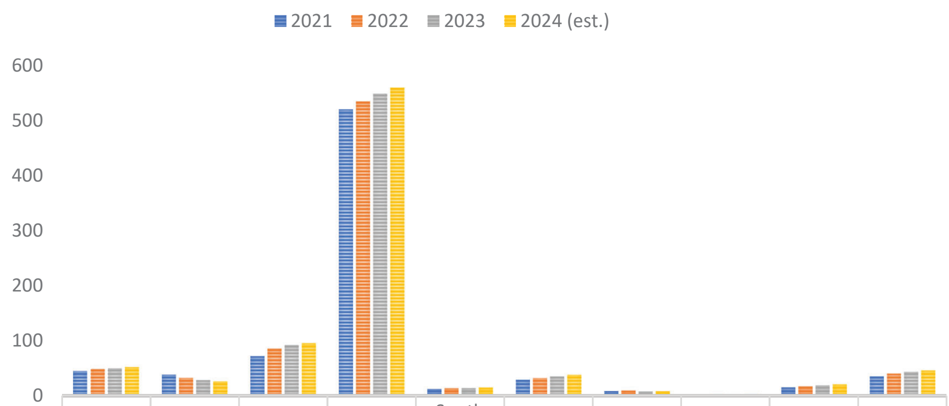
Introduction

In modern economic conditions, the task of creating competitive products to replace those that currently do not enter Russia by import comes to the fore (Dementiev, 2023). The majority of imported products[1] are complex machines, equipment, devices and control systems, electronic component base with high technical and economic characteristics (Fig. 1, 2).



	Brazil	Russia*	India	China	South Africa	UAE	Iran*	Ethiopia	Egypt	Indonesia
2021	45,2	38,7	72,3	520,4	12,80	29,5	8,9	1,2	15,6	35,8
2022	48,6	32,4	85,6	535,1	13,50	32,1	9,3	1,5	17,2	40,3
2023	50,1	28,5	92,1	548,7	14,00	35,4	7,8	1,8	19	43,6
2024 (est.)	52	26	95,5	560	14,80	38	8,2	2	20,5	46

Figure 1. High-Tech Product Imports in BRICS+ Countries (2021–2024), USD billions

* Exact information is not available.

Source: developed by A.A. Chursin, V.A. Shiboldenkov based on the “United Nations Statistics Division. (2025). UN Comtrade database: Free access to detailed global trade data. United Nations. https://comtrade.un.org/data/ (Accessed 13 January 2025)”.

The study is based on the average data for the period from 2021 to 2024, reflecting the dynamics of imports of high-tech products in the BRICS+ countries. For Russia and Iran, in 2022–2023, a decrease in import volumes was recorded due to the introduction of international sanctions and trade restrictions, which was marked with special markers.

[1] United Nations Statistics Division. (2025). UN Comtrade database: Free access to detailed global trade data. United Nations. https://comtrade.un.org/data/ (Accessed 13 January 2025).

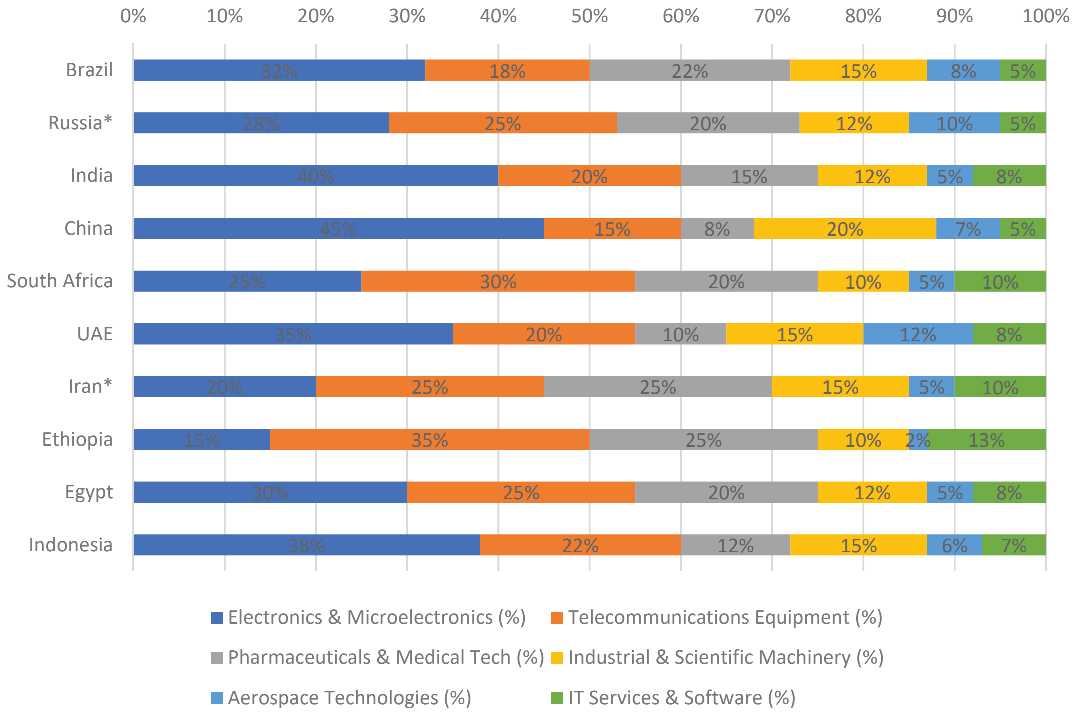


Figure 2. Structure of High-Tech Product Imports in BRICS+ Countries (2021–2024)
Source: developed by A.A. Chursin, V.A. Shiboldenkov based on the "United Nations Statistics Division. (2025). UN Comtrade database: Free access to detailed global trade data. United Nations. https://comtrade.un.org/data/ (Accessed 13 January 2025)".

The accuracy of the data may vary depending on the calculation methodology used, in particular when accounting for or excluding dual-use technologies. The main sources of information were the UN Comtrade databases, statistics from the World Trade Organization (WTO), as well as official customs reports from the participating countries.

In this study, high-tech imports are goods with a high share of research and development (R&D) costs, corresponding to the classification of the Organization for Economic Cooperation and Development (OECD). It should be borne in mind that for individual countries (Iran, Russia) there may be statistical discrepancies related to the presence of unofficial supply channels and alternative trade patterns.

In order to replace these products on the Russian market and ensure the development of enterprises in Russia, the task arises in a short time to develop and implement production preparation and production in general (including personnel training) for the release and sale of newly developed products (Chursin et al., 2020). Currently, with the development of digital technologies, the scientific direction of creating digital counterparts of products, production and organization is developing (Gorlacheva et al., 2019). However, at present, the process of forming digital twins is quite complicated and highly expensive. These costs mainly lie in the field of creating full-fledged PLM systems ((Product Lifecycle Management, hereinafter PLM)) for the design and modeling of digital twins (Chursin et al., 2024). The use of PLM systems is an expensive procedure, but with the development of technology, maturity increases, the possibilities of effective application and economic feasibility expand. However, the application of such systems faces issues of their high-quality domestic information support, as well as the training and competence of the relevant personnel (Drogovoz et al., 2023).

In our opinion, the solution is a qualitative construction of the technical and economic appearance of the product (hereinafter TEAP). Its formation depends on the continuous receipt of data from the information space on the indicators of similar products, and the prospects for the development of these product lines. Hence, the task arises of constant monitoring of information databases in order to create a TEAP with the help of end-to-end digital technologies, and on the basis of which the DTP will be formed, and then make appropriate adjustments to the TEAP of the DTP.

The achievement of the indicators is determined by many factors, which include the competence of developers, modern technical and technological design base, the possibility of technology transfer and other issues.

The created technical and economic appearance of the product becomes the basis for digital product modeling, which makes it possible to create a digital twin of the product (hereinafter DTP) based on it. When developing a DTP, methods and technical means are used that form the essence of the proposed methodological approach, which allows for the implementation of multivariate scenario modeling (hereinafter MVSM) to study the functional, consumer and economic aspects of the future product, thereby achieving adaptation to the diverse requirements and expectations of end users.

MVSM makes a significant contribution to the effective integration and synergy of research, production and operational processes. This is achieved through a targeted selection of materials, advanced technologies and processing techniques, as well as optimal components of the future product. Special attention is paid to the design of the product taking into account the specified cost, which determines the competitive price in the market. The task of the MVSM is to optimize such critical characteristics as reliability, weight, overall dimensions and other physical parameters of the product in a fully virtual environment (Boginsky, Zelentsova, Tikhonov, 2019; Tyulin et al., 2023).

The use of DTP provides the possibility of computer modeling and visualization, which gives specialists the opportunity to analyze various parameters of product performance and reliability in real time. This is especially valuable for periodic adjustments of solutions at various stages of the product life cycle, starting from the initial appearance and ending with the final phase of operation. Thus, the DTP contributes to improving the efficiency of product management and optimizing resources at each stage of development, production and operation of the future (Drogovoz et al., 2023).

The purpose of the research is to develop a new methodology for the formation of the technical and economic appearance of a product based on end-to-end digital technologies and digital twins, which makes it possible to model life cycle scenarios and choose optimal solutions with minimal costs.

Methods

The work uses a set of research methods aimed at studying the competitiveness of radically new products using the concepts of digital twin and digital shadow. The methodology is based on an analysis of literary sources and a review of existing research, which makes it possible to systematize theoretical and practical developments in the field of digital modeling, assessment of technological feasibility and market potential of innovative products (Chubakova, Drobkova, 2025).

Benchmarking and comparative analysis of statistical data, including a comparison of the structure of high-tech exports and imports of key countries, plays an important role. This makes it possible to identify global trends, competitive advantages, and technological gaps affecting the positioning of new products on the international market (Drogovoz, Nevredinov, 2024; Drogovoz, Kashevarova, Starikova, 2024).

Special attention is paid to the study of the regulatory and scientific and methodological framework that defines the requirements for the development and implementation of innovative solutions. The analysis of legislative and standardized frameworks provides an understanding of the limitations and opportunities when creating radically new products (Kashevarova, 2024).

In addition, the analysis of classes of digital twin models and their economic efficiency is carried out, which makes it possible to assess the applicability of various approaches to forecasting the product lifecycle, optimizing production processes and minimizing risks. Together, these methods provide a comprehensive study of the factors influencing the competitiveness of innovative products in the context of digital transformation (Samoldin, 2023; Samoldin, Serebryanaya, 2023).

Relevance, problem and hypothesis of the study

The relevance of the study lies in the fact that the use of end-to-end digital technologies (Drogovoz, Yudin, Grosheva, 2021) in combination with DTP significantly increases economic efficiency and reduces costs at all stages of LC due to significant opportunities for multivariate scenario modeling and analysis of a radically new products are still under development (Chursin et al., 2020).

An important point, not fully disclosed in the literature, is the formation of the technical and economic appearance of the product, on the basis of which a CDP can be formed, on the basis of which radically new products (RNP) will be developed (Preobrazhenskaya, Gorlacheva, 2019). RNP refers to products with technical and economic characteristics significantly superior to existing analogues on the market and capable of ensuring dominance in sales markets, as well as penetration into new market niches (Omelchenko et al., 2019).

The main criteria that make it possible to classify products as RNP include:

1. Superior technical characteristics compared to the best analogues.
2. The presence of unique consumer properties aimed at meeting the existing and foreseeable needs of customers.

3. The optimal cost of purchase and operation for the end user.

These criteria should be adapted according to the characteristics of each specific product category.

The problem lies in the fact that traditionally, the definition of technical and economic characteristics for tasks for the development of new products was carried out by a linear parametric approach. Based on the express analysis of the best international and domestic samples, engineers set target parameters, usually just 10–15% higher than current market solutions. But in the context of digitalization of production and changing market realities, this step-by-step approach requires significant revision and improvement based on intelligent systems.

Based on the above, it is possible to form a research hypothesis: the formation of the technical and economic appearance of products based on the use of a complex of end-to-end digital technologies and the DTP approach allows developers to carry out as a result of MVSM and choose the optimal design options for this product with minimal costs and maximum economic efficiency, thus increasing the competitiveness of the products being developed at all stages of the life cycle.

The main provisions of the technology of digital product twins

GOST R 57700.37–2021 “Computer models and modeling. Digital counterparts of products. General provisions”[2] defines “the digital twin of a product (DTP) as a system consisting of a digital item model (DIM-mathematical and computer models, as well as electronic product documents) and two-way information links with the product and/or its components at all stages of the life cycle (specified in the terms of reference)”.

The purpose of the standard is to define the general provisions of the development and application of the DIM. It is recommended to classify computer models according to GOST R 57700.22.

The standard covers the stages of product development, production and operation:

- The introduction of DIM technology at the product development stage improves the quality of design, ensures compliance with technical requirements and reduces the number of tests.
- The introduction of DIM technology at the stage of production of serial products adjusts the technological documentation depending on specific production conditions.
- The introduction of DIM technology at the stage of product operation automates the planning of product application, making informed decisions about maintenance and repair.

[2] Federal Agency on Technical Regulating and Metrology. (2021). GOST R 57700.37–2021: Computer models and simulation. Digital twins of products. General provisions (Date of introduction: 2022-01-01). https://docs.cntd.ru/document/1200180928

In the process of developing digital models that strive for the highest level of adequacy to a real product, it is necessary to take into account a set of systemic factors (Fig. 3):

1. Competence of personnel: The basis for successful development of digital models is the availability of highly qualified specialists. Engineers must have not only in-depth knowledge in their fields, but also the skills to work with modern information technologies and artificial intelligence methods.
2. Advanced technological solutions: The effectiveness of digital modeling directly depends on the technologies used. We are talking about high-quality software and modeling techniques that should be integrated into design and analytical processes.
3. High-performance computing systems: An important prerequisite for processing large amounts of data and performing complex calculations is the use of powerful computing systems. These systems should provide high data processing speed and the ability to simulate various scenarios in real time.
4. Optimization of the project time frame: Competent timing planning at each stage of digital model development allows not only to meet customer requirements, but also to reduce the risks of exceeding the budget. Effective project management and adequate allocation of time resources are critical for the successful completion of project tasks (Mikhnenko, 2018; Mikhnenko, 2020).
5. Ensuring adequate funding: Substantial financial resources are required to develop and support high-level digital models. This includes investments in software, hardware, staff training and support, as well as continuous updating of the technical and software base.

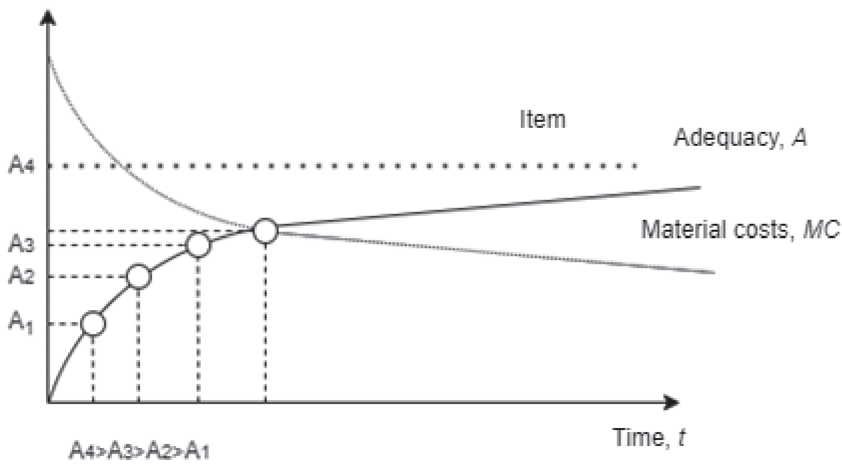


Figure 3. Dependence of the adequacy of digital product models

Source: developed by A.A. Chursin, V.A. Shiboldenkov based on the “Federal Agency on Technical Regulating and Metrology. (2021). GOST R 57700.37–2021: Computer models and simulation. Digital twins of products. General provisions (Date of introduction: 2022-01-01). https://docs.cntd.ru/document/1200180928”.

In addition to these factors, interaction with key stakeholders, including customers, consumers and regulators, should be taken into account to ensure that digital models comply with current and future market standards and requirements (Yudin et al., 2021). This contributes to improving the quality and accuracy of digital models, as well as their cost-effectiveness and market competitiveness (Drogovoz, Filobokova, Drobkova, 2021); Drogovoz, Gutenev, Korenkova, 2023).

In the process of creating and using a digital product double, compliance with the norms and standards established by GOST plays a key role. An important aspect is the assessment of the product's compliance with the requirements defined in GOST 16504. This includes methods of verification and validation of mathematical models according to GOST R 57188, as well as verification of compliance of computer models and software according to GOST R 57700.1, GOST R 57700.2, GOST R 57700.24 and GOST R 57700.25.

As part of the product life cycle, the use of the digital twins software and technology platform, recommended by GOST R 56135, provides not only integration and coordination of all processes related to the product, but also contributes to more accurate modeling of real-world operating conditions and product behavior.

In addition, the management of electronic documentation at all stages of the creation and operation of the product is also subject to certain standards, including GOST 2.001, GOST 3.1001, GOST 3.1102, GOST 19.101, GOST 34.601 and GOST R 58301. These standards regulate the processing and exchange of electronic documents, which is an integral part of working with digital counterparts.

Such a scheme of standardization and related procedures ensures a high level of quality and reliability of the digital twin, as well as contributes to effective and safe project management in various fields of application. In the international and Russian standardization systems, there is an active process of developing and implementing standards related to the technology of digital twins (Sadovsky, Drogovoz, 2019; Maslennikova, Brom, 2021).

Models and types of digital twins

A digital twin (DT) in a broad sense is a technology for creating an exact virtual copy of a real object, process, or system. It can be any object, from small items to entire production lines or the infrastructure of the city (Drogovoz, Yusufova, Gutenev, 2022).

Such a data center can cover different levels: from individual components to complex systems, including entire enterprises or urban agglomerations. The main goal is to optimize processes, improve management and increase the efficiency of real objects or systems through their modeling and analysis (Susov, Samoldin, 2023a; Susov, Samoldin, 2023b; Samoldin, Lagunova, 2022).

A digital product twin (DTP) is a more specific implementation of the idea of digital twins, focused around individual products (objects, products and systems). It is usually limited to one product or its specific components (Kashevarova, 2024).

The scope of the DTP is production processes, where detailed modeling and analytical support of each product is required throughout the entire life cycle, from design to operation and maintenance. DTP allows you to trace in detail all aspects of the life cycle of a particular product, which is key to optimizing production, reducing costs and improving the quality of the final product (Kashevarova. Akulshin, 2023; Kashevarova, Ivanov, 2023; Kashevarova, Panova, 2023; Drogovoz, Kashevarova, Kapran, 2021).

One of the key approaches to the development and use of digital twins is the model proposed by Professor Michael Graves (Zhdaneev, Vlasova, 2023; Ivanyugin, 2020).

Graves models cover various aspects of product management at all stages of its life cycle and offer an integrated classification system for information flows and processes.

The main provisions of the Graves model in the context of digital twins:

1. Integration of data throughout the product lifecycle: The Graves model emphasizes the need to collect, process and analyze data from the initial concept of the product to its disposal. The digital twin, following this principle, should provide the possibility of interaction between different stages of the life cycle.
2. Modularity and scalability: The ability to scale and upgrade modularly is key. The digital twin must support the integration of new data and analysis methods, allowing it to adapt to changing conditions and requirements.
3. Interoperability: The use of standardized data formats and open interfaces for data exchange between different systems and devices is important to eliminate "information islands" and ensure compatibility between different platforms and tools.
4. Multi-level analysis and modeling: Digital twins should support multi-level modeling, including the physical condition of the product, its behavior in various operating conditions, as well as economic and environmental aspects.
5. Real and virtual interaction: One of the key points is the development of mechanisms for effective interaction between a physical product and its digital counterpart. This includes ensuring real-time data synchronization and the ability to make automated decisions based on analysis conducted by a digital twin.

The Graves model offers an extensive framework for organizing product management processes, and digital twins fit into this model as tools that can significantly improve the efficiency of these processes through advances in data collection, analytics and modeling.

Graves proposed his own classification of DT types:

1. The digital twin of the product (DTP): Focused on a single product or product. This type is created to simulate the physical and functional properties of a specific product, for example, a car or an airplane engine, which allows for detailed performance analyses and product improvement options at the design stage and during operation.

2. Process Digital Twin (DTPR): Focuses on the simulation and optimization of business processes or production processes. These kinds of digital twins can be used to model and optimize supply chains, logistics operations, or production lines, allowing businesses to increase efficiency and reduce costs.
3. Digital Twin of the system (DTS): created to model and analyze larger systems that may include many interconnected products and processes. An example is aviation, where such a twin includes both aircraft and ground operations, maintenance, and so on.

Results

The design of any product, including radically new products, begins either with a technical requirements specification (hereinafter TRS) from the customer, or at the initiative of the manufacturer's organization, in order to increase the product range, or create a product with high competitive advantages, which ensures stable economic development of the organization. In some cases, the manufacturing organization carries out technological improvement of the product in order to create an additional competitive advantage for it in the market.

In order to make a decision on designing products on its own initiative, the organization must monitor the global information space, the industries to which the products under development belong and trends in consumer preferences, and formulate future technical and economic characteristics of these products. And based on this, what are the technical specifications that would allow these products to dominate the market or completely conquer the market, both Russian and foreign. Thus, a qualitatively developed TEAP can underlie the creation of a data center and ensure the effectiveness of design.

The technical and economic appearance is a detailed description of the products being developed, including (Tyurchev, 2021; Chursin et al., 2024):

1. A list of the main consumer characteristics and the level of their implementation (consumer model).
2. Description of the components of the product (component model).
3. Description of the main functions of the product (functional model).
4. Preliminary cost estimates and forecasts of the economic efficiency of the product (organizational and economic model).

Based on the formed technical and economic appearance, it is possible to carry out argumentation and planning for the successful development and launch of production of RNP.

Figure 4. is a diagram of the product life cycle (PLC)[3], which is modeled using a digital product twin, which makes it possible to apply a multivariate scenario (hereinafter MVS) of product production and choose from these scenarios by the

[3] Tyulin, A., & Chursin, A. (2020). The New economy of the product life cycle: Innovation and Design in the Digital Era.

method of technical and economic ranking the most effective with optimal timing, quality and cost of the product. The use of a digital double is fully described in key guidance documents, such as GOST R 57700.37–2021

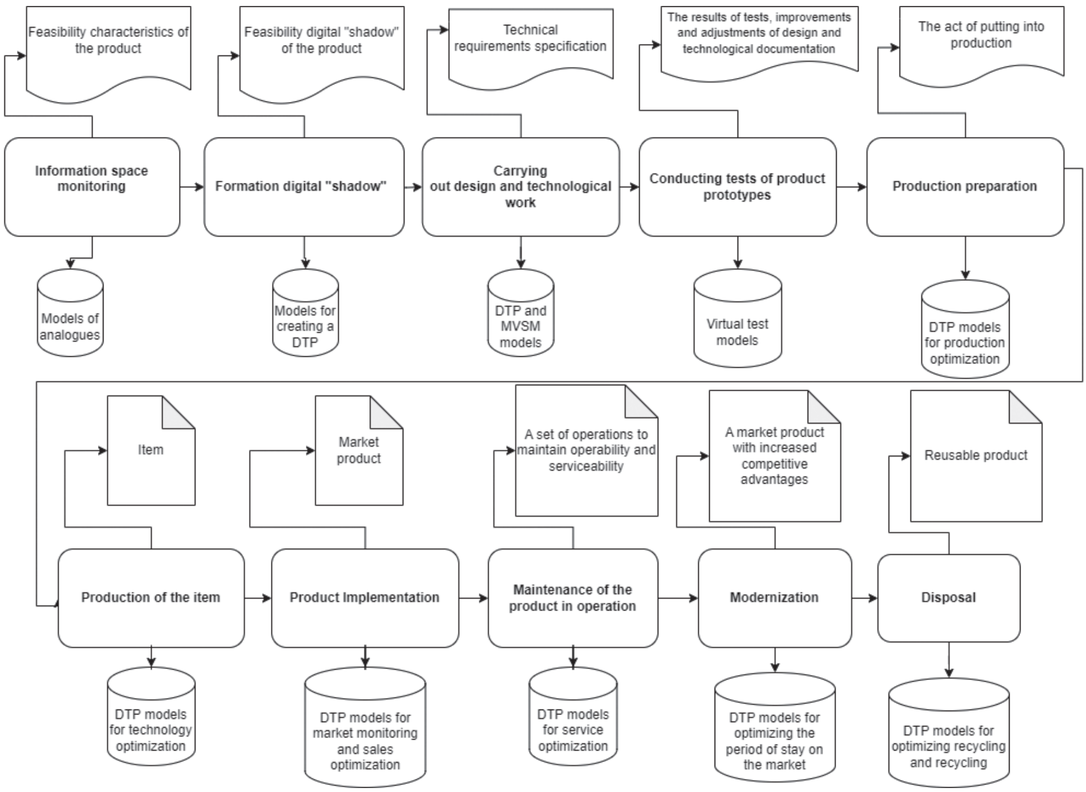


Figure 4. Diagram of the life cycle stages of radically new products, taking into account the technology of digital twins

Source: developed by V.A. Shiboldenkov based on the book[4].

When analyzing the life cycle of an RNP, the use of a digital double allows you to significantly expand the possibilities at each stage of the PLC (Fedorova, Druchok, Drogovoz, 2022; Drogovoz, 2021; Fedorova et al., 2022; Fedorova, Ledyaeva et al., 2022; Fedorova et al., 2021). The disclosure of the potential of the DTP at various stages of the PLC RNP provides the following advantages (Fig. 5).

In each of these areas, the significant economic effect of the use of DTP primarily comes from the modeling capabilities of the MVS. The integration of the DTP into the management of the life cycle of the RNP contributes not only to improving quality and reducing costs at each stage, but also provides a deep understanding of the processes, which is the key to innovation and technical improvement of products. Digital twins provide comprehensive opportunities to improve efficiency, reduce costs and accelerate innovation at all levels of the organization, from design to equipment operation and strategic planning.

[4] Tyulin, A., & Chursin, A. (2020). *The New economy of the product life cycle: Innovation and Design in the Digital Era.*

The conceptualization stage	At this stage, the CDP allows you to visualize various conceptual solutions, conduct simulations to assess the functionality and potential effectiveness of the proposed designs.	This helps to identify the most promising areas of development before the start of the project.
The design stage	The digital twin contributes to fine-tuning the technical characteristics and features of the product, allowing detailed simulations of the RNP operation in various conditions.	Processes such as design optimization, stress analysis, thermal analysis, and ergonomics testing are becoming more in-depth and informative.
The test stage	The CDP eliminates the need to create physical prototypes, allowing for virtual tests.	This reduces the risks and costs associated with real-world testing and allows you to simulate operational conditions that are difficult or impossible to reproduce physically, such as extreme weather conditions or prolonged operation.
The production stage	Using CDP at this stage allows you to optimize production processes even before the actual production run is launched, choose the best materials, technologies and equipment, which minimizes the risk of errors and defects.	This includes the possibility of final correction of the design adapted to production constraints or market needs.
Operation and maintenance phase	At this stage, the data center provides operators and service personnel with data on how the product will behave in real conditions.	This allows you to optimize maintenance plans and repair procedures, increasing the reliability and duration of the RNP. Decommissioning phase At the last stage of the life cycle, the CDP helps to assess the optimal ways of recycling or recycling the product, This minimizes the environmental impact and maximizes the benefits of possible recycling of materials.

Figure 5. The main directions of application of the digital double of products in organizations at each stage of the housing and communal services

Source: developed by S.V. Nazyuta.

Let's consider the principles of creating a TEAP ("Digital Shadow") (Nevredinov, Yusufova, 2020):

1. Analysis of the market situation and definition of a product renewal strategy: in the context of the formation of the technical and economic appearance of products (TEAP), the main attention is paid to the study of the global information space. Such an analysis includes the study of information on similar products, both in Russia and abroad, which allows us to formulate key organizational, economic and technical indicators of a new or upgraded product, determine the potential of its competitiveness and viability in target markets.

2. Development of national industry through import substitution: Solving the problem of import substitution with a new product requires a thorough analysis of domestic and international industrial trends and developments. The organization implementing the TEAP forms a strategic vision for the creation of products previously imported, which contributes to the independence and independence of the national economy, as well as strengthening domestic production.

3. Taking into account the customer's requirements when creating or upgrading products: The starting point for the development of a new product or improvement of an existing one is the technical specification from the customer company. Careful compliance and consideration of all requirements in the TEAP ensures that the final product accurately meets the customer's expectations, which is the basis for its successful implementation on the market and achieving the customer's goals in the field of product quality and functionality.

Based on the above, we propose the following economic and mathematical models of RNP competitiveness at all stages of housing and communal services, which should be applied in a complex in order to achieve maximum efficiency in the creation and application of DTP. We are bringing this issue up for discussion.

Discussion

Taking into account the potential of the digital twin, we have the opportunity to conduct a comprehensive analysis of the product life cycle (PLC), which allows us to determine key economic indicators (KEI) in advance, effectively reach the break-even point and deploy other financial strategies in the context of economic efficiency of production. Despite the fact that our analysis is not initially focused on the formation of digital twin technology, its principles and capabilities are taken into account when solving economic problems and contribute to a deeper understanding of economic processes within production.

Special attention should be paid to the task of assessing the competitiveness of products (CP), which is a key factor in ensuring sustainable dynamic development and success of the product in the market.

To develop such a model, it is important to identify key parameters such as cost of production (C), time to market (T), product quality (Q), degree of innovation (I) and demand for the product (D). These parameters can be estimated based on the data provided by the digital twin of the product, which allows you to simulate various aspects of the production and operation of the product.

The competitiveness model of new products K can be represented by the following formula:

$$K = \frac{f(Q, I, D) - g(C, T)}{\alpha C + \beta T + \gamma Q + \delta I + \varepsilon D}, \tag{1}$$

where $f(Q, I, D)$ — a function that evaluates the benefits of a product based on its quality, innovation, and demand; $g(C, T)$ — a function that estimates production costs and time to market; α, β, γ, δ, ε — coefficients reflecting the impact of relevant economic and production factors on overall competitiveness.

We will propose a scientific and methodological apparatus[5] models of organizational and economic indicators of efficiency and competitiveness of the RNP:

$Q(t)$ includes, in addition to the direct effectiveness of the RNP lifecycle management, the influence of external and internal factors on the dynamics of efficiency $G(t, Q(t))$ in the form of quantitative influence $B_k(t)$ competitive advantages $G_k(t)$, assessment of the personnel and competence potential, the production and technological level of enterprises, assessment of the timing of the creation and production of unique equipment, as well as the construction and organization of production and its infrastructure:

[5] Developed by (Chursin at al., 2024).

$$\frac{dQ(t)}{dt} = A(t)Q(t) + G(t, Q(t)) = A(t)Q(t) + \sum_{k=1}^{M} B_k(t)G_k(t), \qquad (2)$$

where $A(t)$ — the matrix of economic diffusion of performance indicators.

The inertia of the organization's performance indicators is often due to the indirect influence of consumer characteristics of products. In this context, organizations offering a limited range of products within the service model face limited opportunities to increase economic efficiency. However, the transition to a business model for the sale of products with new consumer and operational properties, implemented according to a clear algorithm, can stimulate the creation of new growth points. This implies the introduction of improvements aimed at increasing customer satisfaction and optimizing product usage processes, which ultimately contributes to improving overall business efficiency.

The stages of the life cycle of the RNP can be taken into account using the results of economic growth, where the function $R(A(T))$ describes a sufficient level of economic results when analyzing the production of RNP and its effectiveness:

$$R(A(T)) = \gamma(t)c(t)\left(\frac{T(t) - A(t)}{T(t)}\right); \qquad (3)$$

where $c(t)$ — a function that depends on the level of development of the competencies of specialists in the field of using information to manage the economic processes of the RNP; $T(t)$ — the "ideal" level of satisfaction of needs in an environment where all the necessary technologies are developed and delivered to the consumer without a time lag, assumes the most effective and prompt satisfaction of consumer requests; $\gamma(t)$ — infrastructure development indicator.

Then the marketing component of scientific and technological potential $A(t)$:

$$A(t) = \frac{\gamma(t)c(t)}{\gamma(t)c(t) + \lambda(H)} T_0 e^{\lambda(H)t}; \qquad (4)$$

where $\gamma(H)$ — the growth rate.

New business models are effective if they generate revenue for the enterprise that exceeds traditional sales models and allow financing innovative development aimed at creating competitive products with improved performance characteristics.

Let's express it in terms of the product competitiveness indicator IQ:

$$IQ \underset{\max}{\rightarrow} \left(\frac{QS_F}{\frac{S_0}{N} + S_1}\right)(1 - R)(1 + F); \qquad (5)$$

where Q — technical and economic indicators of products that form their competitiveness (vector of indicators); U — technical and economic indicators of market leaders (or indicators achievable at the current level of scientific and technical development) (vector of indicators); S_0 — the cost of the resource costs incurred to create products and start production for its release; S_1 — the cost of a unit of production; S_F — the price of similar products on the market (if there are no analogues, then $S_F = S_1$); N — the estimated number of units that will be sold on the market; R — internal factors that arise in the process of creating new products; F — external factors accompanying the sale of products on the market.

The combined model of competitiveness of new products can be represented by the following equation:

$$K_{\text{total}} = \frac{\left(f\left(Q, I, D\right) - g\left(C, T\right)\right)}{\left(\alpha C + \beta T + \gamma Q + \delta I + \varepsilon D\right)} \cdot \frac{\left(1 - R\right)\left(1 + F\right)}{\left(\dfrac{S_0}{N} + S_1\right)}; \qquad (6)$$

where the competitiveness model of the new product K (1) is combined with the technical and economic indicators of the product that form its competitiveness (5).

The combined model makes it possible to comprehensively assess the competitiveness of new products, taking into account both the technical and economic aspects of the products, as well as market factors and production readiness. This model allows you to evaluate various scenarios and analyze the sensitivity of indicators, which is especially important when introducing radically new products.

The assessment of competitiveness can be deepened and expanded with the help of data obtained from the digital twin, which allows you to model changes in the market and evaluate the product's response to various external influences. Thus, the use of digital twins can significantly improve the accuracy of forecasting marketing and economic strategies than traditional methods.

Conclusion

The technology of the digital twin of the product contributes to the comprehensive description of products, systematization of approaches to their development, production and operation. This technology is actively used in the industry and can significantly reduce time and costs for all stages of the product life cycle, from design and testing to operation and maintenance. Due to the DTP, the need to make changes to the designs of already developed products is minimized, which leads to a reduction in additional costs and contributes to greater optimization of production processes.

The key feature of the digital twin technology is to provide access to reliable and updated data for each component of the model. This means that the model being formed remains accurate and reliable due to the high level of adequacy to a real physical object, which is of great practical importance for the design, manufacture and operation of high-tech products.

An urgent task of the present time is the development of integrative digital modeling models that take into account not only the technical parameters of products, but also their potential economic and consumer characteristics, as well as predict the competitiveness of the product. Taking into account the need to create radically new products, this approach allows you to create products that will not only be technically perfect, but also in demand on the market.

The development of digital twins is an advanced area closely related to product lifecycle management systems. It is expected that the integration of such systems with advanced artificial intelligence technologies will help reduce their cost and improve efficiency. Such integration can lead to the creation of more flexible modeling systems that can adapt to changes and optimize processes at all stages of the product lifecycle.

Digital twins, in fact, are tools for multivariate scenario modeling of the future product, which allow for detailed analysis of each stage of the life cycle of the RNP, which ensures the identification of potential bottlenecks and difficulties that may arise during the implementation of the technological process, providing significant results for optimization and acceleration of processes. Additionally, the opportunities provided by digital twins create the conditions for a more multilateral and integrated design of the RNP.

However, it is important to understand that product development may require innovative materials, new systems and electronics components, as well as the development of new competencies. This involves the application of architectural innovation to address issues related to the manufacture of products.

It is believed that the implementation of these tasks should be based on intelligent process management systems based on artificial intelligence technologies. The development of such systems will allow effective interaction and exchange of information between various elements of the production chain, which turns digital twins into a comprehensive platform for managing production processes.

The use of digital twins has significant prospects, however, a high economic effect can only be achieved by solving the above complex tasks. Achievements in this field are confirmed by economic and mathematical models that allow quantifying the benefits of integration and optimization of production processes through the use of digital technologies.

References

Boginsky, A.I., Zelentsova, L.S., & Tikhonov, A.I. (2019). Intelligent monitoring as the basis for improving the competitiveness of high-tech production. In *The International Scientific and Practical Forum "Industry. Science. Competence. Integration"*. pp. 436–443. Cham: Springer International Publishing.

Chubakova, V.D., & Drobkova, O.S. (2025). Regulatory requirements integration for the sustainable innovation classification. In *2025 7th International Youth Conference on Radio Electronics, Electrical and Power Engineering (REEPE)*. pp. 01–06. IEEE. https://doi.org/10.1109/REEPE63962.2025.10971063

Chursin, A., Boginsky, A., Drogovoz, P., Shiboldenkov, V., & Chupina, Z. (2024). Development of a mechanism for assessing mutual structural relations for import substitution of high-tech transfer in life cycle management of fundamentally new products. *Sustainability, 16*(5), 1912. https://doi.org/10.3390/su16051912 EDN: FTUQAQ

Chursin, A.A., Yudin, A.V., Filippov, P., & Grosheva, P. (2020). The fundamentals of the formation of the technical and economic appearance of radically new products in providing state support for its production. *Economics and Management: Problems, Solutions, 12*(4), 43–51. (In Russ.). https://doi.org/10.36871/ek.up.p.r.2020.12.04.007 EDN: KHOEHJ

Dementiev, V.E. (2023). Technological sovereignty and production localization priorities. *Terra Economicus, 21*(1), 6–18. (In Russ.). https://doi.org/10.18522/2073-6606-2023-21-1-6-18 EDN: COKINW

Drogovoz, P.A., Kashevarova, N.A., Kapran, N.P. (2021). Approach to valuation of aerospace technologies commercialization capability. *In AIP Conference Proceedings* (Vol. 2318, No. 1, p. 070003). AIP Publishing LLC.

Drogovoz, P.A., Filobokova, L.Y., & Drobkova, O.S. (2021). An approach to the integration-balanced management of industrial complexes development in the space industry. *In AIP Conference Proceedings* (Vol. 2318, No. 1, p. 070008). AIP Publishing LLC.

Drogovoz, P.A., & Drobkova, O.S. (2023). An approach to application of inter-sectoral models to manage the structure of scientific and production cooperation in the space industry. In *AIP Conference Proceedings*. Vol. 2549. No. 1. AIP Publishing. https://doi.org/10.1063/5.0107990

Drogovoz, P.A., & Nevredinov, A.R. (2024). Application of Text Analysis and Ensemble Algorithms in Forecasting Companies Bankruptcy. In *Ecological Footprint of the Modern Economy and the Ways to Reduce It: The Role of Leading Technologies and Responsible Innovations*. pp. 117–121. Cham: Springer Nature Switzerland.

Drogovoz, P.A., Gutenev, A.V., & Korenkova, D.A. (2023). A method for fuzzy combinatorial optimization of digital space-based services project portfolio. In *AIP Conference Proceedings, 2549*(1). AIP Publishing. https://doi.org/10.1063/5.0108627

Drogovoz, P.A., Kashevarova, N.A., & Starikova, I.S. (2024). Development of blockchain platforms for tokenization of real assets. In *Ecological Footprint of the Modern Economy and the Ways to Reduce It: The Role of Leading Technologies and Responsible Innovations*. pp. 173–177. Cham: Springer Nature Switzerland.

Drogovoz, P.A., Kashevarova, N.A., Dadonov, V.A., Sadovskaya, T.G., & Trusevich, M.K. (2021). Industry 4.0 in Russia: Digital transformation of economic sectors. *In Industry 4.0 in SMEs Across the Globe*. pp. 191–207. CRC Press.

Drogovoz, P.A., Yudin, A.V., & Grosheva, P.Yu. (2021). An algorithm for decision-making to manage the innovative potential of organizations based on its assessment and forecasting. *AIP Conference Proceedings, 2549*(1): 210022. (In Russ.). https://doi.org/10.1063/5.0108344 EDN: LKOOPN

Drogovoz, P.A., Yusufova, O.M., & Gutenev, A.V. (2022). An approach to the economic assessment of scientific and technical realizability of the aircraft and space systems development. In *AIP Conference Proceedings, 2383*(1). AIP Publishing. https://doi.org/10.1063/5.0074916 EDN: TKRNAH

Fedorova, E., Drogovoz, P., Nevredinov, A., Kazinina, P., & Qitan, C. (2022). Impact of MD&A sentiment on corporate investment in developing economies: Chinese evidence. *Asian Review of Accounting, 30*(4), 513–539.

Fedorova, E., Drogovoz, P., Popova, A., & Shiboldenkov, V. (2023). Impact of R&D, patents and innovations disclosure on market capitalization: Russian evidence. *Kybernetes, 52*(12), 6078–6106. https://doi.org/10.1108/k-08-2021-0760 EDN: UZCFQO

Fedorova, E., Druchok, S., & Drogovoz, P. (2022). Impact of news sentiment and topics on IPO underpricing: US evidence. *International Journal of Accounting & Information Management, 30*(1), 73–94. https://doi.org/10.1108/IJAIM-06-2021-0117 EDN: GOOOBB

Fedorova, E., Ledyaeva, S., Drogovoz, P., & Nevredinov, A. (2022). Economic policy uncertainty and bankruptcy filings. International Review of Financial Analysis, 82, 102174. https://doi.org/10.1016/j.irfa.2022.102174 EDN: HVHSQE

Fedorova, E., Stepanov, I., Drogovoz, P., Rashchupkina, A., & Remesnik, A. (2021). Impact of the level of disclosure of corporate social responsibility on the share price: Quantitative and textual analysis. *Economic Journal of the Higher School of Economics, 25*(3), 423–451. https://doi.org/10.17323/1813-8691-2021-25-3-423-451 EDN: JSDNIH

Gorlacheva, E.N., Omelchenko, I.N., Drogovoz, P.A., Yusufova, O.M., & Shiboldenkov, V.A. (2019). Cognitive factors of production's utility assessment of knowledge-intensive organizations. In *AIP Conference Proceedings, 2171*(1). AIP Publishing. https://doi.org/10.1063/1.5133228 EDN: VKGEZK

Ivanyugin, M.A. (2020). Innovation management as the competitiveness of entrepreneurship. *International Journal of Humanities and Natural Sciences*, (4–2), 85–89. (In Russ.). https://doi.org/10.24411/2500-1000-2020-10351 EDN: RMOJEZ

Kashevarova, N.A. (2024). Analysis of the methods of intellectual property management in innovation ecosystems. In *Ecological Footprint of the Modern Economy and the Ways to Reduce It: The Role of Leading Technologies and Responsible Innovations*. pp. 221–226. Cham: Springer Nature Switzerland.

Kashevarova, N.A., & Akulshin, N. (2023). Prospects in developing the public-private partnership in space industry. In *AIP Conference Proceedings, 2549*(1). AIP Publishing. https://doi.org/10.1063/5.0108955

Kashevarova, N.A., & Ivanov, N.A. (2023). Prospects of digital transformation in the Russian space industry. In *AIP Conference Proceedings, 2549*(1). AIP Publishing. https://doi.org/10.1063/5.0108957

Kashevarova, N.A., & Panova, D.A. (2023). Space industry of the People's Republic of China: Ecosystem transformation. In *AIP Conference Proceedings, 2549*(1). AIP Publishing. https://doi.org/10.1063/5.0108953

Maslennikova, Y., & Brom, A. (2021). Methodology of quantitative and qualitative evaluation of an industrial enterprise digital potential on the example of evaluation of the "Personnel resources" component. In *IOP Conference Series: Earth and Environmental Science* (Vol. 666, No. 6, p. 062100). IOP Publishing.

Mikhnenko, P.A. (2018). Los modelos matemáticos del desarrollo organizacional y los cambios organizacionales. *Revista de Métodos Cuantitativos para la Economía y la Empresa, 25,* 42–53. https://doi.org/10.46661/revmetodoscuanteconempresa.2378 EDN: SAYHKR

Mikhnenko, P.A. (2020). Mathematical model and method of complex organizational diagnostic. *Serbian Journal of Management, 15*(1), 19–31. https://doi.org/10.5937/SJM15-18513 EDN: GYDZSG

Nevredinov, A.R., & Yusufova, O.M. (2020). The use of machine learning in digital counterparts of production processes. In *The Future of Russian Engineering.* pp. 364–368. (In Russ.). EDN: RYAFMZ

Nisha, S., & Jonathan, K. (2020). The latest information support practices for strategies to increase competitiveness. *Foresight, 14*(3), 30–39. (In Russ.). https://doi.org/10.17323/2500-2597.2020.3.30.39 EDN: SZHPHM

Omelchenko, I., Drogovoz, P., Gorlacheva, E., Shiboldenkov, V., & Yusufova, O. (2019). The modeling of the efficiency in the new generation manufacturing-distributive systems based on the cognitive production factors. In *IOP Conference Series: Materials Science and Engineering, 630*(1), 012020. IOP Publishing. https://doi.org/10.1088/1757-899X/630/1/012020 EDN: XVKTAQ

Preobrazhenskaya, V.V., & Gorlacheva, E.N. (2019). Cognitive production factors in the digital economy. In *The International Scientific and Practical Forum "Industry. Science. Competence. Integration*" (pp. 193–200). https://doi.org/10.1007/978-3-030-40749-0_23 EDN: OTHHKC

Sadovskaya, T.G., Drogovoz, P.A., Dadonov, V.A., & Melnikov, V.I. (2009). The application of mathematical methods and models in the management of organizational and economic factors of competitiveness of an industrial enterprise. *Audit and Financial Analysis*, (3), 364–379. (In Russ.). EDN: KVEVHV

Sadovsky, G.L., & Drogovoz, P.A. (2019). The open innovation model as a tool for increasing the competitiveness of a machine-building enterprise. In *The Future of Russian Engineering*. pp. 1002–1005. (In Russ.). EDN: WOLTKR

Samoldin, A.N. (2023). Game theory approach in marketing management of science intensive enterprises. In *AIP Conference Proceedings, 2549*(1). AIP Publishing. https://doi.org/10.1063/5.0108787

Samoldin, A.N., & Lagunova, M.S. (2022). Transformation of the environmental management system model in the context of digitalization of production. In *AIP Conference Proceedings, 2383*(1). AIP Publishing. https://doi.org/10.1063/5.0074836 EDN: JVQUIT

Samoldin, A.N., & Serebryanaya, V.S. (2023). Customer relationship management in the knowledge-intensive enterprises. In *AIP Conference Proceedings, 2549*(1). AIP Publishing. https://doi.org/10.1063/5.0108788

Susov, R.V., & Samoldin, A.N. (2023a). Transformation of business processes of science-intensive manufacturing based on digital models. In *AIP Conference Proceedings*, *2549*(1). AIP Publishing. https://doi.org/10.1063/5.0108895

Susov, R.V., & Samoldin, A.N. (2023b). Transformation of high-tech manufacturing business processes based on digital models. In *AIP Conference Proceedings, 2549*(1). AIP Publishing. https://doi.org/10.1063/5.0108896

Tyulin, A.E., Chursin, A.A., Ragulina, J.V., Akberdina, V.V., & Yudin, A.V. (2023). The development of Kondratieff's theory of long waves: the place of the AI economy humanization in the 'competencies-innovations-markets' model. *Humanities and Social Sciences Communications, 10*(1), 1–13. https://doi.org/10.1057/s41599-022-01434-8 EDN: UUIGGO

Tyurchev, K.S. (2021). Management of innovation systems: from national to local level. *Issues of State and Municipal Management,* (4), 185–206. (In Russ.). https://doi.org/10.17323/1999-5431-2021-0-4-185-206 EDN: MGBAWL

Viktorovich, J.A., Anatolevich, D.P., Jurevna, G.P., & Mihajlovich, S.A. (2021). Method for evaluating the resource maintenance for the development of remote sensing services. In *AIP Conference Proceedings, 2318*(1), AIP Publishing. https://doi.org/10.1063/5.0035794

Yudin, A.V., Drogovoz, P.A., Grosheva, P.J., & Solovev, A.M. (2021). Method for evaluating the resource maintenance for the development of remote sensing services. In *AIP Conference Proceedings* (Vol. 2318, No. 1, p. 070015). AIP Publishing LLC

Zhdaneev, O.V., & Vlasova, I.M. (2023). Challenges and priorities of the digital transformation of the coal industry. *Coal,* (1), 62–69. (In Russ.). https://doi.org/10.18796/0041-5790-2023-1-62-69 EDN: EIXIHN

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