https://doi.org/10.33271/nvngu/2023-4/130

Aigul Tilemissova[1],
orcid.org/0000-0001-9171-5180,
Dmytro Kozachenko[*2],
orcid.org/0000-0003-2611-1350,
Roman Vernyhora[2],
orcid.org/0000-0001-7618-4617,
Maral Izteleuova[3],
orcid.org/0000-0002-7631-5223,
Muratbek Arpabekov[4],
orcid.org/0000-0002-7998-2507

1 – Academy of Logistics and Transport, Almaty, the Republic of Kazakhstan
2 – Ukrainian State University of Science and Technologies, Dnipro, Ukraine
3 – Almaty management university, Almaty, the Republic of Kazakhstan
4 – L. Gumilyov Eurasian National University, Astana, the Republic of Kazakhstan
* Corresponding author e-mail: dmytro.kozachenko@outlook.com

COMPETITIVENESS ASSESSMENT OF THE RAILWAY NETWORK OF KAZAKHSTAN IN THE PERFORMANCE OF TRANSIT CONTAINER TRANSPORTATION

Purpose. To improve the methods for assessing the routes of transportation of containers by transit railway administrations.

Methodology. The results of the presented scientific research were obtained on the basis of general methods of cognition such as abstract-logical analysis, systematization, the method of theoretical generalization, as well as on the basis of special methods of economic and mathematical modeling, the theory of railway operation and transport geography.

Findings. In the course of the study, an analysis was made of the transport network of the Eurasian continent as a whole and the railway transport network of Kazakhstan, as part of it, in particular. An assessment was made of the socio-economic development of the regions, transportation between which can potentially be carried out through the territory of Kazakhstan. Indicators of the duration and cost of shipping containers by sea and rail between East Asia and Europe have been established. An assessment of the competitiveness of container transportation routes passing through the territory of Kazakhstan in comparison with alternative routes was made.

Originality. In this paper, the method for estimating the routes of transportation of containers by transit railway administrations has been improved. Unlike existing methods, the assessment of the duration of transportation is carried out throughout the entire length of transportation "from door to door". Also, the paper proposes to evaluate the effectiveness of railway routes, taking into account the service of the entire territory through which they pass, and not just the starting and ending points.

Practical value. The results of the research allow railway administrations to improve the efficiency of planning the development of transit container traffic on different routes. The regions for which the railways of Kazakhstan can compete with maritime transport both in terms of price and in terms of the speed of transportation for the entire container traffic, as well as regions for which competition can be carried out only for the market share of transportation in containers of valuable and perishable goods, have been established.

Keywords: *international transportation, railway transport, container, competition, route selection*

Introduction. The development of international trade is inextricably linked to the availability of reliable transport systems. Moreover, with the development of globalization, transport system services are one of the most important exports and form a significant share of the budget of individual countries. One of the main directions of international trade is East Asia – Europe in general and China – the European Union in particular. In 2021, the volume of trade between China and the EU countries reached 828.1 billion USD. One of the main cargoes that are transported in this direction is containers. In the period from 1995 to 2020, the volume of cargo transportation in containers in the direction of East Asia – Europe increased by 5.5 times. The main volume of cargo transportation on this route falls on maritime transport. The main volume of cargo transportation on this route falls on maritime transport. The duration of delivery of goods by sea from East Asia to Europe is on average 30–35 days. In this regard, in the last decade, overland, primarily railway, transportation routes have been actively developed. Geographically, the Republic of Kazakhstan is located at the crossroads of land routes from East Asia to Western Europe. In this regard, the study of issues of improving the logistics of container transportation through the Republic of Kazakhstan is a practically significant task.

Literature review. In modern conditions, an essential feature of international relations is globalization, which is an integration process in various fields of activity both at the interstate, and at the state and regional levels. Globalization processes lead to a change in the geography of transport and economic relations both in separate regions and in the world as a whole [1]. They cause changes in the requirements for the transport industry that provides international trade, as well as an increase in the level of competition between individual modes of transport and transport systems of different countries. One of the most dynamically developing sectors of the transportation market is container transportation between East Asia and Europe. The change in traffic volumes in this direction is shown in Fig. 1.

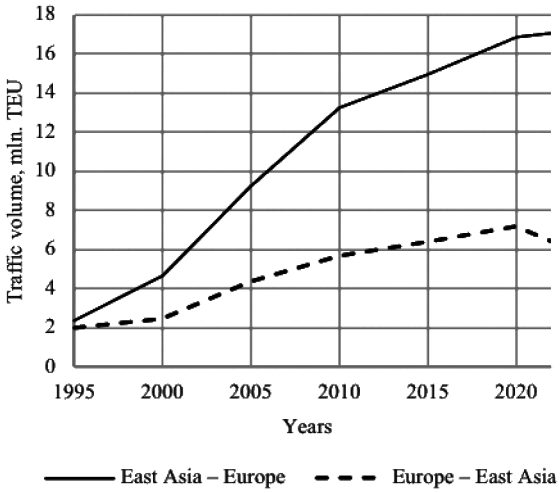

Fig. 1. Dynamics of container flows between East Asia and Europe

The main modes of transport that provide transportation of containers on the route East Asia – Europe are sea, air and rail [2]. A significant amount of scientific research is devoted to the study of existing and promising routes for container flows. Here are the main routes:

- Southern Sea Route through the Suez Canal;
- Northern Sea Route;
- sea route around the Cape of Good Hope;
- railway routes;
- aviation routes.

To compare the characteristics of these routes, various indicators are used. The main ones are the volumes of transportation, cost and delivery time. In addition, studies evaluate CO_2 emissions, safety, reliability of delivery, etc. Estimation of the cost of transporting containers on the China-European Union route is presented in Table 1 and the time spent on transportation in Table.

Tables 1 and 2 data analysis shows that air transport significantly exceeds sea and rail transport in terms of speed, but has a much higher cost of transportation. In this regard, air transportation occupies a separate market niche from sea and rail transport. The share of air transport in the transportation of containers from China to the EU is about 0.5 %. In this regard our paper does not consider air transport further when comparing the logistics routes for the delivery of containers. A comparison of sea and rail transport shows that sea transport is two to three times cheaper than rail transport, but the duration of transportation that it provides is two to three times longer. It should be noted that time and cost indicators of sea and rail transport routes are usually indicated between existing logistics hubs oriented to sea transport. When evaluating door-to-door routes, these indicators can change significantly. Such research results are presented in the paper of Pomfret [7], where the destinations are:

- one of the largest European ports of Rotterdam;
- medium-sized seaport Gdynia;
- a large landlocked city, Warsaw.

The results presented in [7] show that the difference in the cost of transporting goods to Warsaw using sea transport is only 11 % lower compared to rail transport. At the same time, it should be noted that, as a rule, large cities of the European Union have good communication with ports [10]. Under such conditions, sea transport is and will remain the main carrier of goods from East Asia to the European Union. It accounts for about 96–98 % of container traffic in this direction.

The problems of sea transport are related to the lag in the development of its carrying capacity from the growth rate of traffic volumes. Studies performed by Pan, et al. [11] show that the main limitation on the route of the Southern Sea Route is the capacity of the Suez Canal. Alternative routes of the Southern Sea Route are the route around the Cape of Good Hope and the Northern Sea Route. A comparison of these routes is given in Vukic & Cerban [12]. In accordance with the comparison made, the Southern Sea Route will be a priority for the delivery of containers with fairly significant fluctuations in transportation condition. Studies presented in Du, et al. [13] indicate that the cost of passing ships through the Suez Canal is set based on the cost and other conditions for allowing ships to pass on alternative routes. In such conditions, given the unlimited capacity of the route around the Cape of Good Hope, the exhaustion of the capacity of the Suez Canal will significantly affect the increase in the duration of the journey and less on the cost of transportation. Musso & Sciomachen [14] considered the problem of building container ships with a carrying capacity of more than 20,000 TEU. An increase in the carrying capacity of container ships will, to some extent, solve the problem of the capacity of the Suez Canal. At the same time, an increase in the carrying capacity of ships will affect the time of accumulation of ship consignments in the ports of departure, as well as waiting and downtime in anticipation of the removal of containers in the ports of destination. These factors will also worsen the temporal performance of shipping containers. Therefore, in the short and medium term, the change in the cost of sea transport will occur under the influence of general economic factors and competition between maritime carriers. The fluctuations in the cost of sea transport will be small compared to the difference in the cost of sea and rail transport. At the same time, with an increase in transportation volumes, one can expect an increase in the duration of delivery of goods by sea.

Railway communication between East Asia and Europe is carried out in the following main directions:

- Manchurian route: China – Russia-Belarus – EU;
- Mongolian route: China – Mongolia – Russia – Belarus – EU;
- Trans-Asian Railway: China – Kazakhstan – Russia – Belarus – EU and China – Kazakhstan – Uzbekistan – Turkmenistan – Iran – Turkey – EU;

Table 1

Shipping costs for containers on the China-European Union route

Source	year	Transport mode		
		sea	rail	air
Bucsky [3]	2019	1500–2500 USD/TEU	5000 USD/TEU	24,000–36,000 USD/TEU
Li, et al. [4]	2019	11532,8 CNY/TEU	31840,4 CNY/TEU	–
Ţical & Grajdeanu [5]	2020	1072 EUR/TEU	5000 EUR/TEU	3,3 EUR/kg
Zhang & Schramm [6]	2020	2410 USD/FEU	6,350 USD/FEU	32490 USD/FEU
Pomfret [7]	2021	2200–4500 USD/TEU	4500–5000 USD/TEU	37000 USD/TEU

Table 2

Duration of transportation of containers on the route China-European Union, days

Source	year	Transport mode		
		sea	rail	Air
Li, et al. [4]	2019	38,71	17,43	–
Zhang & Schramm [6]	2020	30	16	4
Pomfret [7]	2021	27–50	15–19	5–9
Neumann [8]	2021	45	12	–
Bersenev, et al. [9]	2020	36–48	12–16	–

- Trans-Caspian route: China – Kazakhstan – Azerbaijan – Georgia – Turkey – EU.

The key transit countries, through whose territory four of the six main container transportation routes between East Asia and Europe pass, are Kazakhstan, as well as Russia and Belarus.

A significant push in the development of international rail traffic is associated with the Belt and Road Initiative, a global strategic infrastructure development program adopted by the Chinese government in 2013. A significant amount of scientific research is associated with this program. In particular, a comparison of railway routes connecting China with Europe was made in the works of Bucsky [3], Bersenev, et al. [9]. An assessment of the economic efficiency of railway routes is presented in the work of Zhang & Schramm [6]. A detailed analysis of the cost of transporting various types of cargo between the main logistics centres is presented in the work of Lasserre, et al. [15]. An assessment of the prospects for the development of the "New Silk Route" based on the Southern Corridor of the Trans-Asian Railway was made in the work of Wagener, et al. [16].

The development of the Eurasian railway routes will have an impact not only on the directions of international trade, but also on the conditions for the functioning of national transport systems and transport systems associated with the main routes of the transcontinental network. Such studies are given, for example, in the works of Shi [17] for the conditions of China, Stopyra, et al. [18] for the conditions of Poland, Kukeyeva for the conditions of Kazakhstan [19], Shariatinia & Azizi for the conditions of Iran [20].

A variety of mathematical methods are used to study the problems of organizing container flows. One of the main tasks that are considered in this case is the problem of choosing the route for transporting containers. An example of solving such a problem, taking into account the indicators of the cost of transportation, delivery time, safety, environmental friendliness, is presented in the work of Wen, et al. [21]. To assess the parameters of the routes, the methods of economic and mathematical modelling were used in the paper. The presence of parallel transportation routes causes competition for cargo flows between carriers and owners of transport infrastructure. The study of these problems is carried out by the methods of game theory. In the work of Chen, et al. [22], the problem of competition between carriers for consignors was studied using game theory methods, and in the work of Kozachenko, et al. [23], the problem of competition between railway infrastructure operators for freight traffic was studied.

The analysis of scientific works on the organization of container transportation in the direction of East Asia – Europe shows that they tend to grow. At the same time, the volume of container transportation by rail will increase. At the same time, the main attention of researchers is concentrated on the two poles of the routes – China and Western Europe. This approach is acceptable in the analysis of sea and air transportation. At the same time, when organizing rail transportation, the active participants in the transportation process are the operators of the railway infrastructure and locomotive traction that serve transportation [24], as well as the states through whose territory the routes pass. In addition, the railway infrastructure is oriented towards serving the entire territory, through which it passes, and not just the starting and ending points. In this regard, methods for assessing the effectiveness of container rail transport from the perspective of transit railway administrations require improvement.

Purpose. The purpose of the paper is to improve the methods for assessing the routes of transportation of containers by transit railway administrations.

Methods. The results of the presented scientific research were obtained on the basis of general methods of cognition such as abstract-logical analysis, systematization, the method of theoretical generalization, as well as on the basis of special methods of economic and mathematical modeling, the theory of railway operation and transport geography.

Results. The main container flows in the East Asia-Europe direction are formed in China and follow to Western Europe (Fig. 1). In this regard, the study conventionally assumed that the point of origin of container flows is China. A 20-foot container (TEU) is accepted as a unit of container flow. Delivery of containers on routes between Asia and Europe is currently predominantly carried out by sea; while rail transportation is considered as an alternative technology. The main transit railway administrations on the route from China to Europe are Kazakhstan Temir Zholy (KTZ), Russian Railways (RZD) and Belarusian Railways (BCh). The dynamics of the volumes of container transit traffic by these railway administrations is shown in Fig. 2.

Analysis of Fig. 2 shows that the geographical location significantly affects the volume of container flows. European Union sanctions imposed in 2022 led to a sharp decline in RZD and BCh traffic, while KTZ traffic continues to grow. This is due to the unique position of Kazakhstan in the centre of Eurasia, which ensures the variability of transport routes passing through its territory.

The scheme of the main routes for container trains through the territory of Kazakhstan is shown in Fig. 3.

The distance of transportation of containers across the territory of Kazakhstan for various routes is: Alashankou – Petropavlovsk – 1.9 thousand km; Alashankou – Kartaly-1 – 2.2 thousand km; Alashankou/Khorgos – Iletsk-1 – 2.7 thousand km; Alashankou/Khorgos – Ozinki – 3.1 thousand km; Alashankou/Khorgos – Aktau – 3.1 thousand km; Alashankou/Khorgos – Keles – 1.8 thousand km.

Dynamics of volumes of transportation of containers by railway transport of Kazakhstan in various directions is presented in Fig. 4.

In Kazakhstan, when transporting containers by rail, the following standard speeds are established: container shipment – 180 km/day; wagon shipment – 330 km/day; route dispatch 550 km/day; the speed of container trains is 1050 km/day. The actual speed of container trains is 1083–1152 km/day.

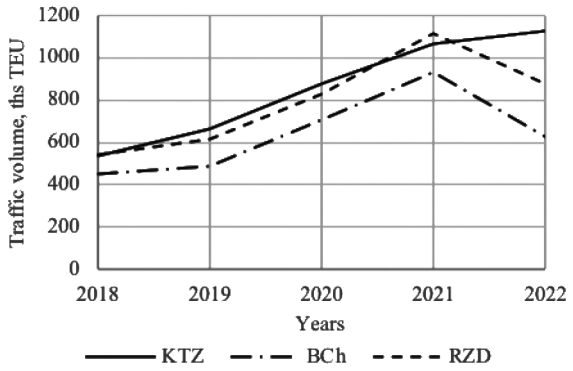

Fig. 2. Dynamics of railway transportation of containers for 2018–2022

Fig. 3. Scheme of the main routes for container trains through the territory of Kazakhstan

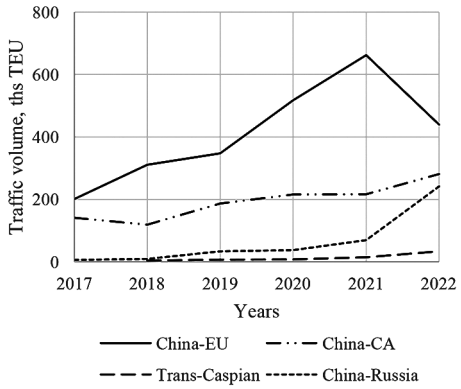

Fig. 4. Dynamics of container transportation volumes by destinations

When transporting goods in international traffic, the speed of their delivery is set in accordance with the "Agreement on International Rail Freight Traffic" and is 150 km/day for container shipments and 200 km/day for other shipments. At the same time, 1 day is additionally taken into account for departure and for 2 days separately for each reloading of cargo into wagons of a different gauge, for each rearrangement of wagons to bogies of a different gauge, as well as for transportation in direct international rail-ferry traffic.

As points of origin and repayment of container flows passing through Kazakhstan, the following regions can be considered: China, Western Europe, Russia and Belarus, Iran and Central Asia, Turkey and the Caucasus.

Characteristics of the regions, transportation of containers between which are carried out through Kazakhstan, are presented in Table 3.

Analysis of the data given in Table 3 shows that the main volume of production and consumption of goods transported in transit through Kazakhstan is located at different ends of the Eurasian transport corridors in Western Europe and China, where 84 % of the population and 91 % of GDP are concentrated. Other regions are characterized by both significantly lower GDP and population.

In order to assess the distances of transportation between the regions of departure and destination of containers, an analysis of the transport networks of Eurasia was carried out. The analysis shows that the main part of China's production is concentrated in regions with good access to seaports. The bulk of China's population is also concentrated in these regions. Land crossings in China are located at a considerable distance from the main points of production and consumption of products. Western Europe has a significant coastline with a high density of seaports. At the same time, the main direction of sea transportation between Europe and Asia passes along the route through the Suez Canal. The countries of Western Europe have several railway crossings connecting them with countries to the east. This study considers the following crossings: Kapıkule/Svilengrad (Turkey/Bulgaria), Brest/Małaszewicze (Belarus/Poland) and Buslovskaya/Vainikkalan (Russia/Finland). Joint transportation across the territory of Ukraine and Russia was not considered in this study. Transportation between China on the one hand and Russia and Belarus on the other is possible by sea using the Baltic, Black Sea and Pacific ports of Russia. Ports of the Arctic Ocean were not considered in the study due to the significant seasonality of traffic. It is also possible to transport by rail using routes through Kazakhstan and the alternative Manchurian and Mongolian routes. Transportation of containers to Armenia and Azerbaijan is possible through the Black Sea ports of Georgia, as well as by rail through Kazakhstan using the Aktau-Baku ferry across the Caspian. Transportation of containers to Iran, Turkmenistan and Uzbekistan is possible by sea through the ports of Iran in the Persian Gulf, as well as by rail through Kazakhstan with their transfer through the border crossing with Uzbekistan Saryagash/Keles. Transportation of containers to Turkey is possible using sea transport mainly through the ports of the Mediterranean Sea, as well as by rail through the border crossings of Akhalkalaki-Kars (Georgia/Turkey) and Razi-Kapikoy (Iran/Turkey).

Table 3

Characteristics of the regions, transportation of containers to which is carried out through Kazakhstan

Region		Population, million people	GDP, billion USD
China	Northwestern (NWC)	103.5	1032
	Southwestern (SWC)	204.9	2010
	Central (MC)	410.8	4875
	Northeastern (NEC)	97.3	849
	Eastern (EC)	425.2	6783
	Northern (NC)	168.9	2185
	Total	1410.6	17734
Western Europe	Western (WEU)	198.4	10207
	Southern (SEU)	127.4	4009
	Northern (NEU)	27.1	1813
	Eastern (EEU)	115.7	2020
	Total	468.6	18049
Russia. Belarus	Central (CR)	40.2	610.9
	Northwestern (NWR)	13.9	243.5
	Southern (SR)	16.6	116.5
	North Caucasian (NCR)	10.2	39.5
	Volga (PR)	28.7	247.4
	Ural (UR)	12.3	244.7
	Siberian (SBR)	16.6	165.4
	Far Eastern (FER)	7.9	108.1
	Belarus (BY)	9.3	68.1
	Total	155.7	1844
Iran. CA	Iran	81	636
	Uzbekistan	33	92
	Turkmenistan	6.2	41
	Total	120.2	769
Turkey. Caucasus	Turkey	84.7	761
	Azerbaijan	10	47
	Georgia	3.7	18
	Total	98.4	826

Based on the studies performed, the average distances of sea transportation between ports, the average distances of transportation by land transport to seaports, as well as the average distances of rail transportation through Kazakhstan and alternative distances of rail transportation bypassing Kazakhstan were established. The specified distances are given respectively in Tables 4–7.

In addition to the distances specified in the Table 6, when transporting containers to Azerbaijan, Georgia and Turkey, 0.5 thousand km is taken into account for transporting containers by ferry across the Caspian Sea.

The evaluation of the competitiveness of container transportation routes passing through the territory of Kazakhstan was carried out according to the criteria of the duration and cost of transportation.

Table 4

Average distances for the transportation of containers by sea, thousand km,*

Route end	Route start					
	NWC	SWC	MC	NEC	EC	NC
WEU	20.5	19.2	18.2	20.3	19.2	20.5
SEU	16.3	15.0	14.0	16.1	15.0	16.3
NEU	21.6	20.3	19.3	21.4	20.3	21.6
EEUBL	16.3	15.0	14.0	16.1	15.0	16.3
EEUBA	21.8	20.5	19.5	21.6	20.5	21.8
CR	22.4	21.1	20.1	22.2	21.1	22.4
NWR	22.4	21.1	20.1	22.2	21.1	22.4
SR	16.6	15.3	14.3	16.4	15.3	16.6
NCR	16.6	15.3	14.3	16.4	15.3	16.6
PR	22.5	21.2	20.2	22.3	21.2	22.5
UR	22.5	21.2	20.2	22.3	21.2	22.5
SBR	2.2	1.9	3.1	1.9	1.9	2.2
FER	2.2	1.9	3.1	1.9	1.9	2.2
BY	22.5	21.2	20.2	22.3	21.2	22.5
IR	11.2	9.9	8.9	11.0	9.9	11.2
UZ	11.2	9.9	8.9	11.0	9.9	11.2
TM	11.2	9.9	8.9	11.0	9.9	11.2
TR	15.3	14.0	13.0	15.1	14.0	15.3
AZ	16.7	15.4	14.4	16.5	15.4	16.7
GE	16.7	15.4	14.4	16.5	15.4	16.7

* Table 3 for conventional designations

Table 5

Average distances of container transportation by rail transport to seaports, thousand km, *

Route end	Route start					
	NWC	SWC	MC	NEC	EC	NC
WEU	2.4	2.5	1.1	1.1	1.0	0.8
SEU	2.4	2.5	1.1	1.1	1.0	0.8
NEU	2.4	2.5	1.1	1.1	1.0	0.8
EEUBL	2.4	2.5	1.1	1.1	1.0	0.8
EEUBA	2.4	2.5	1.1	1.1	1.0	0.8
CR	2.7	2.8	1.4	1.4	1.3	1.1
NWR	2.1	2.2	0.8	0.8	0.7	0.5
SR	2.2	2.3	0.9	0.9	0.8	0.6
NCR	2.6	2.7	1.3	1.3	1.2	1.0
PR	3.5	3.6	2.2	2.2	2.1	1.9
UR	4.5	4.6	3.2	3.2	3.1	2.9
SBR	7.1	7.2	5.8	5.8	5.7	5.5
FER	3.1	3.2	1.8	1.8	1.7	1.5
BY	2.8	2.9	1.5	1.5	1.4	1.2
IR	3.2	3.3	1.9	1.9	1.8	1.6
UZ	4.3	4.4	3.0	3.0	2.9	2.7
TM	3.8	3.9	2.5	2.5	2.4	2.2
TR	2.4	2.5	1.1	1.1	1.0	0.8
AZ	2.8	2.9	1.5	1.5	1.4	1.2
GE	2.2	2.3	0.9	0.9	0.8	0.6

* Table 3 for conventional designations

The duration of the transportation of containers by sea transport was determined by the formula

$$t_s = \left(\frac{L_s}{v_s} + \frac{L_d - 0.6}{v_d} \right) 10^3 + t_{pd} + t_{ad} + t_{od},$$

where L_s, L_d are the distance of transportation of goods by sea and land transport to and from seaports respectively, thousand km (Tables 4 and 5); v_s, v_d are the speed of transportation of containers by sea and land transport respectively; v_s = 578 and v_d = 840 km/day taken respectively; 0.6 is distance of the initial and final stages of transportation, thousand km; t_{pd} is demurrage of a container at the port of departure, days; t_{ad} stands for additional time for crossing the Suez Canal, the Bosporus, processing in transit ports, crossing land borders, changing the width of the railway track, etc., days; t_{od} is time spent at the point of departure and destination, as well as at the initial and final stages of transportation, days.

Table 6

Average distances of container transportation by rail through Kazakhstan, thousand km, *

Route end	Route start					
	NWC	SWC	MC	NEC	EC	NC
WEU	8.4	10.0	10.6	10.6	10.6	9.6
SEU	9.7	11.3	11.9	11.9	11.9	10.9
NEU	8.5	10.1	10.7	10.7	10.7	9.7
EEUBL	8.9	10.5	11.1	11.1	11.1	10.1
EEUBA	7.6	9.2	9.8	9.8	9.8	8.8
CR	6.4	8.0	8.6	8.6	8.6	7.6
NWR	6.5	8.1	8.7	8.7	8.7	7.7
SR	6.3	7.9	8.5	8.5	8.5	7.5
NCR	6.4	8.0	8.6	8.6	8.6	7.6
PR	5.4	7.0	7.6	7.6	7.6	6.6
UR	5.3	6.9	7.5	7.5	7.5	6.5
SBR	5.9	7.5	8.1	8.1	8.1	7.1
FER	10.2	11.8	12.4	12.4	12.4	11.4
BY	6.7	8.3	8.9	8.9	8.9	7.9
IR	7.5	9.1	9.7	9.7	9.7	8.7
UZ	4.1	5.7	6.3	6.3	6.3	5.3
TM	5.0	6.6	7.2	7.2	7.2	6.2
TR	7.2	8.8	9.4	9.4	9.4	8.4
AZ	5.2	6.8	7.4	7.4	7.4	6.4
GE	5.7	7.3	7.9	7.9	7.9	6.9

* Table 3 for conventional designations

Table 7

Average distances of container transportation by rail and road transport on alternative routes, thousand km, *

Route end	Route start					
	NWC	SWC	MC	NEC	EC	NC
WEU	11.4	11.8	11.6	10.5	11.2	10.2
SEU	12.7	13.1	12.9	11.8	12.5	11.5
NEU	11.5	11.9	11.7	10.6	11.3	10.3
EEUBL	11.9	12.3	12.1	11	11.7	10.7
EEUBA	10.6	11	10.8	9.7	10.4	9.4
CR	9.3	9.7	9.5	8.3	9.1	8.1
NWR	9.3	9.7	9.5	8.4	9.1	8.1
SR	9.6	10	9.8	8.7	9.4	8.4
NCR	9.5	9.9	9.7	8.6	9.3	8.3
PR	8.4	8.8	8.6	7.3	8.2	7.2
UR	8	8.4	8.2	7	7.8	6.8
SBR	4.9	5.3	5.1	4	4.7	3.7
FER	6.1	6.5	6.3	3.9	5.7	4.7
BY	9.8	10.2	10	8.9	9.6	8.6

* Table 3 for conventional designations

The duration of transportation of containers by rail was determined by the formula

$$t_{rw} = \frac{10^3 L_{KZ}}{v_{KZ}} + t_r + t_f + t_{ad} + t_{od},$$

where L_{KZ} is the distance of transportation of containers by rail across the territory of Kazakhstan, thousand km; v_{KZ} is the

speed of transportation of containers by rail across the territory of Kazakhstan, km/day; t_r is the duration of transportation of containers by rail across the territory of other states, days; t_f is the duration of transportation of containers by ferry, days.

The value of t_r was calculated based on the speed of transportation of containers by rail across the territory of Russia and Belarus 1050 km/day, Europe and China 840 km/day, other countries 320 km/day.

The magnitude of the reduction in the duration of transportation of containers by rail through Kazakhstan in comparison with sea transport is presented in Table 8, and in comparison with alternative railway routes in Table 9.

The use of rail transport for the transportation of containers through Kazakhstan provides a significant reduction in the duration of delivery between China and the countries of Western and Northern Europe, Eastern Europe, gravitating towards the Baltic Sea, Belarus, Azerbaijan, and Georgia, as well as Russia, with the exception of the Far East and Siberia federal districts. The use of rail transport for the transportation of containers through Kazakhstan leads to an increase in delivery times compared to competing routes for transportation from North, Northeast and East China, as well as to the Far East and Siberian Federal Districts of Russia. The time spent on transporting containers to other districts of Russia through Kazakhstan and alternative railway routes is close. It should be noted that the internal tariffs for the transportation of goods in Russia are significantly lower than the transit railway tariffs of Kazakhstan. Therefore, the activation of container traffic between Russia and China through the territory of Kazakhstan is currently associated with the limitation of the capacity of the Trans-Siberian Railway and the restriction of traffic through the Russian ports of the Baltic and Black Seas due to the imposed sanctions. In this regard, in the long term, when transporting containers to Russia, the railways of Kazakhstan will face the need to compete with lower domestic tariffs of the Russian railways. In the future, transportation routes through Kazakhstan from North, Northeast and East China, as well as transportation to Russia were not considered due to the availability of more competitive routes.

Table 8

Reduction in the duration of transportation of containers by rail through Kazakhstan in comparison with sea transport, days, *

Route end	Route start					
	NWC	SWC	MC	NEC	EC	NC
WEU	31	27	23	27	25	28
SEU	23	18	14	18	16	19
NEU	35	31	27	31	29	32
EEUBL	26	22	18	22	20	23
EEUBA	37	32	28	32	30	33
CR	41	37	33	37	35	38
NWR	40	36	32	36	34	37
SR	32	28	23	27	25	28
NCR	32	28	24	27	25	29
PR	43	39	35	39	37	40
UR	45	41	36	40	38	41
SBR	12	10	9	7	7	9
FER	3	1	0	-2	-2	0
BY	41	37	33	37	35	38
IR	8	4	0	4	1	5
UZ	25	21	17	20	18	22
TM	22	18	13	17	15	18
TR	20	16	12	16	14	17
AZ	34	30	26	30	28	31
GE	30	26	22	25	23	27

* Table 3 for conventional designations

Table 9

Reduction in the duration of transportation of containers by rail through Kazakhstan compared to alternative rail routes, days

Route end	Route start					
	NWC	SWC	MC	NEC	EC	NC
WEU	2	1	0	–2	–1	–1
SEU	2	1	0	–2	–1	–1
NEU	2	1	0	–2	–1	–1
EEUBL	2	1	0	–2	–1	–1
EEUBA	2	1	0	–2	–1	–1
CR	2	0	–1	–2	–1	–1
NWR	2	0	–1	–2	–1	–1
SR	2	1	0	–1	–1	–1
NCR	2	1	0	–2	–1	–1
PR	2	1	0	–2	–1	–1
UR	2	0	–1	–2	–1	–1
SBR	–2	–3	–4	–6	–5	–5
FER	–5	–7	–8	–10	–8	–8
BY	2	1	0	–2	–1	–1

Estimation of the cost of shipping containers using sea transport between China and other regions in thousand USD was carried out according to the formula

$$C_s = L_s c_s + (L_d - 0.6)c_d + c_p + c_{ad} + c_{od},$$

where c_s, c_d are respectively, the cost of container transportation by sea and land transport USD/km; c_s is the cost of handling a container in seaports, thousand USD; c_{ad} is the cost of additional services related to border crossing, changing the gauge, etc. thousand USD; c_{od} is the cost of services at the point of departure and destination, as well as transportation at the initial and final stages, thousand USD.

Estimation of the cost of transit transportation of containers through Kazakhstan in thousand USD was carried out according to the formula

$$C_{ew} = L_{KZ} c_{KZ} + (L_r - 0.6)c_r + c_{ad} + c_{od},$$

where c_{KZ}, c_r are respectively, the cost of transporting a container by rail across the territory of Kazakhstan and other states USD/km; L_r is the distance of transportation of a container across the territory of other states, thousand km.

The difference between the cost of transporting a 20-foot container by sea and by rail through Kazakhstan in the direction of China – Western Europe and Belarus is presented in Table 10.

Table 10 data analysis shows that the difference in the cost of sea and rail transportation for container transportation on the route China – Western Europe and Belarus (with the exception of transportation between Northwestern China and Belarus) exceeds the amount of payments for transit transportation received by Kazakhstan. Therefore, on these routes, competition with sea transport in terms of price is impossible. It should also be noted that a further increase in the achieved speed of transportation of goods by the railways of Kazakhstan does not allow to significantly changing the duration of delivery. In this direction, it is expedient to compete for the transportation of valuable and perishable goods in containers by ensuring the punctuality and safety of transportation. It should be noted that due to the provision of discounts, it is possible to achieve a lower price of transportation between North-West China and Belarus compared to sea transport. However, only 5 % of GDP and 7 % of the population of the regions that will potentially benefit from the discount is concentrated in these regions. Therefore, competition by reducing the cost of transportation on this route is irrational.

The difference between the cost of transporting a 20-foot container by sea and by rail through Kazakhstan in the direction of China – Iran and Central Asia, as well as China – Turkey and the Caucasus is presented in Table 11.

The China-Iran direction is characterized by a short distance between the ports of China and the Iranian port of Bandar Abbas, as well as no need to pass the Suez Canal. At the same time, rail transportation involves the need to cross four borders and perform two gauge changes. Tables 8 and 11 data analysis shows that the organization of container transportation between China and Iran through Kazakhstan is not promising

The conditions for the transportation of containers in the direction of Turkey and Georgia are similar to the conditions for transportation to Western Europe. At the same time, container flows with valuable and perishable goods, sensitive to the duration of transportation, can follow through Kazakhstan.

Transportation by rail [25] through Kazakhstan is more profitable than by sea in the directions of Northwestern China – Uzbekistan and Turkmenistan, Southwestern China – Uzbekistan. Also insignificant is the difference in the cost of shipping containers between Northwestern China and Azerbaijan, Northern China and Uzbekistan. Taking into account the significant advantage of railway transport in terms of transportation time in these directions and a slight difference in their price, the railways of Kazakhstan can compete with sea transport in terms of the cost of transportation for the development of the entire volume of container traffic in these directions. The cost of container transportation can be reduced due to the non-priority schedule of container trains, as well as due to more rational planning of providing trains with locomotives, for example, when organizing the movement of freight trains according to the schedule, Kozachenko, et al. [26]. It should be noted that even with a decrease in the speed of container transportation on these routes from 1050 km/day up to 150 km/day provided for in the "Agreement on International Rail Freight Communication"; transportation through Kazakhstan will be carried out in less time compared to sea transport. At the same time, a 30 % reduction in the cost of transportation makes it possible to make routes through Kazakhstan on the directions of Northwestern China – Azerbaijan and Northern China – Uzbekistan more efficient in terms of cost compared to sea transport.

In general, the **scientific novelty** of the paper lies in the fact that it has improved the method for assessing the routes of transportation of containers by transit railway administrations.

Table 10

Difference between the cost of transporting a 20-foot container by sea and by rail through Kazakhstan in the direction of China – Western Europe and Belarus, thousand USD

Route end	Route start		
	NWC	SWC	MC
WEU	4.0	5.5	7.6
SEU	5.5	7.0	9.1
NEU	4.0	5.6	7.6
EEUBL	4.7	6.2	8.3
EEUBA	3.1	4.7	6.7
BY	1.6	3.2	5.3

Table 11

Difference between the cost of transporting a 20-foot container by sea and by rail through Kazakhstan in the direction of China – Iran and Central Asia, as well as China – Turkey and the Caucasus, thousand USD

Route end	Route start					
	NWC	SWC	MC	NEC	EC	NC
IR	2.7	4.3	6.4	6.3	6.4	5.5
UZ	–2.0	–0.5	1.6	1.5	1.6	0.8
TM	–0.6	1.0	3.0	2.9	3.1	2.2
TR	3.6	5.2	7.2	7.1	7.3	6.4
AZ	0.9	2.5	4.5	4.4	4.6	3.7
GE	2.0	3.6	5.7	5.6	5.7	4.8

Unlike existing methods, the assessment of the duration of transportation is carried out throughout the entire length of transportation "from door to door". Also, the paper proposes to evaluate the effectiveness of railway routes, taking into account the service of the entire territory through which they pass, and not just the starting and ending points.

Practical significance. The research results allow railway administrations to obtain a reasonable assessment of the economic efficiency of measures aimed at the development of transit container traffic on different routes.

Conclusions. The performed studies allow us to draw the following conclusions:

1. The geographical location of Kazakhstan makes it one of the main participants in the container transit market on the Eurasian continent. At the same time, railway routes passing through Kazakhstan compete both with sea transportation routes and with railway routes passing through the territory of other countries.

2. The direction China – Western Europe is the main direction of transportation of containers through Kazakhstan. This route connects regions where a significant population is concentrated and where the bulk of GDP is generated. Railways of Kazakhstan have an advantage in terms of transportation time between Northwestern, Southwestern and Central China on the one hand and the countries of Western Europe and Belarus on the other. At the same time, the cost of transportation by rail on these routes significantly exceeds the cost of transportation by sea. Therefore, increasing competitiveness should be achieved by increasing the punctuality and safety of transportation while ensuring their standard speed.

3. Railway routes in the direction of China – Russia have close indicators of the duration of transportation. At the same time, due to the difference in the value of internal tariffs of Russia and transit tariffs of Kazakhstan, transportation through Kazakhstan is inferior to transportation along alternative routes in terms of price. In the short and medium term, due to the capacity constraints of Russian railways, the price factor does not affect the direction of container flows. In the long term, the railways of Kazakhstan will face the need to reduce prices in order to compete in the development of volumes of transit container flows.

4. Transportation by rail through Kazakhstan is more profitable than by sea in the directions of Northwestern China – Uzbekistan and Turkmenistan, Southwestern China – Uzbekistan. Also insignificant is the difference in the cost of shipping containers between Northwestern China and Azerbaijan, Northern China and Uzbekistan. On these routes, it is advisable to introduce different technologies for the transportation of containers, which differ in cost and delivery time.

References.

1. Naumov, V., Zhamanbayev, B., Agabekova, D., Zhanbirov, Z., & Taran, I. (2021). Fuzzy-logic approach to estimate the passengers' preference when choosing a bus line within the public transport system. *Communications – Scientific Letters of the University of Žilina*, *23*(3),A150-A157.https://doi.org/10.26552/com.C.2021.3.A150-A157.

2. Taran, I., & Bondarenko, A. (2017). Conceptual approach to select parameters of hydrostatic and mechanical transmissions for wheel tractors designed for agrucultural opeations. *Archives of transport*, *41*(1), 89-100. https://doi.org/10.5604/01.3001.0009.7389.

3. Bucsky, P. (2019). The iron Silk Road: how important is it? *Area Development and Policy*. https://doi.org/10.1080/23792949.2019.1672571.

4. Li, S., Lang, M., Yu, X., Zhang, M., Jiang, M., Tsai, S., Wang, C.-K., & Bian, F. (2019). A Sustainable Transport Competitiveness Analysis of the China Railway Express in the Context of the Belt and Road Initiative. *Sustainability*, *11*(10), 2896. https://doi.org/10.3390/su11102896.

5. Tical, G., & Grajdeanu, L. (2020). Railway between China and EU – challenges for Transport Police. Acta Universitatis George Bacovia. *Juridica*, *9*(1). Retrieved from https://www.ugb.ro/Juridica/Issue17ROEN/5._Calea_ferata_China-UE.Provocari_pentru_Politia_TF.Lucian_Grajdeanu.EN.pdf.

6. Zhang, X., & Schramm, H.-J. (2020). Assessing the market niche of Eurasian rail freight in the belt and road era. *The International Journal of Logistics Management*, *31*(4), 729-751. https://doi.org/10.1108/IJLM-12-2019-0351.

7. Pomfret, R. (2021). The Eurasian landbridge: Implications of linking East Asia and Europe by rail. *Research in Globalization, 3*. https://doi.org/10.1016/j.resglo.2021.100046.
8. Neumann, T. (2021). Comparative Analysis of Long-Distance Transportation with the Example of Sea and Rail Transport. *Energies, 14*(6), 1689. https://doi.org/10.3390/en14061689.
9. Bersenev, A., Chikilevskaya, M., & Rusinov, I. (2020). Silk Road Rail Corridors Outlook and Future Perspectives of Development. *Procedia Computer Science*, *167*, 1080-1087. https://doi.org/10.1016/j.procs.2020.03.407.
10. Taran, I., & Litvin, V. (2018). Determination of rational parameters for urban bus route with combined operating mode. *Transport Problems*, *13*(4), 157-171. https://doi.org/10.20858/tp.2018.13.4.14.
11. Pan, J., Bell, M. G. H., Cheung, K. F., & Perera, S. (2020). Identifying container shipping network bottlenecks along China's Maritime Silk Road based on a spectral analysis. *Maritime Policy & Management*, *48*(2), 1-13. https://doi.org/10.1080/03088839.2020.1841312.
12. Vukić, L., & Cerbán, M. d. M. (2022). Economic and environmental competitiveness of container shipping on alternative maritime routes in the Asia-Europe trade flow. *Maritime Transport Research*, *3*, 100070. https://doi.org/10.1016/j.martra.2022.100070.
13. Du, Y., Meng, Q., & Shi, W. (2019). Impact analysis of the traffic convoy system and toll pricing policy of the Suez Canal on the operations of a liner containership over a long-haul voyage. *International Journal of Shipping and Transport Logistics*, *11*(2/3), 119-144. https://doi.org/10.1504/IJSTL.2019.099276.
14. Musso, E., & Sciomachen, A. (2020). Impact of megaships on the performance of port container terminals. *Marit Econ Logist*, *22*, 432-445. https://doi.org/10.1057/s41278-019-00120-y.
15. Lasserre, F., Huang, L., & Mottet, É. (2020). The emergence of Trans-Asian rail freight traffic as part of the bel and road initiative: Development and limits. *China Perspect, 2*, 43-52. https://doi.org/10.4000/chinaperspectives.10162.
16. Wagener, N., Aritua, B., & Zhu, T. (2020). The New Silk Road: Opportunities for Global Supply Chains and Challenges for Further Development. *LogForum, 16*(2), 193-207. https://doi.org/10.17270/J.LOG.2020.403.
17. Shi, Y., Zhang, N., Shang, Y., Zhang, Z., Li, Y., Li, Z., & Yujiao, Shi (2019). Development Countermeasures on Container Multimodal Transport of Railway in China. *IOP Conference Series: Earth and Environmental Science, 25*(3). https://doi.org/10.1088/1755-1315/295/3/032084.
18. Stopyra, R., Litewski, M., & Antonowicz, M. (2019). Role Of The New Silk Road In Supply Chain Development In Poland. *Proceedings of the 15th International Strategic Management Conference (ISMC 2019). Strategic Management in an International Environment: The New Challenges for International Business and Logistics in the Age of Industry 4.0*, 154-168. https://doi.org/10.15405/epsbs.2019.10.02.14.
19. Kukeyeva, F., & Dyussebayev, D. (2018). Belt and Road Initiative for Kazakhstan: Opportunities and Risks. *Silk Road to Belt Road*, 293-305. https://doi.org/10.1007/978-981-13-2998-2_17.
20. Shariatinia, M., & Azizi, H. (2019). Iran and the Belt and Road Initiative: Amid Hope and Fear. *Journal of Contemporary China*, *28*(120), 984-994. https://doi.org/10.1080/10670564.2019.1594108.
21. Wen, X., Ma, H.-L., Choi, T.-M., & Sheu, J.-B. (2019). Impacts of the Belt and Road Initiative on the China-Europe trading route selections. *Transportation Research Part E: Logistics and Transportation Review*, *122*, 581-604. https://doi.org/10.1016/j.tre.2019.01.006.
22. Chen, X., Zhu, X., Zhou, Q., & Wong, Y. D. (2017). Game-Theoretic Comparison Approach for Intercontinental Container Transportation: A Case between China and Europe with the B&R Initiative. *Journal of Advanced Transportation*, *5*, 1-15. https://doi.org/10.1155/2017/3128372.
23. Kozachenko, D., Skalozub, V., Hermaniuk, Y., Korobiova, R., & Gorbova, A. (2019). A Model of Transit Freight Distribution on a Railway Network. *Transport Problems*, *14*(3), 17-26. https://doi.org/10.20858/tp.2019.14.3.2.
24. Taran, I. A., & Klymenko, I. Y. (2014). Innovative mathematical tools for benchmarking transmissions of transport vehicles. *Naukovyi Visnyk Natsionalnoho Hirnychoho Universytetu*, (3), 76-81.
25. Taran, I., & Klymenko, I. (2017). Analysis of hydrostatic mechanical transmission efficiency in the process of wheeled vehicle braking. *Transport Problems*, *12*(Special Edition), 45-56. https://doi.org/10.20858/tp.12.se. 4.
26. Kozachenko, D., Vernigora, R., Balanov, V., Berezovy, N., Yelnikova, L., & Germanyuk, Yu. (2016). Evaluation of the transition to the organization of freight trains traffic by the schedule. *Transport Problems*, *11*(1), 41-48. https://doi.org/10.20858/tp.2016.11.1.4.

Оцінка конкурентоспроможності залізничної мережі Казахстану при виконанні транзитних контейнерних перевезень

А. Тілемісова[1], *Д. Козаченко*[*2], *Р. Вернигора*[2], *М. Ізтелеуова*[3], *М. Арпабеков*[4]

1 – Академія логістики і транспорту, м. Алмати, Республіка Казахстан
2 – Український державний університет науки і технологій, м. Дніпро, Україна
3 – Алмати менеджмент університет, м. Алмати, Республіка Казахстан
4 – Євразійський національний університет імені Л. Гумільова, м. Астана, Республіка Казахстан
* Автор-кореспондент e-mail: dmytro.kozachenko@outlook.com

Мета. Удосконалення методів оцінки маршрутів перевезення контейнерів транзитними залізничними адміністраціями.

Методика. Результати представленого наукового дослідження отримані на підставі загальних методів пізнання таких як, абстрактно-логічний аналіз, систематизація, метод теоретичного узагальнення, а також на основі спеціальних методів економіко-математичного моделювання, теорії експлуатації залізниць і транспортної географії.

Результати. У ході дослідження виконано аналіз транспортної мережі Євразійського континенту в цілому та залізничної транспортної мережі Казахстану, як її частини, зокрема. Виконана оцінка соціально-економічного розвитку регіонів, перевезення між якими можуть потенційно виконуватися через територію Казахстану. Встановлені показники тривалості й вартості перевезення контейнерів морським і залізничним транспортом між Східною Азією та Європою. Виконана оцінка конкурентоспроможності маршрутів перевезення контейнерів, що проходять територією Казахстану в порівнянні з альтернативними маршрутами.

Наукова новизна. У роботі вдосконалено метод оцінки маршрутів перевезення контейнерів транзитними залізничними адміністраціями. На відміну від існуючих методів, оцінка тривалості перевезень здійснюється на всій протяжності перевезень «від дверей до дверей». Також у роботі запропоновано виконувати оцінку ефективності залізничних маршрутів з урахуванням обслуговування всієї території, якою вони проходять, а не тільки початкових і кінцевих пунктів.

Практична значимість. Результати досліджень дозволяють залізничним адміністраціям підвищити ефективність планування розвитку транзитних контейнерних перевезень різними маршрутами. Встановлені регіони, для яких залізниці Казахстану можуть конкурувати з морським транспортом як за показником ціни, так і за показником швидкості перевезень за весь контейнеропотік, а також регіони, для яких конкуренція може здійснюватися лише за частку ринку перевезення у контейнерах цінних і швидкопсувних вантажів.

Ключові слова: *міжнародні перевезення, залізничний транспорт, контейнер, конкуренція, вибір маршруту*

The manuscript was submitted 03.04.23.