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Time Effect in Logistics

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***Abstract*— The article presents the results of a theoretical study relating the efficiency of indicators of road traffic vehicles as the basis for solving a new problem connected with development of a model needed to correct the effort measurements of the participants in the international supply chains. The necessity for application of the proposed recommendations to the analysis and control of transportation services has been justified. The distinctive feature of the given recommendations consists in providing an objective account of transportation services based on the travelling time factor which ensures comparability of the indicators. We also achieved our research goal to simulate the changes in the transportation services and the amount of transport operations depending on the values of the given coefficient. The basic principles of our study include the method of substitution chains, including the index and comparative approaches. The objective of the research was to develop a flow chart and algorithm in order to calculate the correction coefficient and transportation volumes. The given algorithm was used to test the proposed recommendations in the form of numerical simulations applied to the road vehicle enterprises in Saratov region. Application of the recommended indicators provide the advantages relating the starting points of the analysis based on the scale and performance characteristics. It is proposed to form the "time window" as a tool in regulating the pace and distribution of responsibility in the supply chain.**

Keywords*— transport service, logistics, time factor, road traffic vehicles.

1. Introduction

One of the reasons for poor coordinating activities between the participants in the logistics process and the subdivisions of an enterprise, which are responsible for organization of the transportation process, and the load discharge process as the initial/tail-end operation, including logistics services, is the insufficient theoretical and practical elaboration of the issues relating effective utilization of the working time, particularly, time of the service order for road vehicles. As a result, the enterprises lose in traffic volumes and, accordingly, lose their income and profits. In this article, we have developed a methodology used to develop a model for correction estimates of the transportation rating based on a step-by-step algorithm used to determine the comparable indicators.

The goal of the work is to show that application of the model of corrective estimates to the characteristics of transportation in the logistics services in the form of the time coefficient of the running time of a vehicle allows us to describe and simulate the numerical changes in the transport operations, and the amount of transportation services depending on the values of the given coefficient.

To achieve the goal, it is necessary to solve a new problem, and therefore, simulate a new model for correction of transportation ratings through interaction of the participants in the logistics process. The given model might be used in the analysis and monitoring of the process of transportation services. Utilization of the model ensures more objective estimates of the transportation operations by comparing the rates accepted for calculation and analysis.

Ease of Use The practical outcome of the conducted study demonstrates that application of the proposed model for improving the quality of transportation operations allows for upgrading the reliability of the source data when planning the amount of transportation indicators, the efficiency of labor, transport costs and improve the utilization of the road traffic vehicles through improvement of the ratio of the travelling time and the standing time during the loading, unloading and operations related with the logistics services [1].

Methods. The given research is based on the works of the Russian [1,2,3, 6,7,8,9,10,12,16,17,22,23,25] and foreign scholars [11,15,26], including such methods as the chain substitutions, index and comparative methods. Creation of the model for improvement of the estimates is presented as a step-by-step process which consists of the description of the current state of transportation services by means of operational and volumetric indicators of the transportation process interconnected by the functional inter-dependence and transition to estimation periods.

The importance and topicality of the research is connected with the need to increase the efficiency of road traffic vehicles in the logistics process is, on the one hand, due to the increase in the transportation costs promoted by the rising costs of the operation resources, and on the other, to toughening of the requirements for the terms, quality, and reliability of the delivery services.

In the opinion of Lauri Ojala and Harri Lorentz [26], the level of the logistics competence in Germany, Sweden, Norway, Finland and Denmark is rated in the top 10% of the 166 countries surveyed in the World Bank's LPI. Poland, Estonia, Latvia and Lithuania are rated within the top 1/3, while Russia is just below.

In spite of numerous studies in the field of organization, planning and analysis of transportation operations carried out in different years [16,17,18,19,20,21], there remain a set issues related with the logistics approach to transportation services. Thus, there is a need fo9r the scientific approach to the ways and methods used to identify the reserves for reducing unproductive expenditures and increasing productivity labour in international supply chains through restriction of the working hours. The motor transport enterprises have to reconsider the type of their business and production activities, and forward these activities toward the analysis of technical and performance indicators of utilization of the road transport vehicles, in terms of interconnection between the results of the transportation process and satisfying the customer needs [17]. In the case of the long-distance export-import transportation services, the focus should be made on solving the issues with comparability of transportation indicators. In the given article we propose a formula and a model for calculating the influence of the time factor to be taken as a fraction of time of the road traffic within the total time of the work order. The given formula and the model should be used to achieve comparability of the transport products with average transportation distances, as well as transportation costs and labout productivity of the driver.

One of the reasons for low competitiveness of products in Russia is the cost for the transport and forwarding of the distribution services, which are 2 or 3 times higher than the level of these services in the advanced economies. This may be explained by the deficiencies in the transportation operations and insufficient analysis. Moreover, currently the issues related with upgrading the delivery services are given little attention [17].

By ―delivery" we understand not only transportation operations, but also other operations and services, which all together ensure effective services in the distribution of goods.

According to research conducted in the USA, the share of the transportation costs in the production and distribution processes equals one-third of the end product. Therefore, proper transportation services in the distribution of goods can be considered as one of important reserves in the process [17]. The functions of transport in the distribution system involve the transport and forwarding services.

Transportation services can be defined as activities associated with the process of transfer in space and time of freight and passengers including provision of transportation, storage and handling facilities.

The forwarding services are an integral part in the process of goods transfer from the producers to consumers, and include additional works and operations which are an inherent part of the transportation process at the departure point, and further continued and finalized at the point of destination (forwarding, business and legal, and information-consulting services).

2. Methods

Numerical simulation was conducted for the model object, characteristic for motor transport enterprises in Saratov region. The calculation pattern can be presented as a sequence of steps in time to determine the transport operations and the correction coefficient the travel time share in the overall time of the work order (Figure 1). The calculations were carried out for the planning periods 1 and 2. The results of the calculations are given in Table 2.

To calculate the defining relationships of transport performance indicators, we used the program implemented in every programming language, which allows solving a wide range of problems, including analysis of transport performance factors and the affecting factors. Electronic data processing tools used at auto plants help avoiding the problems with application of the given coefficient. This correction factor is calculated by means of the following formula:

$$kij=fai+di/dj*(1- fai) \quad (1)$$

where fa i coefficient is the time fraction of the movement time defined by the work order;

di is the average haulage distance within the i-period, km.

To consider the example given below for three periods from 0-basic, p-average, n-final final.

i=0,p

j=p,n

Transport operations or cargo turnover can be determined taking into account the travel time coefficient (proportion of movement time in the overall time of the work order):

$$He,z*fa*vf*md*kf*kl = Q , \quad (2)$$

He, z - time in the work order of vehicles (= number of vehicles * calendar time per vehicle per year * technical availability rate * coefficient of vehicle use = 20*2200*0,9*0,6 = 23760), ч.

Example:

23760ч*0,5*25км/ч*10т*0,5*1,0 = 1485000 ткм.

While the coefficient characterizing the share of movement travel in the overall time of the work order (time motion factor) is determined by the relation of the movement time to the total time of the work order, we can estimate this coefficient during the planning process using the following mathematical relationship:

$$fa = d / d + vf * md * kf * kl * hs , \quad (3)$$

where d is the average haulage distance;

vf is the average speed, km/hour;

md is the average dynamic load rating, t;

kf is the coefficient for the mileage;

kl is the coefficient for load rating;

hs is the average off-time at lift-on/lift-off per one ton of cargo.

Using the data given in the example and the table, we can confirm the correlation 0,50= 20 км/ 20км + 25 км/ч*10т*0,5*1,0*0,16 ч/т.

Today indicators of the transportation process are used in planning, calculation and providing reports. They are scarcely used to determine effectiveness and efficiency of innovations aimed at improving utilization of vehicles at enterprises.

Using the possibility of correction together with the index of improvement or implementation of a plan, or in order to compare the basic and planned indicators of transport operations by means of a simple example, we demonstrate the assigned interrelated indicators given in Table 1.

Table 1 Initial indicators for the application of the corrective factor k

Indicator	**Symbol**	**Unit measure.**	**Basic period (o)**	**Account period (1)**	**Account period (2)**
Share of movement time within the total time of the work order	fa	-	0,50	0,60	0,40
Average transportation distance	d	km	20	25	22,5
Transport operations	Q	tkm	200000	250000	225000
Transportation volume	G	t	10000	10000	10000

Development of the calculation model is based on the following principle of the problem.

Let us consider the movement of a vehicle. Let l be the total traffic route where a vehicle moved during the time Tg and was idle during the time Tp.

In this case, we assume the motion to be uniform with an average velocity Vcr. The considered factor influences the volume of work performed (transportation, the traversed path), the cost of works, the value of its influence is recommended to be evaluated by the value of fanε [0,5; 0,6], the correction factor or correction coefficient k0, n is calculated from these values. We calculate the values k0,n of the correction coefficients for the two extreme values fai. The correcting factor itself is calculated by the formula:

kij=fai+di/dj*(1- fai),

Q0(V)=Q0/k0,n

*Q0,n(k)= Q0/ Q0(V)=Q0,n*k0,n*

Consider the calculation in the example for three periods from 0 - basic, p - average, n - final with the following input data: let the car have a constant loadg (0) = g (1) = g (2) = 10 thousand tons. Denote the work done on these sections, respectively, Qn, where n is the sequence number of the path. At the same time Q0 -200 thousand tons, Q1-250 thousand tkm, Q2-225 thousand tkm, then the distances (paths) will be denoted by dn = Qn / gn, then

d0=200/10=20км

d1=250/10=25км

d0=225/10=22,5км

At the same time, we estimate the performance of the Qij transport operation and the Gij traffic volume using the chain substitution method:

Qij= Qj/ Qi

Gij= Gj/ Gi

Substituting the input data:

Q0,1= Q1/ Q0=250/200=1,25 (125%)

G0,1= G1/ G0=10/10=1,0 (100%)

Further, for the next segment

Q1,2= Q2/ Q1=225/250=0,9 (90%)

G1,2= G2/ G1=10/10=1,0 (100%)

then, at fa0=0,5 we have

k0,p=0,5+20км/25км*(1-0,5)=0,9

Under fa0=0,6, we have

k0,p=0,6+25км/22,5км*(1-0,6)=1,04

From the basic formulae (2) и (3)

Q0(V)=Q0/k0,1=200/0,9=222,222

Q0,1(k)= Q0/ Q0(V)=250/222,222=1,125 (112,5%)

or

*Q0,1(k)= Q0,n*k0,n=1,25*0,9=1,125 (112,5%)*

For the following period

Q1(V)=Q1/k0,p=250/1,04=240,385

Q1,2(k)= Q1/ Q1(V)=225/240,385=0,936 (93,6%)

or

*Q1,2(k)= Q1,2*k0,p=0,9*1,04=0,936 (93,6%)*

3. DISCUSSION

The process of changing the location of cargo in the international supply chain can be presented through technical and operational indicators in the form of a mathematical model. The change in the average transportation distance affects the change in time components in the work order [18].

Execution of urgent and one-time transportation, which are identified in the process of work, requires the provision of a reserve capacity for the car fleet for each group of cars. To do this, it is necessary, first of all, to analyze all performance indicators and ways to improve them [19]. First of all, this refers to the indicator which shows the time span of a vehicle under the work order (time in the outfit), which consists of the travel time and the downtime, including loading and unloading time. It is recommended to calculate the time factor of the vehicle on the line for the productive operation of the transport process. However, this method of calculation has a drawback due to the fact that idle time for loading and unloading is an integral part of the transport process and its elimination is not sufficiently justified.

The increase in time in the outfit is an extensive factor, not only the volume of transportation, but also the costs, primarily the variables, depend on this. time in the attire affects the mileage of the rolling stock. During the downtime, loading and unloading operations are influenced by the time of the logistics service operations: preliminary subgrouping of cargo, processing of transport documents, etc. Reducing downtime for these operations within the same time in the outfit leads to a relative increase in driving time, and this affects the increase in the number of riders, the increase in the productivity of cars, as a result of which the fulfillment and overfulfilment of the transportation plan can be achieved [20]. The problematic issue in the development of measures to reduce downtime under logistics operations is to improve planning and accounting for the time spent on these works.

To reduce the time of loading and unloading, and thus to rationalize the material flow, organizational measures in the field of loading and unloading are necessary [21]. For the customer, this means that special attention should be paid to the accumulation of goods at the supplier or freight forwarder for each customer's unloading site. At large customer enterprises, as well as when there is a danger of traffic jams at the gate of the enterprise or during certain unloading sites during the peak hours, the customer should raise the issue of introducing a transport management system (dispatching service) and charging fees for idle time. Minimization of downtime can be ensured through the development of packaging and loading programs, as well as the use of decentralized unloading sites.

For a number of enterprises, a "window of time" is formed. This time is set for each delivery, which is provided with a regulated clearance process at the gate and at the loading platform. In case of non-compliance with the given delivery rhythm, only one excuse is accepted: when the culprit of violations is a client who pays money to the forwarder for a simple. In accordance with the adopted procedure, the driver of a vehicle must provide his documents at the checkpoint. In the same place the compliance with the established deadlines is checked. In the absence of a note on the "time window" in the cargo bill, the driver must bring an appropriate certificate from his expedition, and only after that the delivery will start. The main difficulties in solving the tasks of accelerating the supply are due to the fact that bottlenecks can arise at the "junctions" of the links in the supply chain, and the gaps in the efficiency of managing the logistical flows.

However, V.I. Sergeev assumes that in these cases it is very useful to analyze and interpret its results in the categories of the SCOR model [22]. Also, to eliminate the negative phenomena in the chain, the supply chain engineering can be recommended.

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When adjusting with the factor k, the indices for changing or executing the transport work plan and traffic volume are the same. Therefore, calculation of this factor is sufficient to correct not only the transport work, but also the volume of transportations or the overall performance indicators of the plan for production indicators. Correctness of this method can easily be explained as follows: with the constant average distance of cargo transported, the performance indicators of the plan for volume indicators are always the same. Thus, if the impact of the changed average distance of transportation is eliminated, then corrective indices of transport work and traffic volume must be coordinated. The proposed formula used to compare the transport products with different average distance of transportation, the comparable time factor of traffic allows only at the second step of the calculation to determine the comparable transport operations.

Table 2 Analysis of changes in transport work

Indicators	Value
Changes in transport work Δ Qo,1:	
Total	+ 25%
due to the changes:	
- transport work (cargo turnover)	+ 12,5 %
- average transportation distance	+ 12,5%
Change of transport work Δ Q1 2	
Total	- 10,1 %
due to the changes:	
- transport work (cargo turnover)	- 6,4%
- average transportation distance	- 3,6%

Adjustments can be made either through the indicators of the calculation period, basic indicators or directly through the index of change or fulfillment of the plan. Which option to choose depends on the purpose of the adjustment. Such differentiation should be especially used for economic competition, but it would also be necessary for the production documentation, which reflects the change in transport work, and also would have high information importance for quarterly and annual analysis.

Thus, for an objective assessment of the traffic forecast, it is recommended to determine the ratio of the time share of movement in total time in the order fa and its changes using the corrective factor, since This coefficient is often discussed in the analysis of transport work, in order to plan an innovative commitment aimed at its upgrading.

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