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

Mukhiddin Zhuraev[1*], *Jamshid* Togaev[2], and *Zokirkhon* Yusufkhonov[1]

[1]Tashkent State Transport University, Tashkent, Uzbekistan
[2]Karshi Engineering and Economic Institute, Karshi, Uzbekistan

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, 13, 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

*Corresponding author: mdjurayev82@mail.ru

the random nature of the formation of parameters and fluctuations in their values. This approach made sense to apply when drawing up annual transport plans in a planned economy. Since the average values of the parameters representing them, as a result of repeated repetition of elementary processes, would lose their random character following the law of large numbers, the theory of probability would take the form of constant values. This approach does not meet the requirements of today's conditions, i.e., the principle of providing the consumer with everyday needs at the least cost and in the number of resources.

The process of the automotive system is regular, deterministic, and controlled and belongs to the category of cybernetic systems. When managing transport processes, it is necessary to consider the presence and probabilistic nature of centralized communication channels between systems [14, 15, 16, 17, 19].

In cases where load planning is inherently required to determine solutions to the requirements of the optimal function and equations of constraints, calculation schemes, and computer algorithms are widely used linear programming methods [7, 9, 10, 11, 13, 18, 22].

In the specified planning period, the consumer's actual needs in the daily volume of traffic are unevenly distributed. Sometimes the consumer's need for transportation depends on the flow of goods delivered to him from other remote addresses, and the distribution of their productivity in time becomes probabilistic.

2 Research methodology

The transport service process should be aimed at the continuous satisfaction of 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. The central point in the performance of such a task is the expression of the consumer's need to meet the needs of targeted transportation through indicators of elementary random processes to achieve this goal. To do this, it is necessary to highlight the main elementary processes and form corresponding mathematical models for them. This approach includes the following methodological features and aspects [1]:

1) Basic elementary process is a transportation process performed by a vehicle of a certain type and a driver in a certain transport direction. The elements of this transportation are the processes taking place at the addresses of departure and receipt of cargo and unloaded traffic. Each of the transport elements is first measured by its execution time. The separation of transport and its elements is based, firstly, on the fact that generalized customer service processes are considered as integral elements, and secondly, on the presence of a certain governing body - the driver and the process occurs as a result of his actions;

2) elementary processes are characterized by patterns and indicators of the formation and distribution of their indicators as random variables;

3) these elements are interrelated. Higher-level process indicators are implemented and modeled based on the transformation of random variables associated with elementary processes;

4) generalized indicators characterizing the intensity and efficiency of the provision of transport services to consumers are expressed in the form of random functions formed in the form of a certain structure of elementary transport processes.

The consumer's real need for the volume of cargo on a given day depends on the number of cargo reserves ($Q_з$) remaining at the end of the previous day and the volume of cargo consumption on the same day (Q_u). If $Q_з > Q_u$, then this consumer cannot be shipped that day. Conversely, if $Q_3 < Q_u$, then the company must transport at least (Q_3 - Q_u) tons of cargo to ensure uninterrupted production.

However, in real conditions, the values of Q_u, Q_3 obey certain distribution laws as random numbers. The parameters of this distribution law are determined by indicators (variance, standard deviation, coefficient of variation), which characterize the mathematically expected mean value and individual differences of random variables that occur randomly. Thus, 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*), for 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 $t_{\text{with cargo}}$. And the time of the trip with cargo consists of the sum of the idle time of the vehicle at the shipper and the consignee t_{idle} and the time of the trip with cargo between these points $t_{\text{open-receive}}$, that is

$$t_{\text{with load}} = t_{\text{open-receive}} + t_{\text{simple}} \quad (1)$$

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_{empty}, i.e.

$$t_{trip} = t_{with\ cargo} + t_{empty} = t_{with\ cargo} + t_{empty} + t_{simple} \quad (2)$$

Travel time (t_{trip}) depends on the length of the run with and without cargo ($l_{with\ cargo,}$, l_{empty}) and the technical speed of the rolling stock with and without cargo ($V_{T\ with\ cargo} V_{Tempty}$), i.e.

$$t_{trip} = \frac{l_{with\ cargo}}{V_{T\ loaded}} + \frac{l_{empty}}{V_{T\ porozhek}} + t_{simple}. \quad (3)$$

Number of trips of a motor vehicle Z_{trip} during its stay in the route (T), and the volume of cargo transported ($Q^{п}$) is defined as follows:

$$Z_{trip} = \frac{T - t_0}{t_{trip}} = \frac{T - \frac{\sum l_0}{V_{TO}}}{t_{trip} = \frac{l_{with\ load}}{V_{T\ loaded}} + \frac{l_{empty}}{V_{T\ empty}} + t_{simple}} \quad (4)$$

$$Q^{п} = q_n \gamma_{St} Z_{trip} \quad (5)$$

Rde Σl_0, t_0 is the sum of the zero mileage of the vehicle for the time (T) and the time spent on this mileage; q_n, γ_{st} – the rated load capacity of the vehicle and the utilization factor of the load capacity.

In the above expressions, only the parameters Σl_0, *T*, $l_{with\ load,}$, l_{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.

$$t_{trip} = f\left(l_{with\ the\ load}, l_{is\ empty}, V_{T\ with\ the\ load}, V_{T\ empty}, t_{simple}\right) \quad (6)$$

The speed of movement is formed for each type of vehicle *i* and each direction of transportation (travel) *j* under the influence of various factors, such as, for example, road conditions, the design capabilities of the car and its technical condition, the influence of the type of cargo or passengers being transported, traffic flow on the road, the driver's mode of 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.

Trip time (t_{trip}) and trip time with cargo ($t_{with\ cargo}$) as more General values consist of mathematical expectations of the parameters of elementary processes that make up the trip. Based on this, the quantitative characteristics of vehicles operating on the route are expressed by the following formulas:

$$\mathrm{M}(t_{MT\ with\ load}) = \mathrm{M}(t_{MT\ open-receive}) + M(t_{idle});$$

$$\mathrm{M}(t_{MT\ trip}) = \mathrm{M}(t_{MT\ with\ cargo}) + M(t_{empty}) + M\ (t_{idle});$$

$$\mathrm{M}(t_{trip}) = \frac{l_{with\ cargo}}{M(V_{T\ loaded})} + \frac{l_{empty}}{M(V_{T\ empty})} + M\ (t_{idle}); \quad (7)$$

$$\mathrm{M}(Z_{trip}) = \frac{T - \sum l_0 / M(V_{THEN})}{\mathrm{M}(t_{trip})};$$

$$\mathrm{M}(Q^{\text{п}}) = q_n \gamma_{st} \mathrm{M}(Z_{trip}).$$

From a probabilistic point of view, random variables $X = (t_{simple}, V_{T\ with\ the\ load}, V_{T\ \ empty})$ 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)*. The point value of this function is equal to the probability that the random variable will be less than (x) during testing. That is:

$$F(x) = P(X < x) \quad (8)$$

Suppose the distribution law of a random variable is a continuous function. In that case, it can be represented as an integral of the so-called *f(x)* probability density function.

$$F(x) = \int_{-\infty}^{x} f(x)dx \quad (9)$$

The probability of a random variable *(x)* falling in the range from α to β is determined by the integral *f (x)* from α to β:

$$P(a < x < \beta) = \int_{a}^{\beta} f(x)dx \quad (10)$$

3 Research results

Based on the averaged values of the parameters, we'll consider the reliability of the results of operational transport planning and transport management.

An example. Consider transporting raw cotton from the Nuriston cotton point to the Nishan cotton gin plant. The route length of the direction $l_{with\ cargo,} = l_{empty,} = 30$ 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: $M(Z_{trip}) = 3$ – the mathematical expectation of the number of trips and $\sigma(Z_{trip}) = 0.66$ – the standard deviation. The mathematical expectation of vehicle performance is determined as follows:

$$M(Q^{\text{T}}) = q_{\text{n}} \cdot \gamma_{\text{st}} \cdot M(Z_{trip}) = 5.5 \times 3.0 = 16.5 \text{ t.}$$

For example, to provide a ginnery with raw materials for a continuous production process, it will be necessary to transport at least 100 tons of raw materials per day. Let's have a look at the number of road trains required for this ($A_э$):

$$A_э = \frac{Q^п}{M(Q^T)} = \frac{100}{16.5} \approx 6$$

Now consider the probability of transportation in the volume of at least $Q^П$ =100 tons with 6 road trains. The traffic volume on the route Q^M is a random variable, and its implementation is determined by the parameter Q^T. The probability of performing transportation on the route in the amount of at least $Q^П$ is determined as follows:

$$P(Q^П \leq Q^M < \infty) = P(Q^П \leq A_э \cdot q_n \cdot \gamma_{ST} \cdot Z_{trip} < \infty) = P\left\{\frac{Q^П}{A_э \cdot q_n \cdot \gamma_{ST}} < Z_{trip} < \infty\right\} = P\left|\overline{M\,(Z_{trip})} \leq Z_{trip} < \infty\right|.$$

Where $\overline{M(Z_{trip})} = \frac{Q^П}{A_э \cdot qn \cdot \gamma_{ST}}$ - 6 the average number of trips to complete the transport volume $Q^п$.

Obviously, the probability of performing transportation in a volume not less than the specified volume is provided when the value of the number of trips *(Z_{trip})* is not less than its mathematical expectation $M(Z_{trip})$. Since the distribution of the parameter (Z_{trip}) is expressed by the normal distribution law, this probability is defined as the distribution of the parameter:

$$P\left[M(Z_{trip}) \leq Z_{trip} \leq \infty\right] = f\left[\frac{\infty - M(Z_{trip})}{\sigma(Z_{trip})}\right] - f\left[\frac{\overline{M(Z_{trip})} - M(Z_{trip})}{\sigma(z_{trip})}\right] = 1 - 0.5 = 0.5.$$

Where $f\left[\frac{\infty - M(Z_{trip})}{\sigma(Z_{trip})}\right] = 1,\ f\left[\frac{\overline{M(Z_{trip})} - M(Z_{trip})}{\sigma(Z_{trip})}\right] = 0.5$ – is a normal distribution function, the values of which are given in special literature.

So, it became known that planning based on the average value of the parameter (Z_{trip}*)* does not provide a high probability of performing transportation in a volume no less than the specified volume.

This task can be set and Vice versa. How many road trains are required to transport at least 100 tons of raw meat daily on the route?

For example, the probability of carrying out a shipment of at least 100 tons should be equal to 0.9. In this case, the above expression takes the following form:

$$F\left[\frac{\infty - M(Z_{trip})}{\sigma(Z_{trip})}\right] - f\left[\frac{\overline{M(Z_{trip})} - M(Z_{trip})}{\sigma(Z_{trip})}\right] = 0.9.$$

The first part of this expression is equal to 1 since this part does not depend on the parameter A_{AE}, which follows:

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

Now we have to solve the problem; that is, we must determine the argument of the normal function f by its value. From the corresponding table for *f(x)* = 0,1, we find the argument $x = -1.28$. Therefore:

$$\frac{\overline{M(Z_{trip})} - M(Z_{trip})}{\sigma(Z_{trip})} = -1.28.$$

$$\overline{M(Z_{trip})} = \frac{Q^{п}}{A_{э} \cdot q_n \cdot \gamma_{st}}$$

then

$$\frac{Q^{п}}{A_{э} \cdot q_n \cdot \gamma_{st}} = -1.28\sigma(Z_{trip}) + M(Z_{trip})$$

or $$A_{э} = \frac{Q^{п}}{q_n \cdot \gamma_{st} \cdot [\, M(Z_{trip}) - 1.28 \cdot \sigma(Z_{trip})]} = \frac{100}{5.5 \cdot (3.0 - 1.28 \cdot 0.66)} = \frac{100}{11.85} = 9.$$

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.

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