Intellectualization of Transport and Logistics Infrastructure Agents Network Interaction through Adaptive Information and Communication Technologies

Introduction

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Abstract—The etiology of the Russian Federation transport and logistics infrastructure development heterogeneity is caused by the following factors: many of the elements of the system, territorial distribution, nonlocal effects exist. The article describes a methodological approach to assessing the existing potential of intellectualization of transport and logistics infrastructure agents network interaction through adaptive information and communication technologies introduced. The research is based on the study of fundamental and applied research of foreign and domestic authors in the field of implementation of information technologies in transport and logistics processes. The methods of scientific knowledge were applied: comparative, logical, structural-dynamic, statistical-mathematical analysis and synthesis, cartographical method. The characteristic features of the transport and logistics infrastructure development models in the countries of the logistics efficiency rating leaders are identified; the analysis of software in the field of transport and logistics is carried out. The model of transport and logistics infrastructure agents network interaction assessment is offered, the approbation of the model is carried out on the example of the Russian Federation regions. The model has a set of contextual factors that characterize the level of the Russian Federation regions transport and logistics infrastructure efficiency. The most promising areas for bringing about adaptive information and communication technologies are identified. The software products used by Russian operators do not allow them to scale. This complicates the integration of transport systems into a single customer-oriented environment. A ranking of the Russian Federation regions by assessing of transport and logistics infrastructure agents network interaction eventuality will find problems and set promising areas for future research on this topic.

Keywords—transport and logistics infrastructure, network interaction, information and communication technologies, logistics efficiency, intellectualization

I. INTRODUCTION

Modern challenges of economic paradigm development find the need for a technological reboot, which is impossible without the intellectualization of all processes. One of the systems with inertial development is transport and logistics infrastructure.

Transport and logistics infrastructure development intensity requires the development of methodological approaches to its compliance with the model of optimal functioning. Currently, the development of methodological research in the field of transport and logistics processes is focused on the spread of system methods of transport and logistics systems research and adaptation of economic and mathematical modeling methods.

Systematization of methodological approaches to transport and logistics design and characteristics assessment of its effectiveness can make sure the transition to an integrated paradigm of information resources and radical technological innovations development to make a frontal digital transition to a single transport and logistics information space of the Russian Federation.

II. TRANSPORT AND LOGISTICS INFRASTRUCTURE DEVELOPMENT COUNTRY MODELS

The distinctiveness of transnational transport and logistics systems is determined by a number of factors that depend on the chosen strategy of country administrative-territorial divisions' development and the key driver of growth.

The effectiveness of country models of transport and logistics infrastructure development is confirmed by the positions of the analyzed countries in the logistics efficiency rating (Logistics Performance Index). According to the results of 2018, Germany tops the rating, most of the EU countries are among the top ten, China takes 26th position, the Russian Federation – 78 [1].

The weak position of the Russian Federation in the field of logistics development is due to the insufficient use of adaptive information and communication technologies in the organization complex supply chains by transport and logistics infrastructure agents.

The applied information technologies are at the stage of transformation transition to international standards and norms of formation transport and logistics databases and communication systems and characterized by locality, heterogeneity, low level of adaptability and order. This affects the ability to obtain a synergetic effect from the organization of network interaction by transport and logistics infrastructure agents [2].

Table 1 presents an analysis of transport and logistics infrastructure development country models [3 – 5].
TABLE I. TRANSPORT AND LOGISTICS INFRASTRUCTURE DEVELOPMENT COUNTRY MODELS

<table>
<thead>
<tr>
<th>The Model Name</th>
<th>Country</th>
<th>Key Driver of Growth</th>
<th>Features of the Model</th>
<th>Effectiveness</th>
</tr>
</thead>
</table>
| Eurologistics model | European Union    | The principle of integration of different modes of transport in a multimodal transport network through the creation of effective systems of engineering, communication and information support | - the creation of a pan-European system of goods movement, which provides for the exits of several European reference logistics centers and interacting regional logistics transport and distribution centers;  
- improvement of customs inspection rules, registration, and control of goods and vehicles;  
- involvement of large freight forwarding companies specializing in the delivery of goods with the use of transportation process organization information network and terminal technologies;  
- formation of databases and communication systems of logistics, the introduction of new software products that allow remote control of material flows of warehouse information systems, remote monitoring and quality control of activities in various parts of the logistics chain;  
- the functioning of large transport and logistics companies with an extensive network of offices, warehouses, terminals, complexes throughout the European region and beyond and the creation of global associations. | For example, in the Netherlands, transport and logistics complex activity brings 40% of the income from services export in general, in France – 31%, in Germany – 25%. In Central and Eastern Europe, the average share is 30 %. The total turnover of the European market for logistics services reaches more than 600 billion euros. At the present stage, the European logistics system is equipped with transport and logistics infrastructure objects. |
| German model    | Germany           | Digitalization of transport and logistics processes by strengthening state support. | - digitalization of transport infrastructure and logistics chains (warehouses, logistics centres, railways, etc.));  
- robotization of production;  
- automation of control systems;  
- autopilot systems;  
- strengthening of state support at all levels (allocation of subsidies to the Federal lands budgets, targeted subsidies, and loans)  
- management of transport and logistics centers through special supervisory bodies created by investors (municipalities, investment consortiums, specialized associations, and unions). | Leading positions in international ratings of transport and logistics efficiency.                                                                                                                                                                                                                                                                                                                                                       |
| Chinese model   | China             | Strengthening of foreign integration into the Chinese transport and logistics market. | - creation of free trade zones, where the main activity is logistics and financial services provision;  
- promotion of foreign investment in logistics through special law conditions creation;  
- admission to the transport and logistics market of foreign agents with experience in international trade, international freight transport or practice as an agent for these transportations, as well as the necessary technologies available for activities implementation;  
- create "logistics rings” spatial spanning of the Western and Central country regions;  
- introduction of advanced information technologies in the process of logistics management and increasing the level of automation and logistics operations informatization, a range of new information logistics services development, modern technology use. | Foreign integration into transport and logistics infrastructure encourages highly specialized local operators to develop to increase competitiveness to the level of foreign companies.                                                                                               |
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III. OVERVIEW OF TRANSPORT AND LOGISTICS SOFTWARE

In the eurologistics system, the 5 largest transport and logistics companies cover about 10% of the market, while the 5 largest Russian operators occupy only 5% of the market; the total volume of the transport and logistics segment in Europe is estimated at $ 600 billion, and in the Russian Federation – $ 50 billion. Integration of transport and logistics processes through adaptive ICT introduction allows European companies to cover a wider range of services, strengthen control over the entire supply chain management, while Russian companies focus on limited services related to transportation or warehousing (table 2). [4 – 5].

Table 2 provides an overview of the transport and logistics software.

<table>
<thead>
<tr>
<th>Name</th>
<th>Country</th>
<th>Characteristic</th>
</tr>
</thead>
<tbody>
<tr>
<td>«Vybor-Group»</td>
<td>Russia</td>
<td>The program of optimal placement of cargo in the container of the company.</td>
</tr>
<tr>
<td>TruckLoader</td>
<td></td>
<td>The program for calculating the ideal scheme of cargo placement is designed for use by small and medium-sized enterprises.</td>
</tr>
<tr>
<td>Packer3d</td>
<td></td>
<td>The program is designed to calculate the ideal stacking set of different types of boxes on pallets of standard sizes, formed for different types of vehicles (trucks, wagons, containers and platforms, each type of vehicle is described by its own set of parameters).</td>
</tr>
<tr>
<td>TopLogistic</td>
<td></td>
<td>The program for transportation management, allowing you to create optimal routes for the delivery of goods. Creation of routes takes place taking into account delivery addresses, time intervals and other parameters within the settlement.</td>
</tr>
<tr>
<td>IC-Rarus: Transport logistics and freight forwarding</td>
<td></td>
<td>A program is used to manage transportation in enterprises and various companies. The main function is freight orders management, the organization of work with third-party carriers, choice of contractors, etc.</td>
</tr>
<tr>
<td>Megalogist</td>
<td></td>
<td>The program on the 1C platform for integrated automation of transport logistics allows you to create tasks for transportation, plan routes manually and automatically, check flights online implementation, analyze the KPI and profitability of delivery.</td>
</tr>
<tr>
<td>ABM Rinkai TMS</td>
<td></td>
<td>A program is designed to build optimal transport routes, allowing to take into account all the limitations and factors, as well as to use only the necessary transport.</td>
</tr>
<tr>
<td>Gruzoplan</td>
<td></td>
<td>The program for maintaining a secure document flow for goods transportation helps to organize the systematical processing of applications and their transparent support to the destination.</td>
</tr>
<tr>
<td>NovaTrans</td>
<td></td>
<td>Service for automation of all transport company processes. It allows you to create and check applications, conduct acts, generate reports.</td>
</tr>
<tr>
<td>matCONTR OL</td>
<td>Germany</td>
<td>The program combines the computer system of cargo flow management and warehouse management system matWMS with the system of material resources planning based on the SAP software package.</td>
</tr>
<tr>
<td>«UniWare»</td>
<td></td>
<td>A version of the computer control system of transport and warehouse works. The technical basis of the system consists of portable and mobile terminals combine a wireless system for data exchange.</td>
</tr>
<tr>
<td>«Process-Management System» (PMS)</td>
<td></td>
<td>Computer storage and storage system consists of a number of software modules. PMS-W module is designed to manage high-rack warehouses and automatic warehouses of small piece cargoes. The PMS-E module is designed to manage energy supply and to reduce energy costs.</td>
</tr>
<tr>
<td>Gonrand</td>
<td>France</td>
<td>All information about the goods is entered into the database and continuously enters the system in real-time. The system groups load by senders, recipients, number of seats and provide information about the departure of the rolling stock, the name of the consignee, the number of</td>
</tr>
</tbody>
</table>
The system provides forwards with information on goods availability, types of vehicles, routes of the most efficient traffic, addresses of transport companies with free-rolling stock, and other information. The system provides carriers with information on loading vehicles possibility with cargo, addresses of senders, place and time of loading, time of arrival of rolling stock with cargo, addresses of recipients and other details.

The system is designed to give information services to Belgian transport companies, which can get a fact sheet and enter their own information on the vehicles or goods available for delivery.

The system allows the shipper to contact the information system. The company, which owns the information system, guarantees the carriers to pay for the delivery of the goods even if the customer has not made prompt payment for transportation.

The software products used by Russian operators do not allow them to scale. This makes it impossible to integrate all transport systems into a single client-oriented environment because the software products are implemented on different platforms and equipped with different databases. A common feature of transport and logistics systems of developed European markets is the focus on modernization through the modern information technologies introduction and the range of IT-services expansion [6 – 7].

For the Russian economy, the use of adaptive information and communication technologies in the transport and logistics sector should lead to the Russian Federation transit potential realization, will offer competitive advantages in the markets of the future.

IV. MODEL OF TRANSPORT AND LOGISTICS INFRASTRUCTURE AGENTS NETWORK INTERACTION EVENTUALITY ASSESSMENT

The model of transport and logistics infrastructure agents’ network interaction assessment implies a stages sequence:

- the first stage, identification of the model - determination of the transport and logistics infrastructure agents network interaction assessment quantitative and qualitative indicators;
- the second stage, verification of the model - establishment of the constructed model adequacy to the simulated system.

For the first stage implementation, the indicators were systematized, allowing for an integrated assessment of the Russian Federation transport and logistics infrastructure agents network interaction implementing possibility. The indicators were divided into 4 groups, each of which forms the sum parameter evaluation content. [8 – 10].

The model contains a set of contextual factors that can explain the levels of Russian regions transport and logistics infrastructure efficiency. To show the structural content and cause-effect relationships between the last integral indicator (K) and the total parameters (K1, K2, K3, and K4) of the model, the Ishikawa diagram is used (Fig. 1, Table 3).

![Fig.1 Structure of the model for assessing transport and logistics infrastructure agents’ network interaction eventuality](image-url)
The result of this study is to substantiate the total parameters (K1, K2, K3, K4) composition, taking into account the Russian specifics of the available databases and processing information resources possibility.

The problems that arise in the processing of statistical information that characterizes the state of transport and logistics infrastructure in the Russian regions include:

- lack of indicator values for some entities and availability of this information for others;
- the lack of retrospective information, which makes it difficult to build an integral indicator in the dynamics;
- availability of a limited number of indicators suitable for the purposes of this study;
- updating of databases at long intervals, which makes it difficult to update the results of the analysis.

Taking into account the above limitations, the proposed integral indicator composition is considered the ideal and the most comparable for the purposes of this study (Table 3).

### Table III. Characteristics of Transport and Logistics Infrastructure Agents Network Interaction Indicators Assessment

<table>
<thead>
<tr>
<th>№</th>
<th>The Contents of the Aggregate Parameter</th>
<th>Composition</th>
<th>Characteristics of Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>K1 - Process intellectualization ability</td>
<td>Information and communication technologies at the disposal of companies in monetary terms; Investments in fixed capital in the part of information and communication technologies; The proportion of the population using the Internet to order goods and services in the total; Share of organizations (in the total number of organizations in the business sector) using cloud services.</td>
<td>Reflects information and communication technologies on the balance sheet of companies and their development. Reflects companies’ activity in the creation and acquisition of innovative products. Shows the population share interested in the intellectualization of transport and logistics services. It characterizes the organizations' involvement in the Internet environment and the potential to equip information and communication technologies that need access to the network. Indicates whether data can be accessed remotely and optimized for storage and use.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The degree of transport organizations fixed assets depreciation; Amount of fixed assets in monetary terms; Balanced financial result (profit minus the loss); Freight; Investments in fixed assets: buildings and structures; Investments in fixed assets: vehicles; Fixed capital investment: machinery and equipment.</td>
<td>Characterizes the degree of reduction of the serviceability. Shows the level of technical equipment of companies. Reflects the level of performance of transport and logistics infrastructure companies in monetary terms. Reflects the natural volume of services provided by companies. Characterizes the level of long-term investments in buildings and structures at the disposal of companies: Characterizes the level of long-term investments in the part of vehicles: Characterizes the level of long-term investments in machinery and equipment (not including transportation means).</td>
</tr>
<tr>
<td></td>
<td>K5 - Economic efficiency</td>
<td>Number of enterprises and organizations by type of activity “Transportation and storage”; Share of profitable organizations; Share of loss-making organizations; Indices of tariffs for freight transport.</td>
<td>Characterizes the level of involvement in this type of activity and the number of transport and logistics infrastructure agents; Indicates share successful working companies; Reflects the relative weight inefficiently working companies; Characterizes the level of tariffs for transportation.</td>
</tr>
</tbody>
</table>
The integral index calculation was carried out by the maximum-minimum method according to the formulas (1-4) [1]:

$$Z_j = \frac{x_j - x_{\text{am}}}{x_{\text{max}} - x_{\text{am}}}$$  \hspace{1cm} (1)

The inverse formula (2) was used to estimate the private indicators, the increase in the value of which is negative (for example, "The degree of transport organizations fixed assets depreciation "):  

$$Z_j = \frac{x_{\text{am}} - x_j}{x_{\text{max}} - x_{\text{am}}}$$  \hspace{1cm} (2)

The total value for each group was calculated by the formula (3):  

$$K = \sum_{j=1}^{n} Z_j$$  \hspace{1cm} (3)

The integral indicator of transport and logistics infrastructure agents’ network interaction eventuality is the sum of the total values for each group of the selected parameters (4):  

$$K = \sum_{j=1}^{n} K_j$$  \hspace{1cm} (4)

The advantage of this calculating the integral index method is the minimum and maximum values equalization for all private indicators that have a certain meaningful sense, to cut differences in the spread of values.

The last stage of the assessment is the Russian Federation regions classification to a certain class and promising areas identification for adaptive information and communication technologies introduction. To assess parameter K1 (intellectualization of transport and logistics processes and innovative activity of subjects) contribution to the last integral indicator, compose the estimated parameters and their significance are taken into account with the help of special scales in which four zones are distinguished:

- critical zone (marked in pale pink) - the real state of the transport and logistics infrastructure of the regions of this zone does not allow to realize network interaction between transport and logistics agents through adaptive information and communication technologies introduction;
- unfavorable zone (marked in pink) - the real state of the transport and logistics infrastructure of the regions of this zone is characterized by average values of the analyzed indicators and insufficient potential for technological improvement;
- normal zone (indicated in orange) - the real state of the transport and logistics infrastructure of the regions of this zone is characterized by values of the analyzed indicators above the average, which reflects enough potential for transport and logistics infrastructure agents network interaction implementation;
- optimal zone (marked in brown) - the regions of this zone have a high potential for transport and logistics infrastructure agents network interaction implementation through the adaptive information and communication technologies introduction.

The evaluation scales of the integral indicator and its components are presented in table 4. In order to expand the use of this study results, zoning of the Russian Federation territory was carried out to organize transport and logistics infrastructure agents network interaction. The graphical display is shown in figure 2.

### Table IV. Evaluation Scales of the Integral Index and its Components

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Number of estimated indicators</th>
<th>Max score</th>
<th>Optimal zone (over 70%)</th>
<th>Normal zone (50 to 70%)</th>
<th>Adverse zone (30 to 50%)</th>
<th>Critical zone (below 30%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>K1</td>
<td>5</td>
<td>5</td>
<td>Over 3,501 – 2,501</td>
<td>1,501 – 2,5</td>
<td>Below 1,5</td>
<td></td>
</tr>
<tr>
<td>K2</td>
<td>7</td>
<td>7</td>
<td>Over 4,901 – 3,501</td>
<td>2,101 – 3,5</td>
<td>Below 2,1</td>
<td></td>
</tr>
<tr>
<td>K3</td>
<td>7</td>
<td>7</td>
<td>Over 4,901 – 3,501</td>
<td>2,101 – 3,5</td>
<td>Below 2,1</td>
<td></td>
</tr>
<tr>
<td>K4</td>
<td>11</td>
<td>3</td>
<td>Over 1,501 – 1,501</td>
<td>0,901 – 1,5</td>
<td>Below 0,9</td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>30</td>
<td>22</td>
<td>Over 15,401 – 11,001</td>
<td>6,601 – 15,4</td>
<td>Below 6,6</td>
<td></td>
</tr>
</tbody>
</table>
Fig.2 The cartogram of the Russian Federation territory zoning on the value of the integral indicator.

V. CONCLUSION

The ranking of the Russian Federation regions on the integral indicator allows defining the level of transport and logistics infrastructure agents’ activities intellectualization, the potential use, to assess the state of this sphere and the degree of network interaction organization eventuality.

Users of the model for assessing transport and logistics infrastructure agents’ network interaction eventuality can be agents of this industry, as well as public and regional authorities. The task of finding new, promising areas for expanding the range of services provided, increasing production capacity, updating the database of contractors for further cooperation and strengthening the geographical presence is relevant for the first group of users. State authorities solve the problem of choosing regions that have objective grounds to become participants in strategic development programs. The task of identifying potential drivers of economic growth in the region is important for regional authorities.

Application of the transport and logistics infrastructure agents network interaction evaluation model will allow on the basis of the current state to assess the level of actual implementation of the Russian Federation regions transport and logistics production and innovative potential and to use the results of the assessment in investment justifying areas, assessing the effectiveness of the region development strategy, strategic development programs preparation.

Thus, the intellectualization of the Russian Federation transport and logistics infrastructure and architecture restructuring will increase the demand for complex information and communication products. Their use will accelerate technological transformation in non-industrial sectors such as transport and logistics.

Transport and logistics system of the Russian Federation is a critical infrastructure that has reached the limit of productivity. It is a great challenge for the state and society. Some agents already actively use some current developments in the field of automated transport systems. However, at the same time, there is global systems evolution retardation, as their further development requires a single information space creation.

REFERENCES