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# Transport system of the digital society: Problems and solutions

**T.A. Rudakova**[1, 2]
**O.Yu. Rudakova**[2]
[1] Altai State Technical University named after I.I. Polzunov (Barnaul, Russia)
[1, 2] Altai State University (Barnaul, Russia)

## Abstract

In a transition economy, the issues of reforming the transport system and overcoming the exacerbating problems of industry management become relevant. It seems that technological progress and the digital transformation of business processes should simplify the algorithm of action in management matters. However, as practice shows, during this period new conditions for the functioning of the industry arise (the emergence of new modes of transport or their modification) and elements of the transport system undergo changes. A more serious problem, according to the authors, is the unpredictability of foreign partners' behaviour in relation to exclusive rights to software (SW) used by companies in the transport and logistics sector. The purpose of the study is to develop a model for assessing the cost of the risk of a company's sudden transition to domestic software and test it on the materials of companies in the transport and logistics industry of Altai Krai. The study was conducted in the context of trends in the digital transformation of the transport system, identifying factors and types of risk, and assessing their impact on the information technology landscape (IT landscape) of transport companies in the context of sanctions. The results confirm the need to prepare industry participants homegrown software and to minimise potential risks. A sudden software replacement is more likely to cause serious financial loss to organisation than planned actions that do not disrupt business processes and communications with partners and government agencies. The practical significance of the proposed risk assessment model lies in the possibility of its application when making management decisions on the digitalisation of business processes and the transition to domestic software, regardless of the industry and size of the company.

**Keywords:** transport system, digital society, logistics, risk, software, IT landscape.

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# 数字社会的运输系统：问题与解决方案

**T.A. Rudakova**[1, 2]
**O.Yu. Rudakova**[2]
[1] 以 I.I. Polzunov 命名的阿尔泰国立技术大学（俄罗斯，巴尔瑙尔）
[1, 2] 阿尔泰国立大学（俄罗斯，巴尔瑙尔）

## 简介

在经济转型期，改革运输系统和克服日益严重的行业管理问题成为当务之急。技术进步和业务流程的数字化转型似乎可以简化管理问题的行动算法。　　但是，实践证明，在这一时期，行业运行会出现新的条件（出现新的运输方式或对其进行改造），运输系统的要素也会发生变化。作者认为，外国合作伙伴在运输和物流业公司所使用软件的专有权方面的行动的不可预测性是一个更为严重的问题。本研究的目的是开发一个模型，用于评估公司突然过渡到国产软件的风险成本，并在阿尔泰边疆区运输和物流业公司的材料上进行测试。这项研究是在运输系统数字化转型趋势的背景下进行的，确定了风险因素和类型，并评估了它们在制裁限制背景下对运输公司信息技术状况的影响。研究结果证实，行业参与者应为过渡到国产软件做好准备，并将潜在风险降至最低。与不干扰业务流程以及与合作伙伴和政府机构沟通的系统性行动相比，突然更换软件更有可能给公司造成严重的经济损失。所建议的风险评估模型的实际意义在于，可以不受行业限制和公司经营规模的限制，将其应用于业务流程数字化和向国产软件过渡的管理决策中。

**关键词:** 运输系统、数字社会、物流、风险、软件、IT 环境。

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## 1. Transport system in the context of digital transformation: relevance and issues

The development of society is not possible without transport, which, like any other economic activity, uses advanced scientific achievements and technologies and consumes various types of resources, including labour, energy and natural resources. In turn, transport, as a resource for a separate business entity, is at the same time one of the structural elements of the 'organised whole' - the transport system, because its high-quality use requires additional resources and an infrastructure that ensures interaction.

The spatial development and progress of any territory presupposes its transport accessibility for economic entities to resource potential and sales markets. The transport system contributes to the development of economic processes both within a separate territorial entity and in the country as a whole, as it acts as a locomotive for the redistribution of labour resources between production areas, provides access to natural resources and is an integral part of the strategy for the socio-economic development of territories.

The importance of the transport system for socio-economic development is determined by its level of development, quality and potential. If the world transport system is an element of the world economy, the national transport system unites the transport complexes of a single country, then the regional transport system plays one of the main roles in regional economic integration. Separate economic areas created for transport services form a zonal transport system. At the level of a single economic entity it is a corporate transport system. Separate types of transport can form their own transport systems [Chernysheva, 2020].

Transport systems and infrastructure of regional importance have become the subject of research [Jakimavičius, Burinskienė, 2007; Almetova, 2012; Almetova, Larin, 2014; Glaeser, Kohlhase, 2014; Voronina, 2017; Chen, Vickerman, 2017; Guzman et al., 2017;] and others. The problems of functioning and development of transport infrastructure are studied in articles [Krylov, 2017; Macheret, Ledney, 2018].

Digital transformation of transport system elements is considered in works [Erofeev, 2017; Lapidus, 2018; Berdysheva, Zharkova, 2019; Mikhalchuk, 2019; Pomortsev, 2019; Mashkina, Veliev, 2020; Akbarova, Shonazarova, 2023] and others, but the issue of risks of switching to domestic software (SW) is not covered in sufficient depth.

Today's transport system is a combination of all modes of transport (car, rail, urban surface and underground electric transport, air, water, etc.). Its functionality is determined not only by transport vehicles and means of transport (motorways, railways and waterways, air routes, etc.), but also by the companies that ensure uninterrupted transport processes, management and logistics structures.

The globalisation of a significant part of economic processes and restrictive measures introduced as a result of political disagreements for participants in the global market space have identified one of the main problems in the development of the transport system - a change in the composition of players in the global market and the

architecture of logistics systems, on the one hand, and the complexity of software for the system elements, on the other. A natural and predictable consequence of the development of the current situation was the growth of transaction costs in the construction of new routes for the movement of values for participants in market exchange and additional investment in the development, implementation and replication of the practice of using modern domestic software.

The solution to this problem has been entrusted to the Industrial Competence Centres (ICC) created by the decision of the Government of the Russian Federation, which operate on the principle of consortia and take into account the interests of customers of digital products for representatives of various sectors of the economy. For transport, one of the key sectors of the economy, four ICC have been created and are managed by transport companies: JSC Russian Railways, PJSC Aeroflot, JSC Sheremetyevo International Airport and FSUE Rosmorport (Fig. 1). ICC play the role of curator of projects for the import substitution of 'industrial software, hardware and software systems as well as system and application software'[1]. Participants in the ICC 'Railway Transport and Logistics' included Russian Railways, Moscow Metro, St Petersburg Metro, Mostransavto, Avtodor, GLONASS, Rusatom Cargo, Research Institute of Automobile Transport, Russian Post, Sberbank and SberTroika.

The strategy of digital transformation of JSC Russian Railways until 2025 defines the course of development of railway transport in the range of 10-15 years, and its vector is directed towards the digital space. Priority has been given to technologies that can apply predictive analytics, provide real-time information on the condition of vehicles and the transport process, and respond quickly to emerging failures.

According to a number of researchers, the solution to the transport industry's problems lies in digital transformation and a consistent move towards paperless document management, intelligent transport systems and unmanned transport.

Considering the situation in which the Russian transport system and related industries find themselves, the modern digital technologies planned for implementation should contribute to the creation of a trustworthy environment in freight transport, and all participants in the transport process should solve one of the main tasks: switching to the use of domestic IT solutions in the optimal timeframe.

The results of the work (products) of the ICP 'Railway Transport and Logistics', which can be in demand by both transport companies and business partners, are presented in the form of universal IT products. Some of them are already in use, work on others should be completed in 2024 (Table 1).

## 2. Transport system transformation vector

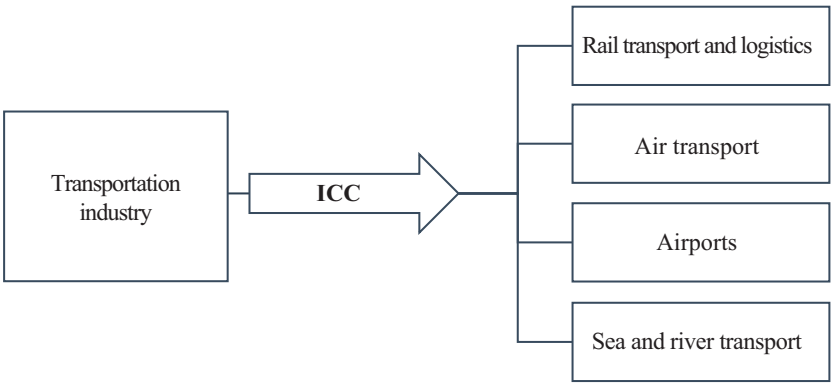
The development of the Russian transport system directly depends on the results of the implementation of the digital transformation strategy of JSC Russian Railways, at least as far as rail transport is concerned. As the main investor in the development of innovative digital solutions, JSC Russian Railways is ultimately interested in spreading the practice of their application to the entire infrastructure.

In the Strategy for the Digital Transformation of Russian Economic Sectors, the section on 'Transport and Logistics' envisages the improvement of the transport system, technologies for managing vehicles and flows through the creation of intelligent transport systems. The transformation of the industry is based on modern information and telecommunications technologies and the GLONASS global navigation system. Multimodal transport must be developed for passenger transport within the country and beyond its borders.

At present, the registration of shipping documents is partly done in electronic form; the complete conversion of documents to digital form will not only speed up registration and processing, but also organise a higher quality and more efficient control of the movement of goods.

Intelligent Transport Systems are the unity and effective interaction of all their elements: the road surface, all types of vehicles, road management systems and infrastructure facilities, including traffic lights, video cameras and lighting systems. The introduction of artificial intelligence technologies in an ideal development scenario should ensure the emergence of intelligent roads, facilitating the spread of digital technologies in road user communication processes, road infrastructure and unmanned transport. One of the main obstacles may be the lack of 5G technology on transport routes, which provides high-speed internet as a necessary condition for the functioning of intelligent roads, unmanned transport and the information and communication infrastructure of all participants in the transport system, including the control system.

Fig. 1. Centres of industrial excellence in the transport system




*Source:* compiled by the authors based on Russian Railways data: https://rzddigital.ru/upload/iblock/d33/0lwx5pswqxi94yczn2ss3wicjaydp34u.pdf.

[1] Industrial Competence Centers (ICC) (2024). TADVISER: State. Business. Technologies. https://clck.ru/3ASegU.

Table 1
Products of the PPI 'Rail transport and logistics'

| Product | Characteristic | Result | Foreign equivalent |
|---|---|---|---|
| Consistent Data Model of the Transport Process - import-independent automated system for operational management of transportation | A single data model for managing and optimising transport processes | More than 100,000 users of automated production systems have been trained to work with the data of the Consistent Data Model of the Transport Process Over 80 automated production systems interact with the Consistent Data model of the Transport Process | IBM |
| Electronic Consignment Note Automated System - automated system for centralised preparation and execution of shipping documents on an import-independent platform | Full technological cycle of registration of transport documents in the electronic document management system | Connected:<br>3846 structural units and 28,439 users of Russian Railways;<br>15,847 organisations and 29,991 clients | Oracle |
| ACS 'Express' of the new generation - a system for railway ticket sales and passenger complex management | Information and reference services for passengers, organisation of baggage and mail transport, management of the operation and repair of passenger vehicles, reporting. | More than 1,500 JSC Federal Passenger Company's checkouts converted to use of ACS Express system<br>More than 1,000 active users | No |
| Unified numbering system for new generation locomotives - import independent unified locomotive numbering system | Accounting for rolling stock, equipment and small mechanised equipment | The development of the basic functionality of Unified numbering system is carried out on the basis of x86/64 architecture. Audit of the current integration interactions of Unified numbering system with the automated systems of Russian Railways, design of a new system. | SAP |
| Automated system for managing freight car repairs - automated system for managing freight car repairs based on economic criteria in operating and repair depots | Automation of business processes of operational and repair wagon depots with regard to the execution of current and planned types of repairs of freight wagons and parts | A business process survey was carried out, core design work began, an architectural solution was prepared, 14 modules were created, consisting of more than 70 different functions, covering the main processes of the current uncoupling repair system and the wagon management system based on economic criteria. | SAP |
| Import-independent infrastructure management system | Improving the efficiency of the production processes of the Central Infrastructure Directorate | The following will be created: A unified model of transport process data, a new generation electronic consignment note | – |
| 'Passenger Flows' $v^2$ - software package for modelling and forecasting passenger flows | Taking into account various demand factors when forecasting passenger flows, including:<br>● economic and demographic forecasts<br>● the impact of other transport modes | An architectural scheme for interaction between Russian Railways systems and systems of external participants in the transport process for exchanging data on the transport behaviour of the population was approved. A methodology for modelling and forecasting passenger flows was developed and approved, taking into account the distribution of intercity passenger flows on the territory of agglomerations and transport hubs. | PTV, VISUM, AIMSUM, TransCAD |

*Source:* compiled by the author based on Russian Railways data: https://rzddigital.ru/upload/iblock/d33/0lwx5pswqxi94yczn2ss3wicjaydp34u.pdf.

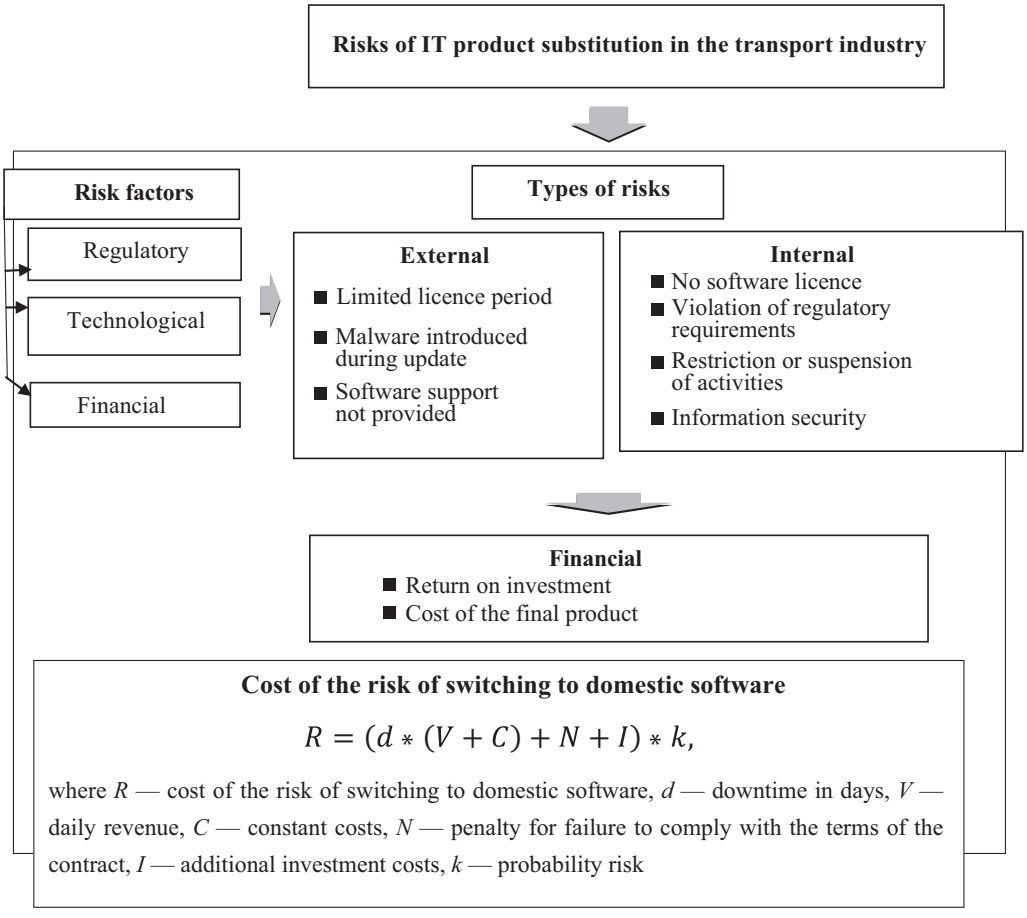
The deployment of 5G technology in the transport sector as part of the implementation of Russia's digital development agenda is a task that requires a collective solution from stakeholders, investors, IT industry specialists, mobile operators, interested parties (for example, the leadership of a territorial entity) and participants in the transport system interacting in the process of its operation. Such a large project is essentially a combination of several projects, the products of which will ensure the construction of a modern, efficient transport system for the territory. The financial component deserves special attention in solving the problem. Since we are talking about a series of projects, the financing can be collective and include the participation of budgets at different levels (when we are talking about federal, regional and local roads) and private investment.

## 3. IT landscape of a transport company in the context of digital transformation and sanction restrictions

Today, almost every business entity uses Internet resources in its activities to organise communication with partners and government institutions, to build business processes, and to perform analytical and accounting work. A set of tools to support business processes, enabling the management of financial, human and material resources, sales activities, appears to the user as a set of information systems, services, products and is called an IT landscape or IT architecture. The number of IT architecture components is determined by the social or commercial focus of the organisation, the size of the business, the geographical location of structural elements, involvement in virtual space, financial capabilities and the use of monolithic or microservice principles.

The IT landscape is a flexible system that can change to ensure business security when the opportunity or need for change arises. Due to the need to maintain technological independence and security of the critical information infrastructure of the Russian Federation in the context of sanctions restrictions, the Decree of the President of the Russian Federation of 30 March 2022 No. 166[2] establishes the requirement for transition to domestic IT solutions for companies with state participation before the beginning of 2025. Despite the fact that, according to the document, the obligation to migrate applies to government agencies and organisations with government participation, it should be remembered that for other companies this will not be

Fig. 2. Factors and risks of IT product substitution in the transport industry




[2] Decree of the President of the Russian Federation dated 30.03.2022 N 166 'On Measures to Ensure the Technological Independence and Security of the Critical Information Infrastructure of the Russian Federation'. http://www.kremlin.ru/acts/bank/47688.

Table 2
Revenue of transport and logistics companies in the Altai Territory by type of activity for 2022 (RUB mln)

| Type of activity | Revenue | | |
|---|---|---|---|
| | Vav | Vmin | Vmax |
| Automotive and freight transport | 371 | 101 | 1 872 |
| Freight transport by road and transport services | 162 | 100 | 341 |
| Wired telecommunications activities | 301 | 154 | 566 |
| Inland water transport | 112 | 104 | 120 |
| Supporting and auxiliary transport activities | – | – | 692 |
| Other supporting transport activities | 517 | 102 | 2958 |
| Rail transport: Freight transport | 761 | 129 | 3620 |
| Railway infrastructure | – | – | 182 |
| Other computer and related activities not included in other groups | – | – | 138 |
| Computer consultancy and related activities | – | – | 202 |
| Courier activities | 142 | 110 | 164 |
| Passenger air transport | – | – | 143 |
| Warehousing and storage | 508 | 436 | 580 |
| Creation and use of databases and information resources | 131 | 119 | 143 |
| Operation of roads and motorways | 1583 | 547 | 2261 |
| Other land passenger transport activities not included in other groups | – | – | 114 |
| Land passenger transport activities: urban and suburban passenger transport | 145 | 106 | 167 |
| Other computer and related activities | 230 | 116 | 481 |
| Newspaper publishing | 271 | 102 | 440 |
| Freight transport by non-specialised vehicles | 215 | 105 | 405 |
| Freight transport by specialised vehicles | 449 | 122 | 1013 |
| Suburban passenger rail transport | – | – | 595 |
| Provision of transport services | 221 | 103 | 332 |
| Computer software development | 162 | 103 | 331 |
| Urban and suburban regular passenger bus services | 166 | 149 | 375 |
| Urban and suburban regular passenger bus services | 0 | 0 | 0 |
| Urban and suburban regular passenger services by trolley bus | 118 | 101 | 134 |
| Urban and suburban regular passenger rail services | 0 | 0 | 0 |
| Storage and handling of grain | – | – | 273 |

*Source:* compiled by the authors based on SPARK data: https://spark-interfax.ru/.

an obligation in the near future, but an urgent necessity, due to the high probability of restrictions on the use and maintenance of foreign software.

IT landscapes can be categorised by end user (internal and external with access by company employees and external users), functional use, architectural separation, type of ownership or creation. Given that the IT landscape belongs to a certain classification group and the principles of its construction for a specific user (monolith or microservices), it is recommended that the transport organisation make or postpone a decision on replacing foreign IT products with domestic software, taking into account the calculation of the cost of its update and comparison with the cost of the potential risk. The process of replacing IT products is associated with risks of various types (Fig. 2).

In order to calculate the cost of the risk of IT product substitution, the authors used data on the revenues of transport companies in the Altai Territory, examined them

Table 3
Revenues and additional costs for companies that suddenly switch to domestic software (RUB mln)

| Вид деятельности | Daily revenue | | | Transitional revenue ($d$ = 14) | | | Fixed costs during the transition period ($d$ = 14, $C$ = 0.4) | | | Penalty for 14 days ($N$ = 0.3) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $V_{av}$ | $V_{min}$ | $V_{max}$ | $dV_{av}$ | $dV_{min}$ | $dV_{max}$ | $C_{Vav}$ | $C_{Vmin}$ | $C_{Vmax}$ | $N_{Vav}$ | $N_{Vmin}$ | $N_{Vmax}$ |
| | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| Road freight transport | 30.9 | 0.3 | 5.1 | 432.7 | 3.9 | 71.8 | 2423.0 | 21.6 | 402.2 | 2855.6 | 25.4 | 474.0 |
| Freight transport by road and transport services | 0.4 | 0.3 | 0.9 | 6.2 | 3.8 | 13.1 | 34.7 | 21.5 | 73.2 | 40.9 | 25.3 | 86.3 |
| Wired telecommunications activities | 0.8 | 0.4 | 1.5 | 11.5 | 5.9 | 21.7 | 64.6 | 33.1 | 121.4 | 76.1 | 39.0 | 143.1 |
| Inland water transport | 0.3 | 0.3 | 0.3 | 4.3 | 4.0 | 4.6 | 24.1 | 22.3 | 25.9 | 28.4 | 26.2 | 30.5 |
| Supporting and auxiliary transport activities | — | — | 1.9 | — | — | 26.7 | — | — | 149.4 | — | — | 176.0 |
| Other supporting transport activities | 1.4 | 0.3 | 8.1 | 19.8 | 3.9 | 113.5 | 111.1 | 21.9 | 635.4 | 130.9 | 25.8 | 748.8 |
| Rail transport: Freight transport | 2.1 | 0.4 | 9.9 | 29.2 | 4.9 | 138.8 | 163.5 | 27.6 | 777.5 | 192.7 | 32.5 | 916.3 |
| Railway infrastructure | — | — | 0.5 | — | — | 7.0 | — | — | 39.1 | — | — | 46.1 |
| Other computer and related activities not included in other groups | — | — | 0.4 | — | — | 5.3 | — | — | 29.6 | — | — | 34.8 |
| Computer consultancy and related activities | — | — | 0.6 | — | — | 7.8 | — | — | 43.4 | — | — | 51.2 |
| Courier activities | 0.4 | 0.3 | 0.5 | 5.4 | 4.2 | 6.3 | 30.5 | 23.7 | 35.4 | 35.9 | 27.9 | 41.7 |
| Passenger air transport | — | — | 0.4 | — | — | 5.5 | — | — | 30.8 | — | — | 36.3 |
| Warehousing and storage | 1.4 | 1.2 | 1.6 | 19.5 | 16.7 | 22.2 | 109.1 | 93.6 | 124.6 | 128.5 | 110.3 | 146.8 |
| Creation and use of databases and information resources | 0.4 | 0.3 | 0.4 | 5.0 | 4.6 | 5.5 | 28.2 | 25.6 | 30.8 | 33.3 | 30.2 | 36.3 |
| Operation of roads and motorways | 4.3 | 1.5 | 6.2 | 60.7 | 21.0 | 86.7 | 340.0 | 117.4 | 485.7 | 400.7 | 138.4 | 572.4 |
| Other land passenger transport activities not included in other groups | — | — | 0.3 | — | — | 4.4 | — | — | 24.4 | — | — | 28.7 |
| Land passenger transport activities: urban and suburban passenger transport | 0.4 | 0.3 | 0.5 | 5.6 | 4.1 | 6.4 | 31.1 | 22.8 | 35.9 | 36.7 | 26.9 | 42.3 |
| Other computer and related activities | 0.6 | 0.3 | 1.3 | 8.8 | 4.4 | 18.5 | 49.3 | 24.9 | 103.3 | 58.1 | 29.3 | 121.8 |
| Newspaper publishing | 0.7 | 0.3 | 1.2 | 10.4 | 3.9 | 16.9 | 58.3 | 22.0 | 94.6 | 68.7 | 25.9 | 111.5 |
| Freight transport by non-specialised motor vehicles | 0.6 | 0.3 | 1.1 | 8.2 | 4.0 | 15.6 | 46.2 | 22.6 | 87.1 | 54.4 | 26.6 | 102.7 |
| Freight transport by specialised motor vehicles | 1.2 | 0.3 | 2.8 | 17.2 | 4.7 | 38.9 | 96.4 | 26.2 | 217.7 | 113.7 | 30.9 | 256.6 |
| Urban passenger transport by rail | — | — | 1.6 | — | — | 22.8 | — | — | 127.7 | — | — | 150.5 |
| Land transport | 0.6 | 0.3 | 0.9 | 8.5 | 4.0 | 12.7 | 47.4 | 22.2 | 71.3 | 55.8 | 26.1 | 84.1 |
| Computer software development | 0.4 | 0.3 | 0.9 | 6.2 | 3.9 | 12.7 | 34.7 | 22.1 | 71.0 | 40.9 | 26.1 | 83.7 |
| Urban and suburban regular passenger bus services | 0.5 | 0.4 | 1.0 | 6.4 | 5.7 | 14.4 | 35.7 | 32.1 | 80.5 | 42.0 | 37.8 | 94.9 |
| Urban and suburban regular passenger bus services | 0.3 | 0.3 | 0.4 | 4.5 | 3.9 | 5.2 | 25.3 | 21.7 | 28.9 | 29.8 | 25.6 | 34.0 |
| Regular urban and suburban passenger transport by trolleybuses | — | — | 0.7 | — | — | 10.5 | — | — | 58.6 | — | — | 69.0 |
| Urban and suburban regular passenger tram services | 2.0 | 0.8 | 3.1 | 27.3 | 10.8 | 43.8 | 152.9 | 60.3 | 245.4 | 180.2 | 71.1 | 289.2 |
| Storage and handling of grain | 0.5 | 0.3 | 1.6 | 7.5 | 4.0 | 22.0 | 42.3 | 22.2 | 123.1 | 49.8 | 26.1 | 145.1 |

*Source:* compiled by the authors based on SPARK data: https://spark-interfax.ru/.

Table 4
Cost of the risk of sudden replacement of IT products for transport and logistics companies in the Altai Territory (RUB mln)

| Type of activity | Cost of risk for 14 days (k = 1) | | | Cost of risk for 14 days (k = 0.1) | | | Cost of risk for 14 days (k = 0.5) | | | Cost of risk for 14 days (k = 0.8) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $V_{av}$ | $V_{min}$ | $V_{max}$ | $V_{av}$ | $V_{min}$ | $V_{max}$ | $V_{av}$ | $V_{min}$ | $V_{max}$ | $V_{av}$ | $V_{min}$ | $V_{max}$ |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Road freight transport | 5711.4 | 51.0 | 948.2 | 571.1 | 5.1 | 94.8 | 2855.7 | 25.5 | 758.6 | 4569.2 | 40.8 | 758.6 |
| Freight transport by road and transport services | 82.1 | 50.8 | 172.8 | 8.2 | 5.1 | 17.3 | 41.0 | 25.4 | 138.2 | 65.7 | 40.7 | 138.2 |
| Wired telecommunications activities | 152.5 | 78.2 | 286.5 | 15.2 | 7.8 | 28.6 | 76.2 | 39.1 | 229.2 | 122.0 | 62.5 | 229.2 |
| Inland water transport | 56.9 | 52.7 | 61.2 | 5.7 | 5.3 | 6.1 | 28.5 | 26.3 | 48.9 | 45.5 | 42.1 | 48.9 |
| Supporting and auxiliary transport activities | 0.2 | 0.2 | 352.2 | 0.0 | 0.0 | 35.2 | 0.1 | 0.1 | 281.8 | 0.2 | 0.2 | 281.8 |
| Other supporting transport activities | 262.1 | 51.8 | 1497.8 | 26.2 | 5.2 | 149.8 | 131.0 | 25.9 | 1198.3 | 209.6 | 41.4 | 1198.3 |
| Rail transport: Freight transport | 385.7 | 65.2 | 1832.9 | 38.6 | 6.5 | 183.3 | 192.8 | 32.6 | 1466.3 | 308.6 | 52.2 | 1466.3 |
| Railway infrastructure | 0.2 | 0.2 | 92.4 | 0.2 | 0.2 | 9.2 | 0.2 | 0.2 | 73.9 | 0.2 | 0.2 | 73.9 |
| Other information service activities not included in other groups | 0.2 | 0.2 | 69.9 | 0.2 | 0.2 | 7.0 | 0.2 | 0.2 | 55.9 | 0.2 | 0.2 | 55.9 |
| Computer consultancy and related activities | 0.2 | 0.2 | 102.6 | 0.2 | 0.2 | 10.3 | 0.2 | 0.2 | 82.1 | 0.2 | 0.2 | 82.1 |
| Courier activities | 72.1 | 56.0 | 83.5 | 7.2 | 5.6 | 8.4 | 36.0 | 28.0 | 66.8 | 57.7 | 44.8 | 66.8 |
| Passenger air transport | 0.2 | 0.2 | 72.8 | 0.0 | 0.0 | 7.3 | 0.1 | 0.1 | 58.3 | 0.2 | 0.2 | 58.3 |
| Warehousing and storage | 257.3 | 220.9 | 293.8 | 25.7 | 22.1 | 29.4 | 128.6 | 110.4 | 235.1 | 205.8 | 176.7 | 235.1 |
| Activities related to the creation and use of databases and information resources | 66.7 | 60.6 | 72.8 | 6.7 | 6.1 | 7.3 | 33.4 | 30.3 | 58.3 | 53.4 | 48.5 | 58.3 |
| Operation of roads and motorways | 801.7 | 277.0 | 1145.0 | 80.2 | 27.7 | 114.5 | 400.8 | 138.5 | 916.0 | 641.3 | 221.6 | 916.0 |
| Other land passenger transport activities not included in other groups | 0.2 | 0.2 | 57.7 | 0.2 | 0.2 | 5.8 | 0.2 | 0.2 | 46.1 | 0.2 | 0.2 | 46.1 |
| Land passenger transport activities: urban and suburban passenger transport | 73.6 | 54.0 | 84.8 | 7.4 | 5.4 | 8.5 | 36.8 | 27.0 | 67.9 | 58.9 | 43.2 | 67.9 |
| Computer and related activities, other | 116.4 | 58.8 | 243.8 | 11.6 | 5.9 | 24.4 | 58.2 | 29.4 | 195.0 | 93.2 | 47.0 | 195.0 |
| Publishing of newspapers and periodicals | 137.5 | 51.9 | 223.3 | 13.8 | 5.2 | 22.3 | 68.8 | 26.0 | 178.6 | 110.0 | 41.6 | 178.6 |
| Freight transport by non-specialised vehicles | 109.0 | 53.4 | 205.5 | 10.9 | 5.3 | 20.6 | 54.5 | 26.7 | 164.4 | 87.2 | 42.7 | 164.4 |
| Freight transport by specialised vehicles | 227.5 | 61.9 | 513.4 | 22.8 | 6.2 | 51.3 | 113.8 | 31.0 | 410.7 | 182.0 | 49.5 | 410.7 |
| Urban passenger rail transport | 0.2 | 0.2 | 301.2 | 0.2 | 0.2 | 30.1 | 0.2 | 0.2 | 241.0 | 0.2 | 0.2 | 241.0 |
| Land transport | 111.8 | 52.5 | 168.4 | 11.2 | 5.2 | 16.8 | 55.9 | 26.2 | 134.7 | 89.5 | 42.0 | 134.7 |
| Computer software development | 82.1 | 52.3 | 167.6 | 8.2 | 5.2 | 16.8 | 41.0 | 26.2 | 134.1 | 65.7 | 41.9 | 134.1 |
| Urban and suburban regular passenger bus services | 84.3 | 75.8 | 190.0 | 8.4 | 7.6 | 19.0 | 42.1 | 37.9 | 152.0 | 67.4 | 60.6 | 152.0 |
| Regular interurban bus services | 59.9 | 51.4 | 68.2 | 6.0 | 5.1 | 6.8 | 29.9 | 25.7 | 54.6 | 47.9 | 41.1 | 54.6 |
| Urban and suburban regular carriage of passengers by trolley bus | 0.2 | 0.2 | 138.2 | 0.2 | 0.2 | 13.8 | 0.2 | 0.2 | 110.6 | 0.2 | 0.2 | 110.6 |
| Urban and suburban regular passenger rail services | 360.6 | 142.3 | 578.6 | 36.1 | 14.2 | 57.9 | 180.3 | 71.2 | 462.9 | 288.4 | 113.8 | 462.9 |
| Storage and handling of grain | 99.8 | 52.5 | 290.3 | 10.0 | 5.2 | 29.0 | 49.9 | 26.2 | 232.3 | 79.8 | 42.0 | 232.3 |

*Source:* compiled by the authors based on SPARK data: https://spark-interfax.ru/.

in terms of types of activity and divided them into three categories: revenues calculated using the simple average method ($V_{av}$), maximum revenues ($V_{max}$) and minimum revenues ($V_{min}$) (Table. 2).

The transition period to domestic software may vary (number of days $d > 1$) depending on the readiness of the enterprise to switch to domestic IT products (availability of the right to use the IT product, personnel skills for data translation, technical capabilities of the enterprise and organisational characteristics). The amount of fixed costs ($C$) can be determined based on the planned value in the unit cost structure of the service or the actual value for the month per day. The penalty ($N$) for breach of the terms of the contract is determined in accordance with paragraph 5 of Article 28 of the Law on Protection of Consumer Rights[3] in the amount of 3% of the price of the work (service) performed in case of breach of the terms for performance of the work (service) established in the contract per day. Additional investment costs ($I$) will depend on the needs of the business and will be determined by the parameters of the desired IT landscape and the principle of its construction (monolithic or microservices).

At the time of writing, the IT products market offered Russian programmes for the automation of motor transport companies, transport companies, logistics, cargo and passenger transport: SHEDEX, Smart logistics, Maxoptra, CyberLog, Zavgar.Online, CARGO. RUN, Megalogist, AutoTransport, TIS Online, 1C:TMS Logistics, 4logist, BIT:Autotransport, AutoPlan, Advantum TMS, 1C:Motor Transport Management, GdeMoi, Logista Tools 24, Trans-Manager, TransTrade, Cargo Transport, G-Soft, BIA Logistics Assistant, Expedit, PROLOGISTA, Vehicle Control and Accounting, Kargobar, Novator CRM, AutoGRAPH GPS, Gruzoplan, AB:CARGO, Kors Avtopredpriyatiye[4]. These are cloud programs, online services, online systems, FMS systems, digital logistics platforms, programs on the 1C platform, offering services for the organisation of the activities of companies in the transport and logistics industry, automation of business processes in digital and cloud implementation. The cost of using the proposed software for one microservice starts from 33 thousand roubles, and programs for automating individual functions from 90 thousand roubles. The total cost of building a CT landscape based on homegrown software depends on the number of microservices or complex programs required by the company.

The probability of risk ($k$) is determined by expert judgement, involving specialists with expertise in assessing the situation in the IT product markets, geopolitical trends, sanctions pressure and their impact on internal economic processes.

To calculate the cost of the risk of substitution of IT products of companies in the Transport and Logistics industry of the Altai Territory, the necessary parameters were set: investment costs ($I$) - 200 thousand rubles; transition period ($d$) - 14 days; level of fixed costs ($C$) in revenue - 40%; probabilities of risk occurrence - 10, 50, 80 and 100%, or ($k$) = 0.1, 0.5, 0,8 and 1.0.

The results of the calculations of the volume of lost sales during the transition period, the amount of fixed costs, the amount of penalties for non-compliance with the terms of contracts in the event of forced replacement of software due to the sudden cessation of operation of foreign analogues are presented in Table 3, the costs of the risk of a sudden transition with various degrees of probability of the event occurring are presented in Table 4.

The results of the research support the conclusion that sudden software replacement is more likely to result in significant financial losses for companies in the transport and logistics industry than the cost of planned and parallel actions that do not disrupt business processes and relationships with partners and government institutions. The results of the research support the conclusion that sudden software replacement is more likely to result in significant financial losses for companies in the transport and logistics industry than the cost of planned and parallel actions that do not disrupt business processes and relationships with partners and government institutions. We share the managers' concerns about the need for additional organisational measures, the financial costs of preparing staff for change, the costs of purchasing the necessary software and possibly revising the IT architecture that already supports business processes. We should not forget, firstly, that the suddenness and inevitability of such actions will cost much more (this is confirmed by the presented calculations), secondly, the process of transition to domestic software is irreversible, because even under favourable conditions in terms of the use of foreign software by commercial companies and the obligatory transition to domestic software by 01.01.2025 of companies with state participation, it will be necessary, at best, to search for options of compatibility of IT products used by participants in economic interaction.

## 4. Digital twin as one of the solutions

The current level of IT technology development allows transport logistics management to optimise operational and management processes using the proposed new technological solutions: Digital Twin - a computer program that combines information, an object and a process and builds an algorithm for their interaction. According to the developers, a digital twin is a virtual model that can be updated when there is a need or requirement to change the physical analogue, and is essentially a modular logistics platform designed to automate key supply chain management processes and account for logistics costs.

The concept of a digital twin is an opportunity to identify weaknesses in the construction of a logistics chain based on the results of a virtual copy of expected events and the developed strategy. The trajectory of the cargo movement can be adjusted if an unsatisfactory result is obtained; a course of action can be selected based on a comparison and evaluation of several alternative scenarios. In logistics, the

[3] Law of the Russian Federation dated 07.02.1992 No. 2300-1 'On Protection of Consumer Rights'. https://rg.ru/documents/2008/12/01/pravapotr-dok.html.
[4] Top 10: Software for transport companies (for Russia) (2024). Livebusiness. 12 August. https://www.livebusiness.ru/tools/transport/.

capabilities of a digital twin can be used to minimise the cost of transporting and storing cargo by determining its most advantageous location. One of the main advantages and capabilities of a digital twin is its independence from related processes, given a large number of scenarios, and achieving a predictable result after processing a large number of parameters in a minimum amount of time. The designated capabilities for managing logistics activities are provided by a digital twin of the supply chain based on the AXELOT SCM platform. The AXELOT SCM platform is being developed with the support of the Russian Foundation for the Development of Information Technologies, which acts as an operator of measures to support projects for the implementation of domestic products, services and platform solutions created on the basis of end-to-end digital technologies.

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## About the authors

**Tatyana A. Rudakova**
Candidate of economic sciences, associate professor at the Department of Economics and Finance, Altai State Technical University named after I.I. Polzunov (Barnaul, Russia); associate professor at the Department of Economic Security, Accounting, Analysis and Audit, Altai State University (Barnaul, Russia). ORCID: 0000-0002-8735-7058.
Research interests: digital finance, economic security, risk management, accounting and analytical aspects of bankruptcy, reliability of accounting and reporting information, risks of the real sector of the economy.
aleks_rudakova@mail.ru

**Oksana Yu. Rudakova**
Candidate of economic sciences, associate professor, head of the Department of Management, Business Organisation and Innovation, Altai State University (Barnaul, Russia). ORCID: 0000-0001-9714-2483.
Research interests: anti-crisis management, change and development management, economic security, management consulting, innovation.
rud-oksana@yandex.ru

## 作者信息

**Tatyana A. Rudakova**
经济学博士，以 I. I. Polzunov 命名的阿尔泰国立技术大学（俄罗斯巴尔瑙尔）经济与金融系副教授; 阿尔泰国立大学（俄罗斯巴尔瑙尔）经济安全、会计、分析与审计系副教授. ORCID: 0000-0002-8735-7058.
科学兴趣领域: 数字金融、经济安全、风险管理、破产的会计和分析问题、会计和报告信息的可靠性、实体经济部门的风险。
aleks_rudakova@mail.ru

**Oksana Yu. Rudakova**
经济学副博士, 副教授, 阿尔泰国立大学（俄罗斯巴尔瑙尔）管理、企业组织与创新系主任. ORCID: 0000-0001-9714-2483.
科学兴趣领域: 危机管理、变革和发展管理、经济安全、管理咨询、创新。
rud-oksana@yandex.ru

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