Management of consumers needs for volume of transportation, taking into account the probable nature

Abstract. The article investigates the issue of continuous provision of consumers' needs for transportation, which is formed by chance. At the same time, the indicators of elementary random processes aimed at satisfying the needs of consumers in transportation were investigated, and corresponding mathematical models were formed for them; methodological properties and aspects of this approach were also substantiated. Based on the cost of transporting raw cotton materials from the Nuriston cotton station to the Nishan cotton ginnery, the reliability of the results of operational planning of transportation and transportation management is considered. Based on the mathematical models presented in the article, it becomes possible to continuously meet the production needs of an enterprise at any random cost of consumed and transported goods.

1 Introduction

In the globalization of the services market, the development of information technologies, ensuring the continuity of transport services in business processes and production processes, using the latest technologies, optimizing economic management, and reducing material costs demonstrate the importance of logistics approaches. The transport service must be focused on continuously meeting the transport needs of consumers. This required meeting this need in time intervals. Because of this, it is necessary to satisfy the consumer's need for a certain amount of randomness, which is formed daily. This situation requires the study of basic customer service processes and adequate modeling.

Leading scientists of the world and our country have conducted research to improve the efficient use of road transport and create a scientific base to improve the quality of service [2, 3, 4, 5, 6, 8, 12, 20, 21]. Scientists' studies show that such important factors as the technical nature of the connection of the recipient (or sender), the need for transport capacity, and the relationship of the set of elements that make up transportation in determining the continuity of consumer demand and the scale of interaction between them are not fully taken into account. In this case, the parameters and models characterizing the transfer processes are expressed using averaged indicators, which should take into account...
2 Research methodology

The consumer's need for the volume of cargo on a given day depends on the number of cargo reserves ($Q_z$) remaining at the end of the previous day and the volume of cargo consumption on the same day ($Q_u$). If $Q_z > Q_u$, then this consumer cannot be...
To ensure uninterrupted production, the company must transport at least \( Q_u - Q_3 \) tons of cargo, where \( Q_u, Q_3 < 0 \). The expected value of \( Q_u \) on the next day is probabilistic and cannot be clearly determined. As a result, it is usually possible to guarantee that the amount of daily stocks is much greater than any value of the consumption parameter, which allows the enterprise to constantly meet production needs for any arbitrary value of the amount of consumed and transported goods.

Each element and indicator of the transport process should be defined for each type of vehicle \( i \), each driver \( r \), and each direction of transport \( j \). For example, one of the elementary transportation processes is expressed by the time of travel with cargo \( t_{\text{with cargo}} \). The time of the trip with cargo consists of the idle time of the vehicle at the shipper and the consignee \( t_{\text{idle}} \), and the time of the trip with cargo between these points \( t_{\text{openreceive}} \), that is \( t_{\text{with load}} = t_{\text{openreceive}} + t_{\text{simple}} \) (1).

The travel time takes into account the time spent traveling without cargo to the point of departure of the cargo to deliver the vehicle for the next flight \( t_{\text{empty}} \), i.e. \( t_{\text{trip}} = t_{\text{with cargo}} + t_{\text{empty}} + t_{\text{simple}} \) (2).

Travel time \( t_{\text{trip}} \) depends on the length of the run with and without cargo \( l_{\text{with cargo}}, l_{\text{empty}} \) and the technical speed of the rolling stock with and without cargo \( V_T_{\text{loaded}}, V_T_{\text{empty}} \), i.e. \( t_{\text{trip}} = l_{\text{with cargo}} V_T_{\text{loaded}} + l_{\text{empty}} V_T_{\text{empty}} + t_{\text{simple}} \) (3).

The number of trips of a motor vehicle \( Z_{\text{trip}} \) during its stay in the route \( T \), and the volume of cargo transported \( Q_{\text{p}} \) is defined as follows:

\[
Z_{\text{trip}} = \frac{T - t_0}{t_{\text{trip}}} = \frac{T - \sum_{\text{load}}}{V_T_{\text{loaded}}} + \frac{\sum_{\text{empty}}}{V_T_{\text{empty}}} + t_{\text{simple}} \]

\[
Q_{\text{p}} = q_{n} \gamma_{St} Z_{\text{trip}}
\]

In the above expressions, only the parameters \( \sum_{\text{load}}, T, l_{\text{with load}}, l_{\text{empty}} \) are constant values, and the rest are formed as random indicators. The trip time is formed as a complex function of distance and random speed parameters, i.e. \( t_{\text{trip}} = f(l_{\text{with load}}, l_{\text{is empty}}, V_T_{\text{with load}}, V_T_{\text{empty}}, t_{\text{simple}}) \) (6).
operation, the physical and mental state of the driver, etc. However, the influence of these factors on the speed of movement is not constant over time and along the route. This influence changes over time and on different sections of the route. Therefore, parameters such as the vehicle's technical speed, idle time at the shipper and consignee, and travel time with and without cargo should be considered as the mathematical expectation of random variables.

\[ T_{\text{trip}} = \frac{t_{\text{with cargo}}}{V_T^{\text{loaded}}} + \frac{t_{\text{empty}}}{V_T^{\text{empty}}} + t_{\text{idle}} \]

\[ (Z_{\text{trip}}) = \frac{T - \sum l_i/M(V_T^{\text{THEN}})}{M(t_{\text{trip}})} \]

\[ (Q^n) = q_n \gamma s t M(Z_{\text{trip}}) \]

From a probabilistic point of view, random variables \( X = (t_{\text{simple}}, V_T^{\text{with the load}}, V_T^{\text{empty}}) \) are expressed by the laws of parameter distribution. The distribution law relates the possible values of a quantity to the probability of their realization. There is a universal form of the distribution law for continuous and discrete quantities in which the distribution function is \( F(x) \).

\[ F(x) = P(X < x) \]

\[ F(x) = \int_{-\infty}^{x} f(x) dx \]

\[ P(\alpha < x < \beta) = \int_{\alpha}^{\beta} f(x) dx \]

3 Research results

An example. Consider transporting raw cotton from the Nuriston cotton point to the Nishan cotton gin plant. The route length of the direction with cargo, \( l_{\text{with cargo}} \), is 30 km. The distribution of the possible daily number of trips (for one car) performed on a given route is expressed by the law of normal distribution, and the following parameters are observed:

\[ M(Z_{\text{trip}}) = 3 \text{ – the mathematical expectation of the number of trips} \]

\[ \sigma(Z_{\text{trip}}) = 0.66 \text{ – the standard deviation.} \]

The mathematical expectation of vehicle performance is determined as follows:

\[ M(Q_T) = q n \gamma s t M(Z_{\text{trip}}) = 5.5 \times 3.0 = 16.5 t. \]
\[ A_3 = \frac{Q^n}{M(Q)} = 100 \frac{16.5}{\approx 6} \]

The first part of this expression is equal to 1 since \( f(x) = \frac{M(Z_{\text{trip}}) - M(Z_{\text{trip}})}{\sigma(Z_{\text{trip}})} = 1 - 0.5 = 0.5. \]

\[ P \left[ \frac{\infty - M(Z_{\text{trip}})}{\sigma(Z_{\text{trip}})} \right] = 1, \quad f \left[ \frac{M(Z_{\text{trip}}) - M(Z_{\text{trip}})}{\sigma(Z_{\text{trip}})} \right] = 0.5. \]

\[ P \left[ \frac{\infty - M(Z_{\text{trip}})}{\sigma(Z_{\text{trip}})} \right] = 0.9. \]

\[ P \left[ \frac{M(Z_{\text{trip}}) - M(Z_{\text{trip}})}{\sigma(Z_{\text{trip}})} \right] = 1 - 0.9 = 0.1. \]

\[ f(x) = -1.28. \]
\[
\frac{M(Z_{\text{trip}})}{A_{\text{a}} \cdot q_{\text{n}} \cdot \gamma_{\text{st}}} = \frac{Q^u}{A_{\text{a}} \cdot q_{\text{n}} \cdot \gamma_{\text{st}}}
\]

\[
\frac{Q^u}{A_{\text{a}} \cdot q_{\text{n}} \cdot \gamma_{\text{st}}} = -1.28\sigma(Z_{\text{trip}}) + M(Z_{\text{trip}})
\]

\[
A_{\text{a}} = \frac{Q^u}{q_{\text{n}} \gamma_{\text{st}} \left[ M(Z_{\text{trip}}) - 1.28 \sigma(Z_{\text{trip}}) \right]} = \frac{100}{5.5(3.0 - 1.28 \cdot 0.66)} = 11.85 = 9.
\]

4 Conclusion

Thus, 9 road trains are required to carry at least 100 tons of raw materials daily on the route, with a probability of 0.9. Similarly, it is possible to solve the problem of determining the daily working regime of a car to provide a given traffic volume or organizing transportation according to the needs of various production enterprises.

The article addressed the issue of uninterrupted provision of consumers' need for transportation; this need is formed accidentally, where elementary basic random processes aimed at meeting consumers' needs are expressed through indicators and appropriate mathematical models are built, and methodological features and aspects of this approach are also justified.

Based on the values of the process of transporting raw cotton from the Nuriston cotton station to the Nishan Cotton Treatment Plant, the reliability of the results of operational transport planning and traffic management was considered. Such approaches allow for formalizing generalized transport service processes for targeted consumers in the region and the tasks of effectively managing these processes.

References


