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DYNAMICS OF THE VOLUMES OF OIL AND PETROLEUM PRODUCTS TRANSPORTATION IN UKRAINE

In the period of 2003 – 2021 annual volumes of oil and petroleum products transportation in Ukraine underwent considerable changes. Determination of regression dependences, describing the dynamics of the volumes of oil and petroleum products transportation in Ukraine is a relevant scientific-engineering problem. Objective of the research is the determination of the regression dependences, which describe the dynamics of the volumes of oil and petroleum products transportation in Ukraine and can be used for the prediction of the needed amount of the transport facilities. In the process of investigations, the method of regression analysis of the results of single-factor experiments and other paired dependences with the selection of rational type of function from the most widely used variants by the criterion of the maximum value of the correlation coefficient was used. Regressions were performed on the base of the linearized transformations, which enable to reduce non-linear dependence to linear ones. Determination of the coefficients of the regression equations was performed, applying the least square method, using the developed computer program "RegAnaliz", protected by the Certificate of state registration of the rights to the copyright object. Adequate regression quadratic dependences, describing the dynamics of the volume of oil and petroleum products transportation in Ukraine by railway and automobile transport have been obtained, they can be used for the prediction of the necessary amount of transport facilities. Graphic dependences describing the dynamics of the volumes of oil and petroleum products transportation in Ukraine and allow to illustrate this dynamics and show the sufficient coincidence of the theoretical results with actual data have been constructed. Using the obtained dependence, it was predicted, that the volumes of oil and petroleum products transportation in Ukraine at the present rates of dynamics in 2025 may reach 18 mil. tons for the railway transport and 0.531 mil. tons for automobile transport.

Key words: *liquid cargoes, bulk cargoes, oil, petroleum products, transportation, volumes of transportation, transport vehicle, dynamics, regression analysis, regression dependence.*

Introduction

Selection of the transport facilities and their load capacity at the enterprises, must be performed, taking into consideration specific conditions of operation, stipulated by a number of factors.

But first of all we should consider the notion of transport and what factors influence the choice.

Transport is first and foremost a set of technical facilities for carrying cargoes and passengers, second, it is a branch of economic activity, that provides uninterrupted and timely satisfaction of the needs of economic activity and population in transportation [1].

Transport service is one of the basic logistic functions, connected with circulation of goods by transport means, using certain technologies in the supply chain and consists of certain logistic operations, including cargoes forwarding, loading-unloading operations, packaging, transfer of ownership of goods, hazard insurance, customs clearance of goods, etc. [2].

Transporting of cargoes means the change of location of the stocks by means of transport facilities. As transport operations is the direct expression of the connections between separate stages of goods circulation, the efficiency of this process greatly depends on the facilities, by means of which, cargo, including liquid cargo, is transported.

The problem of the type of transport selection is solved in complex with other logistic problems, such as creation and maintain of optimal level of the stocks and selection of package type. The base for the selection of the most suitable type of transport for the specific transportation is the information regarding the characteristics of various types of cargoes (for instance, liquid cargo) and volumes to be transported [3, 4].

Problem set-up

Liquid cargoes occupy up to 10 %, in the general structure of transportation, main part of liquid cargoes (approximately 90 %) falls on oil and petroleum product (5). That is why, determination of the regression dependences which describe the dynamics of the volumes of oil and petroleum products transportation in Ukraine and can be used for the prediction of the necessary quantity of transport facilities, is relevant scientific-engineering problem.

Analysis of the recent studies and publications

Selection of the corresponding transport facilities for the transportation of various types of cargoes is one of the challenges in logistic. The problem emerges, when the companies decide to own their transport vehicles, sign contracts with drivers or owners of the transport vehicles, chose transport company with certain type of motor vehicles. This especially concerns the transportation of the liquid cargoes, as it is seen from [6, 7], in these studies this problem is paid much attention to.

It is necessary to take into consideration a great number of influencing factors, as the consequences of the transport vehicle choice will have a lasting impact on the efficiency and profitability of the cargoes transportations.

Characteristics of the cargo includes method of loading and unloading of cargo, transporting conditions, usage of transport vehicle carrying capacity, requirements, regarding the cargo safety, these characteristics determine the selection of the truck body type. Body of the truck must be adapted to the characteristics of the cargo to be transported and this needs knowledge of cargo characteristics [8, 9].

After the selection of heavy and extra heavy lifting capacity and type of the body according to the criterion "minimum cost of cargo transportation" it is necessary the select the construction scheme of the truck for road transportation. According to the construction scheme truck can be divided into single trucks and road trains. Road trains consist of tractor-trailer or truck tractors with semi-trailers. Road trains are used for cargo transportation in order to increase the performance, reduce the fuel consumption per ton of the transported cargo, decrease of the transport expenditures and reduction of the number of drivers. Greater part of trucks are designed to operate with trailers and are equipped with towing devices. Tractor units can operate with semitrailers only as a part of a road train.

The next step in the scheme of the transport facility selection is the ranking of the set of the performance and efficiency set. Ranking is necessary for the objectiveness increase and quantitative assessment of the transport vehicles, proposed at the market of the transport vehicles, using the criteria, as well as for the calculation of the transport vehicles rating. For the criteria ranking it is expedient to use the method of focus groups survey. Focus-group must comprise leaders and logistic managers, who are the consumers and performers of the transport function at the enterprise: general direction of the enterprise, logistics manager, incoming logistics manager, production logistics manager and shipping logistics manager [10].

Efficiency assessment is aimed at the solution of four basic tasks [11]:

1) Monitoring of the transport operations.
2) Control of the transport services provision.
3) Operation management on the base of the determined trends.
4) Development of further tactical and strategic measures, aimed at the improvement of the logistic processes.

Development of the system of assessment indices is performed stage by stage [11]:

1) Formation of the strategic objectives of the company.
2) Determination of the casual relationship between strategic and tactical objectives of the company.
3) Selection of indices and determination of the target values.
4) Determination of the connection of indices with business-processes inside the enterprise.
5) Development of tactical and strategic measures.

In the work of M. A. Oklander [12] the scientist comes to the conclusion that the quality of transportations can be characterized by the following criteria: timeliness of the transportations (they

must start without delay and finish on time); completeness of transportations (transportation must be performed for complete carrying capacity of the transport vehicle); safety of transportation (transportation process must not lead to losses or decreasing of the cargo quality); economic efficiency of transportation (provide minimal expenses of the customer for cargo transportation).

For the assessment of the quality of transportation services universal methodological approach, based on the GAP-model Zeitgaml or "divergence model" can be used. The essence of the model is in the determination of the strategies and processes, the companies can use for obtaining the advantages in clients servicing. The central element of the model is «difference between the consumers», which consists of inconsistency between the expectations of the consumers and service perception.

By means of this model management of the company can determine the reasons of customer dissatisfaction with the quality of the logistic service and take necessary measures to eliminate such dissatisfaction [13].

Analysis of the possible ways of transportation and efficiency of transport vehicles showed that in the process of liquid cargoes transportation more efficient and safe types of transport nowadays are railway and automobile transport.

In the study [14] it is noted that railway transport occupies the first position concerning cargoes supply, the second position is taken by pipeline transport and automobile, minor portion is taken by water transport and the smallest by the air transport.

Paper [15] is devoted to the analysis of the state-of-art of transport branch development in Ukraine. Dynamics of the transportation volumes by main types of transport is presented. Analysis of the transportation volumes dynamics by main types of transport enabled to establish that the most important type of transport for carrying passengers and cargoes is automobile transport as it is the most maneuverable and efficient type of transport for carrying small consignments at close distance. This type of transport provides functioning and territorial organization of all branches of business activity and first of all, automobile-industrial complex which occupy an important position in Ukrainian economy.

Paper [16] determines the sources of the statistical information, regarding the operation of automobile transport, indices, describing the operation of this subbranch, in particular, state of cargo and passenger transportation, are considered.

Role of the automobile transport for cargoes transportation is considered in the paper [17], the sequence of cargoes transportation and logistic agents is determined. Analysis of the state-of-art and main trends of modern market of multimodal transportations is performed, characteristic features of multimodal organization of logistic chain and their characteristics are revealed.

Materials of the paper [18] contain the results of the study of modern state and trends of the development of the markets of cargo and passenger transportations, including all the types of transport for the period of 2000 – 2018. It is noted that in Ukraine during last ten years considerable reduction of the volumes both of cargo and passenger transportations is observed. At the market of passenger transportations the fall started in 2008, and on the market of cargo transportation – since 2012, this is directly connected with world financial-economic crisis of 2008.

The study [19] presents the results of investigation of the dynamics and structure of cargo transportations in Ukraine during 2003 – 2014. The ratio of the types of transport in the cargo transportation of the country is analyzed. Dynamics of the passenger transportation and passenger circulation during 2003 – 2014 is studied. Transport intensity factor of gross domestic product is calculated and analyzed.

The analysis of modern state of the interaction of sea transport and railway transport was performed on the example of Odesa port transport hub in [20]. On the base of correlation-regression analysis forecast estimate of the volume of five types of bulk cargoes handling in Odesa port was calculated for the next ten years. The conclusions, regarding the sufficiency of the available railway infrastructure capacity for cargo passage for the forecast period are made.

Studies [21, 22] contain statistical data, concerning the dynamics of the volumes of oil and petroleum products transportation by railway and automobile transport in Ukraine in 2003 – 2021. But

the authors did not reveal any specific mathematical dependences, describing the dynamics of the volumes of oil and petroleum products transportation in Ukraine as a result of the analysis of known publications.

Objective and task of the paper

Objective of the given paper is the construction by means of regression analysis the regression dependences, describing the dynamics of the volumes of oil and petroleum products transportation in Ukraine and can be used in the process of forecasting the needed amount of the transport facilities.

Methods and materials

For the determination of the regression dependences, describing the dynamics of the volumes of oil and petroleum products transportation in Ukraine the following methods are used: regression analysis of the results of single-factor experiments and other paired dependences, computer modeling.

Results of the research

Table 1 shows the dynamics of the transportation volumes of oil and petroleum products in Ukraine [21, 22] в 2003 - 2021, which represent the greater part (approximately 90 %) of the liquid cargoes [5]. On the base of the data from Table 1 it was planned to obtained paired regression dependences, which describe the dynamics of the volumes of oil and petroleum products transportation in Ukraine by railway and automobile transport. As the argument of the regression dependences is one year, the order of its values exceeds by three orders the order of the range width of its change, then to improve the accuracy of the regression dependence it is suggested to assume the year, preceding the start of the studied range ($x = t - 2002$ and $x = t - 2014$ for railway and automobile transport, correspondingly) as the start of the coordinates.

Regression was carried out on the base of the linearized transformations, which enable to reduce non-linear dependence into linear ones. Determination of the coefficients of the regression equations was performed, applying the method of the least squares by means of the developed computer program "RegAnaliz" [23], protected by the Certificate of the State Registration of the rights to the copyright object and described in details in the papers [24, 25].

Table 1

Volumes of oil and petroleum products transportation in Ukraine, mil. tons, in different years [21, 22]

Year		2003	2004	2005	2006	2007	2008
Railway transport		27.4	23.8	20.1	17.6	17.4	13.4
Year		2009	2010	2011	2012	2013	2014
Railway transport		10.8	11.8	11.2	7.4	7.1	3.1
Year	2015	2016	2017	2018	2019	2020	2021
Railway transport	2.7	3.3	3.8	3.5	3.3	10.5	12.4
Automobile transport	0.10554	0.06786	0.05796	0.04991	0.05107	0.12973	0.14398

Program "RegAnaliz" enables to perform regression analysis of the results of single-factor experiments and other paired dependences with the selection of the rational type of function from most widely used variants by the criterion of the maximum correlation coefficient, saving the results in the format MS Excel and Bitmap.

Results of the regression analysis are shown in Table 2, where the cells with maximum values of the correlation coefficients R for each function are colored in grey.

Table 2

Results of the regression analysis of the dynamics of oil and petroleum products transportation in Ukraine

№	Type of regression	Correlation factor R		№	Type of regression	Correlation factor R	
		$m_{O.RT} = f(t)$	$m_{O.AT} = f(t)$			$m_{O.RT} = f(t)$	$m_{O.AT} = f(t)$
1	$y = a + bx$	0.79386	0.45518	9	$y = ax^b$	0.77588	0.12865
2	$y = 1 / (a + bx)$	0.63072	0.26639	10	$y = a + b \cdot \lg x$	0.90040	0.22646
3	$y = a + b / x$	0.82272	0.01137	11	$y = a + b \cdot \ln x$	0.90040	0.22646
4	$y = x / (a + bx)$	0.74861	0.51367	12	$y = a / (b + x)$	0.63072	0.26639
5	$y = ab^x$	0.73222	0.36095	13	$y = ax / (b + x)$	0.48573	0.16359
6	$y = ae^{bx}$	0.73222	0.36095	14	$y = ae^{b / x}$	0.64537	0.08096
7	$y = a \cdot 10^{bx}$	0.73222	0.36095	15	$y = a \cdot 10^{b / x}$	0.64537	0.08096
8	$y = 1 / (a + be^{-x})$	0.36134	0.24151	16	$y = a + bx^n$	0.64199	0.61754
				17	$y = a + bx + cx^2$	0.96317	0.93434

Thus, by the results of the regression analysis, on the base of the data of Table 1 the following regression dependences are taken as the most adequate:

$$m_{O.RT} = 31{,}91 - 4{,}003(t - 2002) + 0{,}1477(t - 2002)^2 \text{ [mil. t];} \quad (1)$$

$$m_{O.AT} = 0{,}1564 - 0{,}06036(t - 2014) + 0{,}008582(t - 2014)^2 \text{ [mil. t],} \quad (2)$$

where $m_{O.RT}$, $m_{O.AT}$ – annual volumes of oil and petroleum products transportation in Ukraine by railway and automobile transport, correspondingly, mil. tons; t – year. Fig 1. shows actual and theoretical graphical dependences, describing the dynamics of the volumes oil and petroleum products transportation in Ukraine.

Comparison of actual and theoretical data showed that theoretical dynamics of the volumes of oil and petroleum products transportation in Ukraine, calculated by means of regression equations (1) and (2), does not differ greatly from the data, presented in the studies [21, 22], this proves the sufficient coincidence of the theoretic results with actual data, determined earlier.

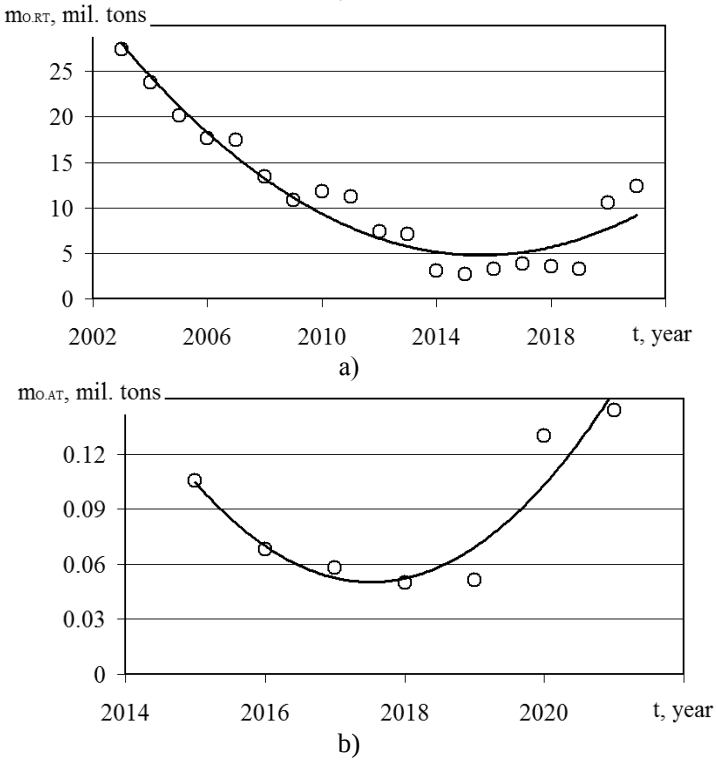

Fig. 1. Dependences, describing the dynamics of the volumes of oil and petroleum products transportation in Ukraine during 2003 - 2021: a) by railway transport; b) by automobile transport; actual ○, theoretical —

Using the dependences (1) and (2), it can be predicted, that the volumes of oil and petroleum products transportation in Ukraine at present rates of dynamics in 2025 may reach 18 mil. tons for railway transport and 0.531 mil. tons for automobile transport.

Conclusions

1. Regression dependences, describing the dynamics of the volumes of oil and petroleum products transportation by the railway and automobile transport are determined, they can be used for the prediction of the necessary amount of transport facilities.

2. Graphic dependences, describing the dynamics of the volumes of oil and petroleum products transportation in Ukraine are constructed, they enable to illustrate this dynamics and show the sufficient coincidence of the theoretical results with actual ones.

3. It is established that in Ukraine in the period of 2003 – 2021 volumes of oil and petroleum products transportation by railway and automobile transport changed according to quadratic dependences.

4. It was predicted that the volumes of oil and petroleum products transportation in Ukraine at present rates of dynamics in 2025 may reach 18 mil. tons for railway transport and 0.531 mil. tons for automobile transport.

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Editorial office received the paper 29.11.2023.
The paper was reviewed 10.12.2023.

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