Economic assessment of the effects of the introduction of digital platforms for the integration of participants in mixed (multimodal) freight transport (based on rail transport)

Ilia Gulyi[1*] and *Elizaveta* Kornienko[1]

[1]Emperor Alexander I St. Petersburg State Transport University, 190031, 9 Moskovsky pr., Saint Petersburg, Russia

Abstract. Purpose: to reveal and describe the functionality, main services and opportunities for participants in the transportation process (cargo owners, operators, service companies) to connect to a digital integrator – a single platform "Electronic trading platform "Freight Transportation" (ETP FT), to substantiate the methodology for the economic assessment of the effects of the introduction of digital platforms for the integration of participants in freight mixed (multimodal) transportation (based on rail transport); calculate the individual economic effects of integration on the platform for various participating parties. Methods: supply chain analysis, evaluation of time-saving effects, analysis of logical flow processes and operations. Results: a methodology has been developed to assess the economic effects of integrating transport market participants into a digital platform, which consists in evaluating individual cost savings elements for a specific platform participant, including: by converting the document flow to an electronic format, by minimizing the cost of storing paper forms of documents, the cost of shipping, forwarding documents and related cash gaps, saving time and shortening financial cycles during the transition to electronic signing of documents and acceptance of electronic forms of documents by participants. Recommendations: The materials are addressed to specialists of companies participating in the transport and logistics market, IT directors and specialists, and all stakeholders interested in the development of the digital ecosystem.

1 Introduction

Since 2017, the Russian transport complex has been implementing a project of an end-to-end digital integrator (a single digital platform) that unites participants in cargo transportation within the framework of the organization of railway and multimodal shipments "Electronic trading platform "Freight Transportation" (ETP FT).

* Corresponding author: ilya.guliy@mail.ru

The operator of the ETP FT is currently a separate legal entity of the Russian Railways holding – Digital Logistics LLC, which is an element of the digital subholding of Russian Railways in terms of building digitalized transport logistics [1-15].

The prerequisites for the creation of a digital ETP FT platform are normative legal documents:

– FAS Regulation No. IA/20187/16, IA/20191/16 dated 03/28/2016;

– the program "Digital Economy of the Russian Federation": Decree of the Government of the Russian Federation dated 07/28/2017 No. 1632-r);

– the concept of the implementation of the integrated scientific and technical project "Digital Railway": order of JSC "Russian Railways" dated 05.12.2017 No.1285);

– The strategy of digital transformation of JSC "Russian Railways" until 2025: developed on behalf of the Board of Directors of JSC "Russian Railways" dated 09/14/2018 No. 2;

– action plan for the development of the ETP FT for 2019-2020: Order of JSC "Russian Railways" No. 2746/r dated 12/21/2018).

2 Materials and methods

The study is based on statistical data from Digital Logistics LLC, the operator of the Electronic Trading Platform Freight Transportation [11], statistical data from Russian statistical state service (RosStat), various analytical sources, and data from the International Union of Railways.

The scientific methodology, the use of which helped the author to come to his own methodology for assessing the economic effects of the introduction of digital platform solutions, is presented in the works of: L.M. Chechenova, N. Batalova [1, 2], Yu.V. Egorov [3, 4], E.M. Volkova [11, 12], N.A. Zhuravleva, T. Kliestik, M. Poliak, J. Kubáňová, M. Jaśkiewicz, N. Lakhmetkina [9, 13]. Part of the research, on the results of which we relied, is devoted to the methodology of the feasibility study of digitalization projects of international transport corridors, routes, digitalization of transport and logistics hubs: M. Grigoryan M., L. Bujanova L. [5], M.A. Marchenko, O.D. Pokrovskaya, E.S. Rodneva [6, 7], E. Panyushkina [8], A. Vorobiev, E. Sivertceva [10].

3 Digital technological platform for interaction of freight transportation participants "Electronic trading platform "Freight transportation", its individual elements and services

By 2023, more than 9 thousand customers (cargo owners) are connected to the ETP FT. In 2022, an event occurred that can be described as a statistical milestone in the development of the platform: the millionth wagon was designed and delivered through the platform.

The digital platform of the ETP FT was originally supposed to provide equal access for participants in the transportation process to the infrastructure of JSC "Russian Railways", the resources of JSC "Russian Railways" and owners (operators) of rolling stock. The ideology of the functioning of the platform (digital platform) is based on ensuring continuous online interaction, on the one hand, cargo owners (customers), on the other hand, participants-performers of the cargo transportation process: 1) carriers (JSC "Russian Railways", foreign railway companies, road carriers, air carriers, river and marine ship owners); 2) operators of the carriage fleet and other logistics intermediaries (stevedoring companies, service providers of terminal and warehouse complexes, security and cargo accompanying organizations); 3) financial and insurance institutions (commercial banks,

insurance companies, commodity exchanges, factoring companies); 4) executive authorities (customs, tax authorities, state services of phyto-sanitary control).

The main principles of the functioning of the ETP FT are defined as follows: publicity, transparency, equal accessibility, customer orientation, continuous constant growth of competitiveness of participants in the supply chain.

The efficiency of the ETP FT is mainly ensured by saving the time of the cargo owner, his staff, specialized services, searching for the most cost-effective, cheap, high-quality way to deliver cargo, saving the total transaction costs necessary for organizing and performing cargo delivery.

Figure 1 shows the estimated time costs in the interaction of cargo owners with carriers and rolling stock operators.

Fig. 1. The main stages (elements) of freight transportation technology and comparative time-consuming parameters in traditional and digitalized transportation methods.Source: made by author based on [14].

Thus, the main effect of the ETP is to optimize the time and, as a result, the financial resources of cargo owners and other participants in the cargo transportation process. Estimation of time savings due to optimization of all accompanying transactional operations: from 1-1.5 months in the absence of a digital platform to about 10 minutes on a digital platform.

Currently, additional services, second-level services are being developed within the framework of the ETP FT: bidding, departure of empty wagons, terminal and warehouse services, cargo security, services of stevedoring companies, online payment, online tracking (tracking the location of cargo).

Due to the significant number of participants connected to the platform, the ETP FT is already a powerful resource for the formation of a database and the application of big data analytics technologies (Big Data) with the subsequent introduction of elements of customizable artificial intelligence (II).

A visual example of a customer (cargo owner) ordering transportation services on an ETP FT is shown in Figure 2. The customer (cargo owner, shipper), as part of online access, sees on the screen the entire process of movement from the point of departure to the destination. The electronic system inside the ETP FT examines, analyzes various supplier offers, finds the optimal solution for the client or several possible options. In the end, the client chooses the best option, concludes an electronic agreement, and makes an online payment. Further, information for the execution of the contract is sent electronically to all participants-executors of the transportation process.

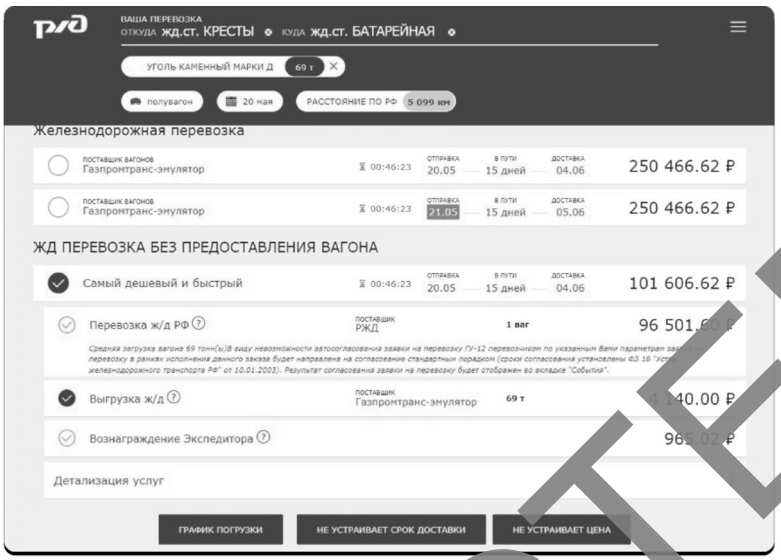

Fig. 2. A visual example of the proposal of the digital ETP FT platform for the shipper. Source: made by author based on [15].

4 Methodology of economic assessment of the effect of the introduction of digital platforms for the integration of freight transport participants

Substantiation of the methodology for assessing the network economic effect in the implementation of digital platforms for interaction between participants in multimodal freight transport.

As a modeled dependent variable, take the following value of the E - the systemic economic effect of joint activities, which is due to the improvement of the properties of the elements that make up the system, due to the interaction of participants in multimodal freight transportation as part of their integration into the digital platform:

$$E = \pm\Delta P_i \pm\Delta C_i, \quad (1)$$

where $\pm\Delta P_i$ – an increase (decrease) in the profit of a system participant (i) due to interaction in the digital exchange network (a change in the state of the parameter after and before joining the platform); $\pm\Delta C_i$ – an increase (decrease) in the costs of a system participant as a result of integration into the digital environment of the platform (a change after and before connection). The value of E is estimated for a specific period of time (year, medium-term period 3-5 years, long-term period).

The magnitude of the E effect consists of the following components (terms of the effect).

$$E = E_1 + E_2 + E_3 + E_4 + E_5, \quad (2)$$

E_1 – the magnitude of the effect for cargo owners participating in the system, achieved due to the convenience of procedures for processing cargo operations, shipping documents, transactions, requests for cargo transportation on the platform in comparison with the traditional design option (connection to the ETRAN automated Control System, as well as directly in the Corporate Transport Service Center). The E_1 parameter also includes the

effect of the cargo owner for processing an application for the provision of a wagon at the same time as the transportation request (integration with the operators of the wagon fleet).

E_1 must be calculated using the following formula 3:

$$E_1 = Q_{sh.goods} * (C_{goods} * \Delta t/365 * r_{BR}/100 + C_{goods}/t_{fc}*\Delta t *R_s/100) + + Q_{sh.goods} * \beta/100 * (C_{wag} * (t_{deliv} + t_{load})) * \lambda + Q_{sh.goods} * (C_{wag} * (t_{deliv} + t_{load}))/t_{car.tun} *\Delta t * R_{op} / 100, \quad (3)$$

where Δt (days) is the saving of time in days due to electronic paperwork and cargo operations in comparison with the situation of non-electronic operations in the interaction of cargo owners with customer transport service units (Corporate Transport Service Center) and cargo owners; r_{BR} is the key rate of the Bank of Russia, %, C_{goods} is the average cost cargo in the car, rubles; t_{fc} is the weighted average value of the duration of the financial cycle of production of goods, the transportation of which to consumers is carried out by rail on average for Russian manufacturing companies; R_s is the weighted average return on sales of Russian manufacturing companies shipping products by rail (%) per year; $Q_{sh.goods}$ is the number of wagons issued through the digital platform (wagonsshipments per year); β is the share (proportion) of orders for the carriage of wagons issued on the site of the digital platform with the order of rolling stock, %, t_{deliv} is the average parameter of the delivery time (from the moment of departure from the departure station to the moment of arrival at the destination station), day; t_{load} is the average parameter of the location of the leased wagon under freight operations, day; C_{wag} – the average rental rate of operators in the market of services for the provision of rental of rolling stock, RUB/day.; λ is a correction factor that estimates the value of the additional beneficial effect of the cargo owner due to the rapid search and registration of wagons on the site of the digital platform (the effect is due to the lack of transactional time spent on searching and registration by the cargo owner of wagons from operators independently); R_{op} is the average level of profitability of operating a wagon fleet by operator companies, %; $t_{car.tun}$ – the average turnover period of the wagon of the operators of the wagon fleet, days.

The value of Δt is estimated as the reduction time from the moment of delivery to the registration of the carriage by the carrier (within the technological time under cargo operations) when switching to cargo operations on a digital platform. Δt is estimated at 6 hours (0.3 days) on average per unit of carriage dispatch.

E_2 is the magnitude of the effect of the cargo owner, as well as the effect of the rolling stock operator, which is generated through the digital service "Bidding for the rental of wagons". The implementation of bidding on the digital platform site leads to covering the shortage of wagons in popular directions – where the need for wagons on the part of cargo owners is the most significant. At the same time, the operator of the carriage fleet receives additional margin due to the rental of wagons at a rate above the average level in the market at a given time, and the cargo owner receives the effect of accelerating the movement of goods, the turnover of funds invested in financing the next delivery of goods.

$$E_2 = (C_{wag} * (t_{deliv} + t_{load})) * Q_{sh.goods} * \beta/100 * (\varepsilon/100) * (k_1 - 1) * R_{op} / 100 + (C_{wag} * (t_{deliv} + t_{load})) * Q_{sh.goods} * \beta/100 * (\sigma/100) * (k_2 - 1) * R_{op} / 100, \quad (4)$$

where ε is the share (proportion) of lots for the rental of wagons sold on the digital platform, exceeding the average rate level above the current market rate level; σ is the share (proportion) of lots for the rental of wagons sold on the digital platform, the level of which is below the average rate level above the current market rate level; k_1 – the average coefficient of excess of rent over the average market rate level; k_2 – the average coefficient of reduction of rent over the average market rate level; R_{op} is the average level of profitability of operating a carriage fleet by operator companies, %.

E_3 is the effect of multimodal transportation participants due to the possibility of a digital multimodal route planning platform, which is achieved by consolidating (centralizing) information about suppliers and customers of a particular transportation. At the same time, carriers receive the effect of a "quick order" - reducing the time to search for customers, reducing transaction costs for processing an application for transportation by issuing a single contract for combined multimodal transportation.

$$E_3 = Q_{sh.goods} * C_{car.wag} * \chi/100 * (P_{multimod} - P_{single})/100, \quad (5)$$

where χ is the specific weight (share) of multimodal transportation issued on the digital platform site, %; $P_{multimod}$ is the marginal profitability of multimodal transportation (the ratio of marginal profit from transportation to the income of a group of transport companies for transportation), %; P_{single} is the marginal profitability of a single shipment of cargo by rail, %; $C_{car.wag}$ – the average rate for carriage of a wagon, RUB/wagon.

E_4 is the effect generated by the proactivity of the data accumulated by the digital platform by increasing the value of the digital system with an increase in the amount of data, as well as the ability for each user to enter data once (once) into the central storage database.

The value of E_4 is derived empirically using the least squares method – this is the effect that the participants of the system receive solely through information access:

$$E_4 = \Theta * (n^2 / 2), \quad (6)$$

where Θ - is the empirical coefficient obtained, which allows us to calculate the magnitude of the effect generated by data proactivity with a certain number of participants (rolling stock operators, carriers, transport and warehouse operators, stevedores, marine line operators); n is the number of participants in the digital platform (connected users).

E_5 – the effect of the digital platform, estimated for the operator (owner) of the digital platform, is generated as the sum of payments made by participants for processing operations for ordering transportation and ordering wagons, as well as ordering wagons based on the results of participation in the "Bidding for the rental of wagons", minus the operating costs of maintaining the functioning of the platform.

$$E_5 = ((C_{car.wag} * Q_{sh.goods}) + C_{wag} * (t_{deliv} + t_{load}) * Q_{sh.goods} * \beta/100) * \varphi/100 - C_{ownerDPl}, \quad (7)$$

where $C_{нер.Bar}$ is the average rate for carriage of a wagon; φ is the remuneration of the owner (operator) of the digital platform, as a% of the cost of organizing transportation (payment of freight charges and provision of a wagon) (currently φ for the operator of the ETP FT – Digital Logistics LLC is 1% of the cost of registration of transportation and fees for the provision of a wagon); $C_{ownerDPl}$ – the costs of the owner (operator) of the digital platform per year related to the operation of the platform, storage and processing of data on the platform, development and maintenance of digital services, per year.

Let's calculate the annual value of the magnitude of the network effect using the example of data from the Electronic trading platform "Freight Transportation" (according to the data of the last reporting year 2023). The initial data for the calculations are shown in Table 1.

Table 1. The values of the initial data of the parameters for the calculation: performance indicators of the ETP FT in 2018-2023.

Indicators	Years					
	2018	2019	2020	2021	2022	2023
The volume of services rendered, billion rubles	2.85	19.00	20.57	21.99	27.36	35.83
Number of users, units	3200	4600	5500	7600	8800	9600
The volume of sent wagons, car shipments	130000	250000	260000	270000	280000	300000
Number of connected service provider companies	22	70	97	125	141	144
including rolling stock operators	19	60	82	109	126	131
carriers	3	3	3	4	4	2
transport and warehouse operators	0	6	3	3	3	3
stevedores	0	3	8	8	8	8
The average rate for carriage of a wagon, RUB/wagon.	47000	49000	51000	52500	63000	67000
The average rental rate for the rental of wagons, RUB/day	1360	1348	1010	1080	1685	2190
Average transportation distance, km	1841	1860	1873	1880	1953	1962
Average speed of transportation by rail, km/day	369.9	372.4	401.5	375	362.3	358
Average delivery time (from the moment of departure from the station t	5.0	5.0	4.7	5.0	5.4	5.5
Average time under cargo operations (technological time), days	6.5	7.1	8.3	7.9	8.1	8.5
The average turnover period of the car of the car park operators, days	15.3	16.1	17.1	16.5	18.0	18.8
Saving time by reducing the waiting time for paperwork, days for 1 shipment	0.3	0.3	0.3	0.3	0.3	0.3
The average cost of cargo in a wagon, RUB.	1987640	2043288	1970953	2698258	2930291	3018200
The key rate of the Bank of Russia, %	7.75	7	4.5	5.5	9.5	16
Weighted average return on sales of Russian manufacturing companies shipping products by rail, %	16.5	15.3	13.6	20.0	19.7	20.2
The share (proportion) of orders for carriage of wagons issued on the site of the digital platform with the order of rolling stock, %	0	0	25	30	30	30
A correction factor estimating the value of the additional beneficial effect of the cargo owner due to the rapid search and registration of wagons on the site of the digital platform, units	0	0	0.02	0.02	0.03	0.03
The average level of profitability of operating a carriage fleet by operator companies, %	16	14	17	10	16.5	15
The weighted average value of the duration of the financial cycle of production of goods transported by rail, days	84.2	73.2	75.6	92.3	65.5	71.2
The share (proportion) of lots for the rental of wagons sold on the site of the digital platform, exceeding the average rate level above the current market rate level, %	0	0	15	23	30	25
The share (proportion) of lots for the rental of wagons sold on the digital platform site, the level of which is below the average level of bids above the current market level, %	0	0	23	20	27	30
The average coefficient of excess of rent over the average market level of rates, units	0	0	1.4	1.5	1.3	1.8
The average rental reduction ratio above the average market rate level, units	0	0	0.7	0.85	0.8	0.7
The specific weight (share) of multimodal (mixed) transportation, issued on the site of the digital platform, %	0	0	2.5	3	4.5	5
Marginal profitability of multimodal (mixed) transportation, %	7.8	3.1	3.7	8.4	9	9.5
Marginal profitability of a single shipment by rail, %	7.6	2.9	3.3	6.9	7.3	7.7
The empirical coefficient obtained, which allows us to isolate the magnitude of the effect generated by the proactivity of data, with a certain number of participants in the digital platform, units	0	0.2	1.2	1.5	1.5	2.5
The costs of the owner (operator) of the digital platform per year related to the operation of the platform, storage and processing of data on the platform, development and maintenance of digital services, rubles	36360000	42723000	72720000	76356000	81810000	90900000
Remuneration of the owner (operator) of the digital platform, as a % of the cost of organizing transportation (payment of freight charges and provision of a wagon)	1	1	1	1	1	1

Source: calculated by the author on the basis of the above-mentioned methodology developed by Digital Logic LLC.

The magnitude of the effect for cargo owners – participants of the system, achieved due to the convenience of procedures for registration of cargo operations, shipping documents, transactions, requests for cargo transportation on the platform:

$$E_1 = (300000*(3018.2*0,3/365*16/100+3018.2/71.2*0,3*20.2/100))+$$

(300000*0.3*(2190*5.5)/1000*0.03)+(300000*(2190*5.5)/18.8*0.3*15/100/1000) = 930903 thousands of rubles = 930.9 million rubles.

The magnitude of the effect of the freight owner and the operator of the rolling stock generated through the implementation of the digital service "Bidding for the rental of wagons":

$$E_2 = (2190*5.5) * 300\,000 * 30/100 * (25/100) * (1.8 - 1) * 15 / 100 + (2190*5.5) * 300\,000 * 30/100 * (30/100) * (0.7 - 1) * 15 / 100 = 17{,}9 \text{ million rubles.}$$

The effect of multimodal transportation participants due to the possibility of a digital multimodal route planning platform, which is achieved by consolidating (centralizing) information about suppliers and customers of a particular transportation.

$$E_3 = 300\,000 * 77000 * 5/100 * (9.5 - 7.7)/100 = 20.8 \text{ million rubles.}$$

The effect generated by the proactivity of the data accumulated by the digital platform by increasing the value of the digital system with an increase in the amount of data:

$$E_4 = 231 \text{ million rubles.}$$

The effect of the digital platform, estimated for the operator (owner) of the digital platform:

$$E_5 = ((77000 * 300\,000) + (2190 * 5.5) * 300\,000 * 30/100) * 1/100 - 90\,900\,000 = 241.84 \text{ million rubles} - 90.9 \text{ million rubles} = 150.94 \text{ million rubles.}$$

5 Conclusion

The proposed methodology for the economic assessment of the network effect of digital platforms for the integration of freight participants made it possible to estimate the increase in net income for each specific participant of the digital platform "Electronic trading platform "Freight Transportation". The monetization of the effect for cargo owners currently connected to the platform due to the convenience of procedures for processing cargo operations, shipping documents, transactions, and requests for cargo transportation on the platform is estimated at 931 million rubles per year. The assessment of the effect of the cargo owner and the rolling stock operator in the implementation of the digital service "Bidding for the rental of wagons" amounted to 18 million rubles. The value of the annual effect due to the possibility of searching, planning and executing mixed (multimodal routes) within the platform is estimated at 21 million rubles. The annual effect generated by the proactivity of the data accumulated by the digital platform of the ETP FT, due to the increase in the value of the digital system with an increase in the amount of data, is estimated at 231 million rubles. For the operator (owner) of the digital platform, the effect of ownership is estimated at 151 million rubles per year.

References

1. Chechenova L. (2022) Artificial intelligence as a basic resource of modern transport infrastructure. In: International Scientific Siberian Transport Forum TransSiberia - 2021. Switzerland, 2022. P. 136-144. DOI: 10.1007/978-3-030-96380-4_16.

2. Chechenova L., Batalova N. (2023) Digitalization of freight rail transportation as a factor in improving their efficiency. In: E3S Web of Conferences, 2023, 460, 06042. DOI: 10.1051/e3sconf/202346006042.
3. Egorov Y. (2022) The evolution of Ramsey pricing in freight rail tariffs. In: International Scientific Siberian Transport Forum TransSiberia - 2021. Switzerland, 2022. P. 83-90. DOI: 10.1007/978-3-030-96380-4_10.
4. Egorov Y. (2023) Assessment of the Impact of the Level of Railway Tariffs on the Evolution of Cargo Supply Chains. In: Lecture Notes on Data Engineering and Communications Technologies, 2023, 157, pp. 35-45. DOI: 10.1007/978-3-031-24434-6_4.
5. Grigoryan M., Bujanova L. (2022) Evaluation of the Effectiveness of Transport Projects from the Position of the Region. In: Lecture Notes in Networks and Systems, 2022, 402 LNNS, pp. 1436–1444. DOI:10.1007/978-3-030-96380-4_159.
6. Marchenko, M.A., Pokrovskaya, O.D., Rodneva, E.S. (2023) Calculation of service devices in the projected traffic-transfer hub. In: E3S Web of Conferences, 2023, 460, 04008. DOI: 10.1051/e3sconf/202346004008.
7. Marchenko M., Pokrovskaya O., Rodneva E. (2023) Methods for calculating and analyzing the capacity of a railway line with mixed traffic. In: E3S Web of Conferences, 2023, 383, 01018. DOI: 10.1051/e3sconf/202338301018.
8. Panyushkina E. (2023) Modern challenges of the digital ecosystem of transport and logistics. In: E3S Web Conf., 2023, 383, 03008. DOI: 10.1051/e3sconf/202338303008.
9. Poliak M., Kubáňová J., Zhuravleva N.A., Jaśkiewicz M., Lakhmetkina N. (2023) Identification of the Impact of Transport Performance on the Economy of Particular Area. In: LOGI - Scientific Journal on Transport and Logistics, 2023, 14(1), pp. 192–202. DOI:10.2478/logi-2023-0018.
10. Vorobiev A., Sivertceva E. (2023) Forecast of the directions of development of international transport corridors on the territory of the Russian Federation under the current restrictions. In: E3S Web of Conferences, 2023, 460, 06039. DOI:10.1051/e3sconf/202346006039.
11. Volkova E. (2022) Development of shared consumption economic forms in urban transportation systems. In: International Scientific Siberian Transport Forum TransSiberia - 2021. Switzerland, 2022. P. 1-9. DOI: 10.1007/978-3-030-96380-4_1.
12. Volkova E. (2023) New Approaches to the Economic Assessment of Transport Projects in the Context of Changing Urban Mobility. In: Lecture Notes on Data Engineering and Communications Technologies, 2023, 157, pp. 59-67. DOI: 10.1007/978-3-031-24434-6_6.
13. Zhuravleva N.A., Kliestik T. (2023) Railway Transport Digitalization: Development Methodology and Effects of Digital Implementation Processes. In: Lecture Notes in Networks and Systems, 2023, 805, pp. 123–146. DOI: 10.1007/978-3-031-46594-9_8.
14. Digital Logistics LLC: official resource [Net resource]. Available by: https://digitalrzd.ru (date of access: 01.04.2024).
15. Electronic trading platform “Freight transportation”