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ECONOMIC-MATHEMATICAL MODEL OF EVALUATING THE EFFICIENCY OF THE TRANSPORT SYSTEM

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Abstract: This article presents modern methods of transport system development, classification of modern management concept methods that form the theoretical and methodological basis for assessing the economic efficiency of integrated transport systems, efficiency of delivery times on options A, B, C, D and proposals for using economic-mathematical model of transport system development given.

Keywords: integrated transport system, railway transport, transport-logistics, transit transportation, cost-effectiveness, modern management approaches, 3PL and 4PL level logistics service providers, just in time.

Introduction

The importance of transport and logistics infrastructure in the ongoing processes of globalization and integration is growing. According to the World Bank, the share of global transport services in GDP is 4.3 trillion. USD (6.9%) and amounted to 110 bln. tons of cargo and 1 trillion. More than 100 million passengers are transported, the number of employees in the transport infrastructure is 100 million. constitutes a person[1]. The development of these sectors is carried out by the global transport and logistics system. Effective organization of management processes in the logistics system of freight delivery will save 30% to 60% of material resources, as well as reduce the transport and logistics costs of enterprises using railway transport services by about 30-35%.

In our country, special attention is paid to the rapid development of transport communications as an important sector of the economy. In this regard, the Action Strategy for the five priority areas of development of the Republic of Uzbekistan for 2017-2021 sets important tasks to "increase competition among national transport and logistics companies"[2] and the Address of the President of the Republic of Uzbekistan to the “Oliy Majlis”. We need to develop the transport and logistics sector to reduce costs "[3] they pointed out. This, in turn, reflects the effective use of the country's transport and transit potential and modern delivery technologies, as well as the expediency of conducting research on the development of the transport system.

Research methodology

The results of scientific research of national and foreign scientists engaged in the analysis of problems in the development of the transport system served as a theoretical and methodological basis for this research. In the preparation of the

article used abstract and analytical observation, comparative and factor analysis, indicative, sample observation, comparison, economic-statistical and other methods.

Analysis and results

Effective management of the integrated transport and logistics system should be based on the principles of scientific validity, efficiency, optimization, comprehensiveness, flexibility, goal-oriented. Given the wide application of the listed principles in modern science, we did not consider it necessary to clarify their content in this study. The classification of modern management conceptual methods, which form the theoretical and methodological basis of the management of the integrated transport system (Table 1).

Table 1

Classification of modern conceptual methods of management, which form the theoretical and methodological basis of the development of the transport system

Management concepts	Methods used in the development of the transport system
Systematic approach	– optimization methods; – statistical methods; – correlation-regression analysis; – forecasting methods; – expert methods; – scenario methods; – graphic styles; – econometrics; – rating method.
Process approach	– methods of modeling transport and logistics business processes; – reengineering of integrated transport and logistics business processes; – outsourcing of transport and logistics business processes; – statistical management of processes; – process innovations; – monitoring of transport and logistics business processes; – benchmarking of transport and logistics business processes;
Process approach	– management of interaction (actions) with suppliers; – supply chain management planning; – management of interaction with consumers.
Logistics management	– logistics audit; – “just in time” concept; – inventory management models; – AVS and XYZ analysis.

Strategic management	– internal and external environmental monitoring; – SWOT analysis; – strategic matrices; – transport and logistics business process outsourcing strategy; – balanced system of indicators; – life cycle model of transport and logistics services.
Operational management	– accounting and standardization of transport and logistics costs; – stock standardization; – Standardization of service personnel of the enterprise.

Compiled by the author as a result of research.

It should be noted that the systematic and process approaches of management, conceptual rules today serve as the basis for all the listed management concepts and theories. The methods, models and tools developed under these approaches are applied in various areas of management.

In order to organize integrated transport and logistics activities, it is necessary to first learn the characteristics of a single transport system, which includes rail, air and road transport. Depending on the management strategy and tasks of the enterprise carrying out transport and logistics operations, the optimal types of transport are selected for the delivery of goods [4].

It takes into account the technical and economic characteristics of the modes of transport, their capabilities and shortcomings, which determine their rational use, taking into account the costs and management indicators. When choosing the type of shipping, the shipper will have to work based on many criteria. These criteria are based on a five-point scale. In this case, "1" - the highest score, "5" - the lowest score (Table 2).

Table 2

The evaluation of different modes of transport in terms of the main factors influencing the choice of mode of transport (on a 5-point scale)

Types of transport	Speed (delivery time)	Reliability (adherence to schedule)	Possibility to transport cargo	Number of geographical points served	Cost per ton-km (price)
railway	3	4	2	2	3
water	4	5	1	4	1
car	2	2	3	1	4
pipe	5	1	5	5	2
the weather	1	3	4	3	5

Compiled by the author as a result of research.

In recent years, the volume of transit cargo transported by rail in our country has decreased by 6% over the past six years. This situation is explained by the lack of entrepreneurial ability in professional transport and the inadequacy of the control

system. Therefore, based on the above considerations, the slow process of transport and logistics management is affected by the following problems:

– lack of container capacity;
– high freight costs by rail;
– lack of development of 3PL and 4PL level logistics service providers;
– about 60% of railway cars have been in service for 20-30 years, and 13% for more than 30 years;
– 1.5% of refrigerated cars are involved in international transportation (15-20% of demand), which is 4% of railway cars;
– lack of a single management mechanism in the transport and logistics system;
– the current mechanism of coordination of the transport and logistics system does not work;
– lack of systematization of methods of general control of the transport and logistics system;
– in 2017, 68% of trucks involved in international transportation were 15-20 years old and 10% were 20-30 years old;
– the share of container traffic in international traffic is 7-8% (in the EU - 14%, in China - 51%);
– more than 70% of the country's highways do not provide optimal traffic speeds;
– about 30% of the fixed assets of the warehouse are physically and mentally obsolete;
– the level of mechanization of loading and unloading operations is 20-30%.

One of the most important aspects in the delivery of clearly defined transport and logistics services is the time that is not dependent on transport [5]. In particular, the time spent on the organization of transportation (in the absence of transport, the inability to find the necessary places at the time of loading, etc.). Sometimes non-transportation time is considered more important than transportation time.

To evaluate the efficiency of cargo delivery time, it is expedient to calculate according to formulas (1), (4) above. Consider a mathematical model for evaluating the efficiency of cargo delivery time when using 3PL and 4PL level logistics services:

– travel time - 36 hours;
– time to start unloading containers - 13:00.
– unloading time is 22:00
– loading and unloading time - 33 hours;
– intensity during unloading - 12.78 containers per hour.

Hence, we consider different options of cargo delivery time (Table 7).

Table 7

Options for transport operations

Options	Options calculation formulas

A	$T_A = T_{1-3} + T_3 + T_{3-4} + T_4 + T_{4-6} + T_6$	(1)
B	$T_B = T_{1-2} + T_2 + T_{2-3} + T_3 + T_{3-4} + T_4 + T_{4-6} + T_6$	(2)
C	$T_C = T_{1-3} + T_3 + T_{3-4} + T_4 + T_{4-5} + T_5 + T_{5-6} + T_6$	(3)
D	$T_Д = T_{1-2} + T_2 + T_{2-3} + T_3 + T_{3-4} + T_{4-5} + T_5 + T_{5-6} + T_6$	(4)

Compiled by the author as a result of research

Here:

1 - point of departure; 2 - raid; 3 - inspection of vehicles; 4 - customs; 5 - transfer of cargo to another mode of transport; 6 - cargo receiving point.

On the basis of formulas (7–10), the delivery time was calculated in all cases for options A, B, C, D. Data on standardization of cargo delivery time and calculation of its results are presented in Table 8.

Table 8

Results of calculation of cargo delivery time options

Options	$T_{вар}$	T_{1-2}	T_2	T_{2-3}	T_{1-3}	T_3	T_{3-4}	T_4	T_{4-5}	T_{4-6}	T_5	T_{5-6}	T_6	$\sum T_i$
T_A	T_{A1}	-	-	-	46	4	0.2	1.5	-	40	-	-	2	93.7
	T_{A2}	-	-	-	41	9	0.3	5.55	-	42	-	-	3	100.8
	T_{A3}	-	-	-	52	6	0.4	5	-	44	-	-	4	111.4
T_B	T_{B1}	33	4	-	-	8	0.3	2.5	-	35	-	-	3	85.8
	T_{B2}	40	2	1	-	9	0.2	1.5	-	30	-	-	4	87.7
	T_{B3}	35	3	-	-	9	0.3	4.5	-	36	-	-	3	90.8
T_C	T_{C1}	-	-	-	41	8	0.4	2.5	0.2	-	58	20.5	3	133.6
	T_{C2}	-	-	-	46	6	0.4	3.5	0.4	-	76	25.5	4	162.8
	T_{C3}	-	-	-	38	7	0.3	4	0.3	-	106	30.5	3	189.1
$T_Д$	$T_{Д1}$	45	3	1	-	8	0.4	3.5	0.4	-	96	31.5	2	189.8
	$T_{Д2}$	46	2	-	-	9	0.4	4.5	0.4	-	146	35.5	3	246.8
	$T_{Д3}$	43	3	1	-	7	0.3	4	0.3	-	180	31.5	3	273.1

Compiled by the author as a result of research

Based on the results of Table 8, the efficiency of the delivery time was evaluated using the transformation coefficient for options A, B, C, D (Table 9).

Table 9

Efficiency of delivery times on options A, B, C, D.

Options	**Calculation of comparable options**	
A	$K_{A2} = 1 + \frac{\sum T_{A2} - \sum T_{A1}}{\sum T_{A1}} = 1 + \frac{100,8 - 93,7}{93,7} = 1,07$ $\delta_{A2} = (K_{A2} - 1) * 100\% = 7\%$ $K_{A3} = 1 + \frac{\sum T_{A3} - \sum T_{A1}}{\sum T_{A1}} = 1 + \frac{111,4 - 93,7}{93,7} = 1,18$ $\delta_{A3} = (K_{A3} - 1) * 100\% = 18\%$	(5)

B	$К_{В2} = 1 + \frac{\sum Т_{В2} - \sum Т_{В1}}{\sum Т_{В1}} = 1 + \frac{87,7 - 85,8}{85,8} = 1,02$ $\delta_{В2} = (К_{В2} - 1) * 100\% = 2\%$ $К_{В3} = 1 + \frac{\sum Т_{В3} - \sum Т_{В1}}{\sum Т_{В1}} = 1 + \frac{90,8 - 85,8}{85,8} = 1,05$ $\delta_{В3} = (К_{В3} - 1) * 100\% = 5\%$	(6)
C	$К_{С2} = 1 + \frac{\sum Т_{С2} - \sum Т_{С1}}{\sum Т_{С1}} = 1 + \frac{162,8 - 133,6}{133,6} = 1,21$ $\delta_{С2} = (К_{С2} - 1) * 100\% = 21\%$ $К_{С3} = 1 + \frac{\sum Т_{С3} - \sum Т_{С1}}{\sum Т_{С1}} = 1 + \frac{189,1 - 133,6}{133,6} = 1,41$ $\delta_{С3} = (К_{С3} - 1) * 100\% = 41\%$	(7)
D	$К_{Д2} = 1 + \frac{\sum Т_{Д2} - \sum Т_{Д1}}{\sum Т_{Д1}} = 1 + \frac{246,8 - 189,8}{189,8} = 1,30$ $\delta_{Д2} = (К_{Д2} - 1) * 100\% = 30\%$ $К_{Д3} = 1 + \frac{\sum Т_{Д3} - \sum Т_{Д1}}{\sum Т_{Д1}} = 1 + \frac{273,1 - 189,8}{189,4} = 1,43$ $\delta_{Д3} = (К_{Д3} - 1) * 100\% = 43\%$	(8)

Compiled by the author as a result of research

Thus, according to the results of the calculations, the transformation coefficient, which shows that more time is spent on transport and logistics operations, allows us to assess the effectiveness of the compared options in the delivery of goods. Accordingly, options A and B provide a 25 percent reduction in delivery time compared to options C and D.

This result can be achieved through effective management of the cargo delivery process. Below we consider an economic-mathematical model for evaluating the management efficiency of an integrated transport and logistics system [6].

Evaluating the effectiveness of integrated transport and logistics management is a rather complex process. It is therefore advisable to identify the main criteria for evaluating the effectiveness of management and to express the interrelationships between them through the math function. Therefore, the main criteria for the operation of the system were:

- cargo mass "*M*", in tons;
- distance traveled "*L*", in kilometers;
- delivery time "*T*", in hours;
- transportation and logistics costs, in "*X*" soums.

The interrelationship between these criteria was expressed on the basis of the following economic-mathematical model:

$$I_к = М^x * L^y * T^z * X^f \quad (9)$$

Where $I_к$ – is an indicator of economic evaluation of integrated transport and logistics activities;

x, y, z, f are general calculated indicators, which are the exact and interpretable result of the analytical examination within the following limits:

$$-3.0 \leq x, y, z, f \leq 3.0 \quad (10)$$

x, y, z, f This relationship can be taken as an indicator that can be applied to any type of transport in general. Therefore, when *x = 0, y = 1, z = 0, f = 0*, the following relation arises:

$$I_к = \mathrm{M}^0 * L^1 * T^0 * X^0\ km, \text{ distance} \quad (11)$$

$x = 0, y = 1, z = -1, f = 0$ then the following equation arises:

$$I_к = \mathrm{M}^0 * L^1 * T^{-1} * X^0 = \frac{km}{time}, \text{ speed of movement} \quad (12)$$

The economic-mathematical model of assessing the effectiveness of the management of the integrated transport and logistics system represents the relationship between the quality management of transport and logistics, taking into account the efficiency indicators [7]. Quality indicators of integrated transport and logistics system management affect efficiency indicators, and the economic-mathematical model of evaluating the effectiveness of integrated transport and logistics system management is characterized by the following indicators:

$$\mathrm{C}_j = f(\mathrm{K}_{me}, I), \quad (13)$$

$$x_{imin} \le x_i \le x_{imax} \quad (14)$$

$$Y = \varphi_i(I_i) \leftrightarrow ext \quad (15)$$

Here:

C_i – cost-effectiveness of integrated transport and logistics;

K_{me} – coefficient determining the level of management efficiency;

x_i – organizational and economic indicators;

x_{imin}, x_{imax} – maximum and minimum values of organizational and economic indicators;

Y – a multifactorial function that affects efficiency.

Thus, the effective management process of the integrated transport and logistics system based on the formulas (1-15) is expressed by the following function.

$$Y = 0.243 * x_1 + 0.192 * x_2 + 0.17 * x_3 + 0.109 * x_4 \quad (16)$$

Thus, the concept of a clear timeline that allows to minimize delivery times, economic-mathematical model of the organization of the logistics company at the level of 3PL and 4PL [8], the target function that allows to evaluate the effectiveness of system management, effective logistics activities, reduce logistics costs.

Conclusions and suggestions

In short, one of the main elements of the efficiency of the transport and logistics system in JSC "Uzbekistan Railways" is the minimization of logistics costs, reducing the time of fulfillment of orders of consumers of services. JSC "Uzbekistan Railways" has confirmed that the use of modern logistics technologies and the concepts of integrated logistics "isikava diagram", "value-added flow map" and "real-time" (JIT) can reduce delivery time by 25%. Proposed methods and recommendations for improving the management of the integrated transport and logistics system Development of short-term and long-term strategies for effective management of the integrated transport and logistics system, system modernization, effective coordination and integration with business partners, quality customer service,

increasing the competitiveness of logistics service providers, while increasing the efficiency of management activities of the integrated transport and logistics system.

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