

To enhance the efficiency of management of enterprises in the agricultural sector, it is necessary to improve logistic processes of delivery of livestock and crop production in the implementation of international road transportation. Delivery of cargo “just in time” is very important, so transportation time planning is relevant and allows reducing costs.

The process of planning the delivery of perishable goods was described. The spread of the required time is presented for transportation with a varied degree of stochasticity. It was found that the specifics of customs clearance affect the availability of a certain minimum time required for such a procedure. The time of customs clearance of cargo and delay time affect the deadline for cargo registration in international road transportation. The widest spread of time is observed by the procedure of customs clearance of cargoes that takes from 12 to 25 hours, and the probability of customs clearance is only 0.435. Accordingly, this affects a decrease in indicators of “just in time” delivery. The functional dependence of the probability of transit time not exceeding the planned time was compared, depending on the data of the specified route. Based on probabilistic analysis, the possibility of unplanned deviations from the estimated terms of each stage was taken into account and the optimal set of time intervals, which allow obtaining the optimal probability of “just in time” delivery, was proposed. The total cargo delivery time does not change.

The recommendations on formulating the requirements for road transport enterprises were given. Namely, to strengthen the requirements for the time of cargo transit. These requirements include the average speed of motion, the choice of appropriate transport, planning the route in terms of the speed mode of highways, etc.

**Keywords:** perishable cargo, road transport enterprises, costs, perishable food, animal husbandry

UDC 656.073

DOI: 10.15587/1729-4061.2021.248191

# OPTIMIZATION OF INTERNATIONAL ROAD TRANSPORTATION OF CARGOES IN THE MANAGEMENT OF ENTERPRISES OF AGRICULTURAL SECTOR AND ROAD TRANSPORT ENTERPRISES

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Received date 18.10.2021

Accepted date 09.12.2021

Published date 29.12.2021

**How to Cite:** Volynets, L., Sopotsko, O., Khrutba, Y., Sevostianova, A., Levchenko, I. (2021). Optimization of international road transportation of cargoes in the management of enterprises of agricultural sector and road transport enterprises. *Eastern-European Journal of Enterprise Technologies*, 6 (3 (114)), 57–63. doi: <https://doi.org/10.15587/1729-4061.2021.248191>

## 1. Introduction

Optimization of international road transportation of cargoes is of great importance to enhance the efficiency of the transport industry and the agricultural and food sector because rapid and rationally organized border crossing is a competitive advantage of any enterprise. Logistic services of cargoes at border crossings points contribute to the development of turnover and increase the strength of supply chains.

To increase the efficiency of management of enterprises in the agricultural sector, it is necessary to improve logistic processes of delivery of livestock and crop production in the implementation of international road transportation.

To improve the interaction of road transport enterprises and enterprises of the agricultural sector, we use the logistic approach. Logistics is at the heart of any process. Production, supply, and sales are relevant logistic processes.

Effective functioning of the enterprises of the agricultural and transport sector depends on the implementation and competent application of logistic approaches, as well as the development of transport infrastructure. Logistics as a science and practice makes it possible to reduce costs in the implementation of international cargo transportation. Logistically competently organized delivery of agricultural products has a significant economic, social, and environmental effect.

To transport perishable goods (food products), it is necessary to comply with sanitary and hygienic standards and rules, since these goods have a limited shelf life, and they must be transported as quickly and carefully as possible.

Transportation of perishable cargoes (seafood, vegetables, fruits, chilled and frozen food, etc.) is carried out with the use of specialized vehicles: refrigerators and isotherms.

When carrying out international road transportation, it is important to strictly adhere to the rules of customs

clearance of cargo within minimally short terms. This is necessary for the cargo to cross the border as soon as possible without any delay. This is especially true for perishable cargoes (food). This guarantees the greatest safety of cargo when crossing the border and makes it possible to deliver cargo with the least cargo damage risks. For example, it may be quality deterioration after a long time of customs clearance as a result of a technical breakdown of a vehicle or a theft of cargo. "Just in time" delivery of cargo is very important, time planning is essential when crossing the customs border as it allows reducing costs in the implementation of international road transportation.

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## 2. Literature review and problem statement

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Paper [1] reports the results of studying the organization of a supply chain of perishable cargoes. This study proposes solutions that ensure the balance between cost, quality, and environmental problems in such a supply chain. In addition, it contains the structures of modeling to support decision-making in designing and operating cold chains in order to reach a compromise between costs, emissions, and quality. However, the issue of making such decisions in the implementation of international road transportation remains unresolved. After all, effective organization of food exports between countries is relevant. At the same time, the issue of food exports between the countries is well researched in paper [2].

In particular, the emphasis was placed on the fact that inefficiency of logistics hinders export and causes delays of food cargo transportation across the border, and is a key factor that increases the cost and unpredictability of a supply chain. The paper points out that delays of cargo at border points are intended to reduce the risk of non-payment of duties and to prevent smuggling. In this study, the risks are compared to the risks to trade caused by unpredictable delays at a border crossing. The wider use of information technologies was proposed to balance the impact of customs and trade risks. The drawback of this study is that it was carried out for such region as South Africa. The development of this issue is necessary and relevant for European countries. It is advisable to conduct research not only for such region as South Africa but also for other regions to develop their food exports.

It is worth paying attention to research [3], which focuses on the principles of a stable distribution of perishable goods and considers an example of the application of such principles to business practice, identifies current problems of sustainable distribution of perishable goods. It is noted that economic and organizational factors are the most important among many other factors. Insufficient attention is paid to the issue of the effective organization of vehicles for the transportation of perishable goods.

The problem of effective transport organization is considered in article [4], which explores the logistics of refrigerators as a difficult task since it deals with costs and time constraints, as well as with requirements for product quality.

This article notes that there is a compromise between such factors as transportation time and the quality of fresh products. One cannot but agree with this. The merit of this work is that at the high value of refrigerators, effective logistics is just as important as effective cargo flows. This causes technical complications and a conflict of interest between cargo shippers and transport owners and terminals.

An option of overcoming the corresponding difficulties may be the approach proposed in paper [5]. It offers to enhance the efficiency of supply management based on the development of the methods and models of rational management of transport service systems in chains of supply of perishable cargo.

When it comes to the problem of reducing the cost of international road transportation, it is considered in papers [6, 7].

Another study [6] examines analytical models developed in the United States which allow solving the problem of the high cost of international transportation. Based on the research, appropriate tools were provided to make decisions for the transportation of Chinese products by road to enter the international market and create distribution networks.

It was proposed in paper [7] to enhance the efficiency of international road transportation by reducing the cost of transport services by applying the methodology for determining the cost of fuel according to the criterion of the highest use of fuel in countries with the lowest prices.

Research [8] used the Fuzzy Delphi and Fuzzy ELECTRE methods to improve cargo transportation by road from Korea to Central Asia.

However, the issue of the time of transportation of perishable cargo and its security remains unresolved, though this is an important factor in such transportation.

An option for overcoming the corresponding difficulties may be the model proposed in paper [9], which is based on two main criteria for assessing the solution: the cost criterion and the cargo safety criterion. The merit of this model is that it includes such factors as acceptable transportation time, minimum or maximum temperature in the direct environment of the cargo, and resistance to mechanical damage. But the issues related to additional characteristics of perishable goods remained unresolved.

Similar problems were considered in article [10]. The problems of the chain of supply of perishable goods related to the temperature being above or below the optimal range and posing a threat to food safety were studied. The emphasis was placed on the study of temperature and time conditions at each stage of such a supply chain to assess its profitability. At the same time, the article does not pay attention to the risks arising in the transportation of perishable goods.

All this allows asserting that it is advisable to conduct a study devoted to the problems of effective organization of international road transportation of perishable cargoes with the optimal organization of transportation time and ensuring maximum safety of cargo. After all, the optimal time for the transportation of perishable cargo reduces the risks of its damage and losses. At the same time, the issue of reducing costs in the implementation of international road transportation remains relevant.

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## 3. The aim and objectives of the study

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The purpose of this research is to determine the ways to optimize the international road transportation of perishable goods in the management of enterprises of the agricultural sector and road transport enterprises. Effective interaction of these two types of enterprises has a positive impact on the economy of any country and the development of both industries.

To accomplish the aim, the following tasks have been set:

- to analyze the route data and compare the dependences of probabilities of the duration of time indicators of customs clearance with the available statistic data;

- to offer an optimal set of time intervals for each of the transportation stages to ensure maximum efficiency of “just in time” delivery;
- to provide recommendations for the organization of international road transportation of perishable goods, which contribute to reducing costs.

#### 4. The study materials and methods

At the initial stage of the study, the results of scientific works in the field of international road transportation were analyzed and the issue of cost reduction in the implementation of such transportations was studied.

Ukraine exports livestock and crop production. The statistical data [11] show what types of goods Ukraine exports and illustrates the fact they include those with limited shelf life.

Since these products require appropriate storage and transportation rules and may be limited by the shelf life, the process of its transportation across the border must be carried out with minimal delays. This will make it possible to preserve products, deliver them on time, and increase the rating of Ukrainian enterprises, both product manufacturers and carriers, in the international market.

In the first half of 2021, exports of goods amounted to USD 29,924.0 million or 130.7 % compared to the first half of 2020, imports made up USD 31,250.6 million, or 128.0 %. The negative balance amounted to USD 1,326.6 million (in

the first half of 2020 it was also negative – USD 1,519.4 million). Table 1 gives the commodity structure of foreign trade in the first half of 2021.

The main positions of perishable foods, according to the UCTSED classifier, include groups 02, 03, 04, 07, 08, 16, 21. The peculiarity of their storage and transportation is the requirement to maintain a certain temperature mode from the moment of production, during the transportation process to the moment of consumption.

Planning the delivery of perishable cargoes (food products) is associated with the need to take into account various irregular factors affecting the transportation time of such cargo from the loading place to the receiver. This process is multi-stage and is especially complicated if it is necessary to cross the state border and carry out procedures for the preparation of accompanying documentation, customs control, etc.

According to the company, the data on which were taken for the research, the late delivery of perishable goods account for 12 % in domestic traffic, and for international transportation, this figure is 35 %, which is much higher.

For the mathematical description of such processes within the logistic cycle, it is advisable to use probabilistic methods [12], based on the available statistical data of the passage of routes. For example, Table 2 gives actual data on the food product delivery by refrigerated transport along the route “Belgium-Meyer – Verbomont – p/p Yagodyn – Chaiky village, Stoyanka village”.

Table 1

Commodity structure of foreign trade in the first half of 2021 (from Supplement 2) [11]

Code and name of goods according to UKTSED	Export	Import				
	USD, thousand	in % to I half of 2020	in % to total volume	USD, thousand	in % to I half of 2020	in % to total volume
Total	29923963.2	130.7	100.0	31250630.4	128.0	100.0
Including:	–	–	–	–	–	–
I. Livestock; animal products	599032.8	105.3	2.0	676849.6	123.4	2.2
01 livestock	19072.2	82.2	0.1	42057.1	125.8	0.1
02 meat and subproducts	373327.1	116.9	1.2	81525.9	121.6	0.3
03 fish and shellfish	15996.4	114.0	0.1	376740.6	127.6	1.2
04 milk and dairy products, poultry eggs; natural honey	178061.5	86.7	0.6	164121.9	115.1	0.5
05 other animal products	12575.6	184.8	0.0	12404.1	121.7	0.0
II. Vegetable products	5046874.1	98.1	16.9	1196732.8	110.5	3.8
06 trees and other plants	4025.7	142.0	0.0	42823.3	175.3	0.1
07 vegetables	65918.9	101.9	0.2	173864.6	90.8	0.6
08 edible fruit and nuts	104901.9	110.7	0.4	367134.0	107.5	1.2
09 coffee, tea	6648.4	97.3	0.0	121680.2	108.1	0.4
10 grain crops	4447626.6	98.7	14.9	118483.0	94.8	0.4
11 products of flour and cereal industry	73199.0	81.0	0.2	32958.2	209.1	0.1
12 seeds and oil plant products	332981.7	96.6	1.1	326038.7	126.0	1.0
13 natural shellac	1845.1	439.9	0.0	13320.4	101.2	0.0
14 plant materials to produce	9726.8	28.4	0.0	430.4	134.3	0.0
III. 15 Animal and vegetable fats and oils	3297894.6	112.5	11.0	201134.9	170.6	0.6
IV. Ready-made food products	1868076.9	115.7	6.2	1558445.0	121.5	5.0
16 Meat and fish products	11411.5	129.5	0.0	81345.9	118.2	0.3
17 Sugar and confectionary products	114105.2	104.3	0.4	86962.2	268.9	0.3
18 Cocoa and its products	102446.6	127.5	0.3	199745.8	131.3	0.6
19 Ready-made grain products	188924.3	139.7	0.6	130676.0	119.8	0.4
20 Products of vegetable processing	77369.1	100.3	0.3	122463.1	129.0	0.4
21 Different foods	90237.4	112.8	0.3	262430.3	121.8	0.8

Table 2

Statistic data on the time of passing the route “Belgium-Meyer – Verbomont – p/p Yagodyn – Chaiky village, Stoyanka village” at various stages of food product delivery

No by order	Registration time, h	Loading by documents	Registration time, h	Unloading	Transit time, day	Clearance at the border, h	Distance, km
1	48	24.03	24	28.03	4	15	2206
2	48	07.04	24	11.04	4	12	2250
3	48	21.04	24	25.04	4	12	2250
4	48	05.05	24	10.05	5	18	2206
5	48	19.05	24	23.05	4	12	2206
6	48	02.06	24	07.06	5	20	2206
7	48	16.06	24	20.06	4	12	2206
8	48	30.0	24	04.07	4	12	2206
9	48	14.07	24	19.07	5	20	2206
10	48	28.07	24	01.08	4	12	2206
11	4+48	23.0825.08	48	30.08	5	18	2560
12	48	08.09	24	12.09	4	12	2206
13	48	22.09	24	26.09	4	12	2206
14	48	06.10	48	11.10	5	18	2206
15	48	20.10	24	25.10	5	20	2206
16	48	03.11	24	07.11	4	12	2206
17	5+48	15.1117.11	48	22.11	5	18	2560
18	48	01.12	24	06.12	5	18	2206
19		21.12		28.12	7	25	2007
20	48	12.01	24	16.01	4	12	2222
21	48	25.01	48	30.01	5	15	2222
22	48	09.02	24	14.02	5	18	2222
23	48	23.02	24	28.02	5	15	2222
24	48	09.03	24	16.03	7	16	2270

Using the example of the presented route of international road transportation of food products, we calculated the time of cargo passage at various stages. The effectiveness of perishable cargo passing without delay allows reducing the risks of its damage. After all, there are situations of increasing the temperature of transportation above the optimal range.

We made a review of the field studies of temporary temperature conditions at each critical stage of the cold chain to assess the current state of commercial cold supply chains. Optimization of cargo passing time at each stage of the supply chain affects its profitability.

**5. Results of research into the ways of optimization of international road transportation of perishable cargo**

**5.1. Analysis of route data and comparison of dependence of the probability of customs clearance during the time**

The conducted analysis of the data at different stages of passing the specified route shows the spread of the required time  $t_i$  (where  $i$  is the stage number) with a different degree of stochasticity.

In particular, clearance time at the border has a fairly wide spread of values in the range from  $t_{Tmin}=12$  hours to  $t_{Tmax}=25$  hours. In order to determine the probability of  $p_T$  [13] of transport going through the clearance procedure within time  $t_T$ , it is possible to use the description of data in Table 2 within Weibull statistics [14], specifically:

$$p_T = p_T(t) = 1 - \exp\left[-\left(\frac{t - t_A}{B_T}\right)^\eta\right], \tag{1}$$

where  $t_A, B_T, \eta_T$  are Weibull coefficients.

To solve the considered problem, ratio (1) cannot be applied directly in the specified form due to the rupture of the function  $p_T(t_T)$ , namely:

$$p_T(t_T) = \begin{cases} 0, & \text{at } t_T < t_{Tmin}; \\ p_{T0}, & \text{at } t_T = t_{Tmin}; \\ f(t_T), & \text{at } t_{Tmin} < t_T < t_{Tmax}; \\ 1, & \text{at } t_T > t_{Tmax}, \end{cases} \tag{2}$$

where  $f(t_T)$  is exponential function of form (1).

This is due to the specifics of customs clearance, namely the existence of a certain minimum time  $t_{min}$  required for this procedure, and delay time  $dt$ , which determines the deadline for registration.

To formalize the mathematical description of  $p_T(t)$  function, we can assume that going through procedure “just in time” and “delayed” are independent, so  $p_T(t)$  can be represented as:

$$p_T(t_T) = 1 - (1 - p_{T0}) \times \exp\left[-\left(\frac{t_T - t_{Tmin}}{B_T}\right)^\eta\right], \tag{3}$$

where  $p_{T0}$  is the probability of customs clearance “on time”,  $dt_T = t_T t_{Tmin}$  is the planned delay time.

Based on the data in Table 2, the probability of customs clearance within time  $t_{Tmin}=12$  hours is  $p_{T0}=0.435$ . Weibull coefficients allow approximation of available statistic data with the best degree of accuracy (Fig. 1) and are equal to  $B_T=5.4$  h and  $\eta_T=3.5$ .

**5.2. Determining the optimal set of time intervals for each transportation stage**

Similarly, we can determine the dependence of the probability of pTR of transit time, which does not exceed the planned time tTR, for which the corresponding coefficients determined according to the presented data have the following values: tTRmin=4 days is pTR0=0.478, BTR=0.5 days, and ηTR=0.8 (Fig. 1, 2).

Two stages of customs clearance of perishable cargo are characterized by poorly expressed stochasticity, and therefore can be described by discrete (threshold) functions  $p_{S1}=p_{S1}(t_{S1})$  and  $p_{S2}=p_{S2}(t_{S2})$  of the following form:

$$p_{S1}(t_{S1}) = \begin{cases} 0, & \text{at } t_{S1} < t_{S1}^{\min} \\ p_{S1}^0, & \text{at } t_{S1}^{\min} \leq t_{S1} \leq t_{S1}^{\max} \\ 1, & \text{at } t_{S1} > t_{S1}^{\max} \end{cases}, \quad (4)$$

$$p_{S2}(t_{S2}) = \begin{cases} 0, & \text{at } t_{S2} < t_{S2}^{\min} \\ p_{S2}^0, & \text{at } t_{S2}^{\min} \leq t_{S2} \leq t_{S2}^{\max} \\ 1, & \text{at } t_{S2} > t_{S2}^{\max} \end{cases}, \quad (5)$$

Based on the data in Table 2, coefficients of ratios (4) and (5) take the following values:  $t_{S1}^{\min} = 48$  hours,  $t_{S1}^{\max} = 53$  hours,  $p_{S1}^0 = 0.913$ ,  $t_{S2}^{\min} = 24$  hours,  $t_{S2}^{\max} = 48$  hours,  $p_{S2}^0 = 0.826$ .

Thus, when planning the delivery time of perishable cargoes (food products), we can use the principles of probabilistic analysis. This analysis makes it possible to take into account unplanned deviations from the estimated terms of each stage.

Based on the results of the analysis, we choose the optimal set of planned time intervals  $t_i$  ( $t=T, TR, S1, S2$ ), which allow obtaining the optimal probability of “just in time” delivery”  $p(t)$ :

$$p(t) = p\left(\sum_i t_i\right) = \prod_i p_i(t_i), i = T, TR, S1, S2. \quad (6)$$

As an example, the following system of planned terms of transportation of perishable cargoes (food products), which corresponds to the estimated magnitude of the probability of fulfilling these terms (Table 3), is considered below.

The planned time was calculated as follows:

$$t = T + TR \cdot 24 + S1 + S2, \quad (7)$$

$$t = 13 + 5.5 \cdot 24 + 50 + 48 = 243 \text{ hours.}$$

Calculation of the probability of plan execution:

$$p = pT \cdot pS1 \cdot pS2, \quad (8)$$

$$p = 0.43632518 \cdot 0.953057 \cdot 0.913 \cdot 0.826 = 0.313603 \approx 0.314.$$

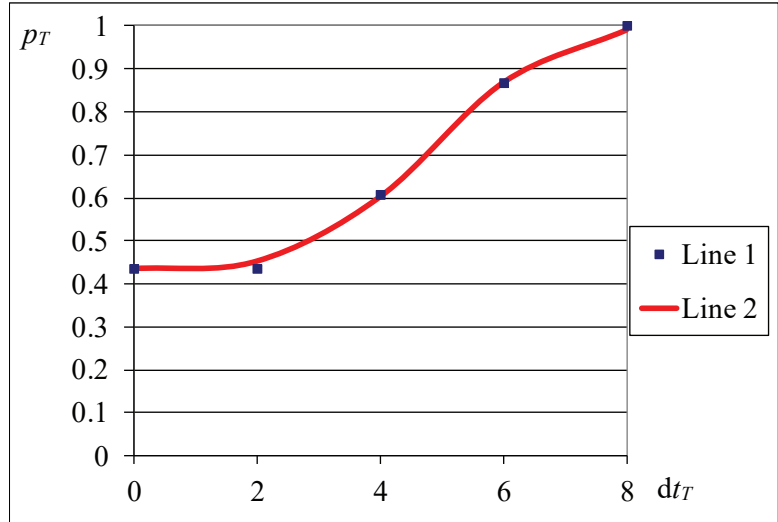


Fig. 1. Comparison of functional dependence of the probability of customs clearance within time  $t_T p_T(t_T) = p_T(t_{Tmin} + dt_T)$  (—) with available statistic data (■)

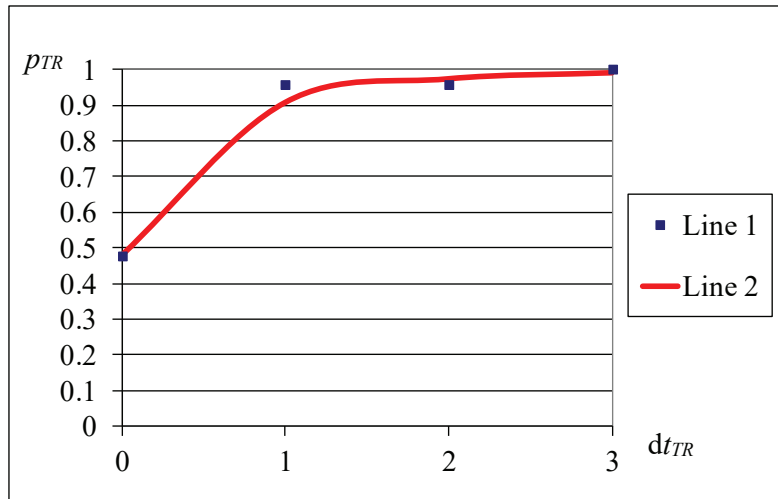


Fig. 2. Comparison of functional dependence of the probability of transit time that will not exceed planned time  $t_{TR} p_{TR}(t_{TR}) = p_{TR}(t_{TRmin} + dt_{TR})$  (—) with available statistic data (■)

Table 3

System of planned terms of transportation of perishable cargoes (food products)

Transportation stages	Planned time, hours	Probability of plan execution
Customs clearance	13	0.436
Transit	132	0.953
Clearance S1	50	0.913
Clearance S2	48	0.826
Total	$t=243$	$p=0.314$

As it can be seen from Table 3, the probability of such a system of delivery terms is characterized by a low total probability of execution – 0.314. This is due to sufficiently high requirements at the stage of customs clearance of perishable cargoes, where the probability of execution is 0.436. At the same time, the optimization of such terms can significantly improve probabilistic indicators of “on time” delivery at the same magnitude of the total delivery time (243 hours). For example, according to such requirements, the probability of execution will be  $p = 0.999 \cdot 0.909 \cdot 0.913 \cdot 1.000 = 0.829$  (Table 4).

**Table 4**  
Probability of “just in time” delivery

Transportation stages	Planned time, h	Probability of plan execution
Customs clearance	22	0.999
Transit	120	0.909
Clearance S1	51	0.913
Clearance S2	50	1.000
Total	$t=243$	$p=0.829$

Table 4 shows the probability of “just in time” delivery based on the conducted calculation. At the same time, we proposed a distribution of transportation time at each stage, different from the existing one, in accordance with the statistics of the route. The total time of cargo delivery does not change. Thus, the probabilities of customs clearance for a certain time were compared with the available statistic data. The results of this study can be used in planning international road transportation of perishable goods. According to calculations in Tables 3, 4, we can conclude that according to existing data, the probability of “just in time” delivery was 0.314, and according to the proposed option – 0.829. Thus, it is possible to increase the probability of “just in time” delivery by 63 %.

**5. Recommendations on the organization of international road transportation of perishable cargoes, which contribute to reducing costs**

According to the results of the data of probabilities of “just in time” delivery of the conducted study, general recommendations for road transport enterprises in the implementation of international road transportation were determined. Among such recommendations, there is strengthening the requirements for the cargo transit time. These requirements include the average speed of motion, the choice of appropriate transport, route planning in terms of the speed mode of highways, etc. At the same time, it is recommended to increase the time allowance for customs clearance.

**6. Discussion of results of determining the ways to optimize international road transportation of perishable cargoes**

The work proposes ways to optimize international road transportation of perishable cargoes. An example of one of the routes of international road transportation was considered. Analysis revealed the shortcomings in the planning of such a route. Alternative solutions, such as more optimal planning of route time, namely increasing time allowances during customs clearance, were proposed. During the calculations, it was found that an increase in time allowances for customs clearance of cargo increases the efficiency of “just in time” delivery.

According to the results of the conducted study, general recommendations for road transport enterprises in the implementation of international road transportation were determined.

The research was carried out according to the route of transportation of perishable cargoes (Table 2). Relevance

and demand are proved by statistics (Table 1), which reflects the indicators of exports of livestock and crop production.

Analysis of route data and comparison of dependences of the probability of customs clearance within the time with available statistics showed the spread of the required time with various stochasticity degrees. It was found that the time of customs clearance at the border has fairly wide spread. Weibull distribution was used in the course of the study. Approximated statistic data were shown in Fig. 1. In addition, using Weibull distribution, the dependence of the probability of transit time was determined and the corresponding Weibull coefficients were found (Fig. 2).

We used the principles of probabilistic analysis, with the help of which unplanned deviations from the estimated terms of each stage were taken into account. Thus, an optimal set of planned time intervals, which, in turn, ensure “just in time” delivery, was formed. Table 3 shows the information about the planned terms of transportation and the probability of their implementation based on the performed calculations. The optimization of delivery time and calculation of the probability of their execution are proposed in Table 4.

The specific features of this method include the possibility of determining time delays at each stage of transportation and making appropriate management decisions. According to this method, it is possible to analyze other routes and determine which stage of transportation has the lowest probability of execution. After that, we find the optimal intervals of transportation time for each stage. After determining the stage with the least probability of execution, it is necessary to pay attention to it and analyze the reasons for this. The reasons for the low probability of execution can be quite diverse – from a single-time breakdown of a vehicle to systemic low cooperation with suppliers. That is why in any case, the indicators of low probability of implementation of the transportation plan show a weak place in the supply chain of perishable cargoes. This allows the identification of more global problems that cause such a situation.

For example, in paper [5], the management of transport service systems was proposed, but the time characteristics in the management of supply chains of perishable food products were not considered. Article [7] proposed ways to improve the efficiency of international road transportation by reducing the cost of transport services. However, the possibility of such optimization through optimal time allocation at the transportation stages, which in turn also contributes to reducing the cost of transportation, was not explored.

Paper [9] is similar, in which the model includes such a factor as an acceptable transport time. Study [10] considers temperature and time conditions at each stage of the supply chain, that is, the study offers the choice of the optimal time with temperature conditions. In the research, we explore the transportation time, not linked to the temperature conditions of cargo transportation. That is why these studies are different.

The limitations of this study are that it was carried out on the example of a route for transportation of perishable goods. The subsequent study can be carried out for other types of cargo.

The drawback of the paper is that the problem of whether the costs will increase if transit requirements are strengthened was not explored. It would be necessary to point out in the recommendations the ways to strengthen transit requirements and conduct relevant analysis according to the statistics of the same enterprise.

The procedure of customs clearance of cargo was not considered either. It was not taken into account what factors affect the time of cargo clearance. It would be expedient to consider the factors influencing the cargo delay during customs clearance and provide recommendations for their elimination. At the same time, we cannot but agree with the provided calculations, which show the expediency of increasing the allowance of time for customs clearance. When it comes to the factors that affect the time of crossing the border by perishable cargo, it may be the object of subsequent research. In addition, the elimination of such factors will make it possible to reduce the time of customs clearance and speed up the process of transportation in general. But an increase in time of allowance for customs clearance of cargoes and identification of factors that affect it are two different studies that contribute to enhancing the efficiency of international road transportation. That is why there are some grounds to believe that recommendations to increase the time allowances when crossing the border are relevant.

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## 7. Conclusions

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1. The study analyses the data of the route for road transportation of perishable cargoes. The spread of the time required for each stage was determined. The widest spread

of time is characteristic of the procedure of cargo customs clearance from 12 hours to 25 hours, and the probability of customs clearance is only 0.435. Accordingly, this affects a decrease in indicators of “just in time” delivery. The functional dependence of the probability of transit time not exceeding the planned time for the data of the specified route was compared. The calculation of “just in time” delivery with the distribution of transportation time at each stage, different from the existing one, was proposed. The total time of cargo delivery does not change, and the probability of executing the plan, in this case, is 0.829.

2. To solve the problem of planning the delivery of perishable goods, taking into account irregular factors affecting the transportation time, unplanned deviations from the estimated time of each stage were taken into account. The optimal set of planned time intervals, which allow obtaining the optimal probability of “just in time” delivery was proposed. Specifically, it was suggested to increase the planned time for customs clearance from 13 hours to 22 hours due to reducing transit time.

3. It was recommended to increase time allowances for customs clearance when planning international road transportation of perishable cargoes. It is also advisable to strengthen the requirements for the transit time of cargo. These requirements include the average speed of motion, the choice of appropriate transport, route planning in terms of the speed mode of highways, etc.

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