MATHEMATICAL MODEL FOR FORECASTING THE DEMAND FOR SPARE PARTS IN AUTO SERVICE ENTERPRISES

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Annotation. This article examines the satisfaction of auto service enterprises' need for spare parts, ensuring the accumulation of optimal spare parts reserves and organizing their storage in warehouses, characterizing the need for spare parts using the Poisson distribution, applying regression models when calculating the need for spare parts for auto service enterprises, not including factors with paired correlation coefficients with a resulting characteristic below the specified significance level in the model, and the possibility of using an adaptive forecasting model based on an average slip scheme to forecast the need for spare parts.

Keywords: auto service enterprises, distribution patterns, mathematical models, regression models, technical service, repair, need, demand, Poisson distribution, operational factors, spare parts store, spare parts, mathematical expectation of distribution.

МАТЕМАТИЧЕСКАЯ МОДЕЛЬ ПРОГНОЗИРОВАНИЯ СПРОСА НА ЗАПЧАСТИ НА ПРЕДПРИЯТИЯХ АВТОСЕРВИСА

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Аннотация: в данной статье рассматривается удовлетворение потребности автосервисных предприятий в запасных частях, обеспечение накопления оптимальных запасов запасных частей и организации их хранения на складах,

характеристика потребности в запасных частях распределением Пуассона, применение регрессионных моделей при расчете потребности в запасных частях для автосервисных предприятий, не включение в модель факторов с парными коэффициентами корреляции с результирующим признаком ниже заданного уровня значимости, возможность использования адаптивной модели прогнозирования на основе схемы среднего скольжения для прогнозирования потребности в запасных частях.

Ключевые слова: автосервисные предприятия, закономерности распределения, математические модели, регрессионные модели, технический сервис, ремонт, потребность, спрос, распределение Пуассона, эксплуатационные факторы, магазин запасных частей, запасные части, математическое ожидание распределения, нормированное отклонение от среднего значения.

Introduction. One of the key indicators of a high-quality auto service is the proper organization of its production and technical base. In this regard, the material and technical supply system plays a crucial role in ensuring the continuous and efficient operation of auto service centers. Several important tasks are identified within this system, the most significant of which include maintaining optimal inventories of spare parts, ensuring their constant availability in warehouses, and optimizing the processes of ordering, purchasing, and delivering these parts.

If these tasks are not performed effectively, it can lead to various issues in the operation of technical service stations. For example, an increasing number of vehicles awaiting maintenance or repair may create a growing need for additional storage space. Consequently, delays in vehicle repairs, longer queues for technical service, and more frequent refusals of service due to a lack of spare parts may occur. This can reduce the competitiveness of auto service enterprises in both domestic and foreign markets and may negatively affect the popularity of certain vehicle brands [1, 2, 4, 6].

Methods. The system for supplying spare parts to auto service enterprises corresponds to the main characteristics of a mass service system. The demand for

spare parts used in vehicle maintenance and repair forms a random flow of requests, and this demand is characterized by a Poisson distribution [1, 2, 5].

$$P_{ka} = \frac{a^k}{k!} e^{-a}, \qquad (1)$$

Here, PkP_kPk represents the probability that the number of required spare parts will be equal to kkk, given that the average number of parts consumed during the observed time period is aaa. The flow of spare parts demand for an auto service enterprise - which includes the company itself, its subdivisions, and the range of services, provided - is divided into components based on the enterprise's specialization and the volume of spare parts consumed by each subdivision. Modern dealership enterprises, in addition to their service facilities, also have departments engaged in wholesale and retail sales of spare parts. These departments are responsible for the distribution and sale of spare parts. Apart from these departments, the enterprise may also include a corporate fleet for internal operational needs, divisions for selling new and used vehicles, and in some cases, a vehicle rental service. To determine the consumption of spare parts within the enterprise, the auxiliary services of technical service and repair can be combined into a single common component of spare parts consumption, since the vehicle fleet and technical service departments provide the aforementioned services. However, expenses related to the spare parts sales department are excluded from this component.

Thus, the demand for spare parts (QQQ) for such an enterprise can be expressed by the following formula:

$$Q = Q_{AS} + Q_{do'k}, \qquad (3)$$

Where: Q_{AS} - the total demand for spare parts in the auto service

$Q_{do'k}$ - the demand for spare parts by the auto parts store

Figure 1 shows the approximate distribution of spare parts consumption among the main consumer departments of the “AVTOTEXXIZMAT-F” JSC auto service enterprise located in Margilan city, based on the results of 2024.

According to the normal distribution law, the probability that QstoreQ_{store}Qstore is less than Q+zσQ + z\sigmaQ+zσ is given by:

$$P(-\infty < Q_{do'k} < \mathrm{Q} + \mathrm{z}\sigma) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{z} e^{\frac{-t^2}{2}} dt, \qquad (4)$$

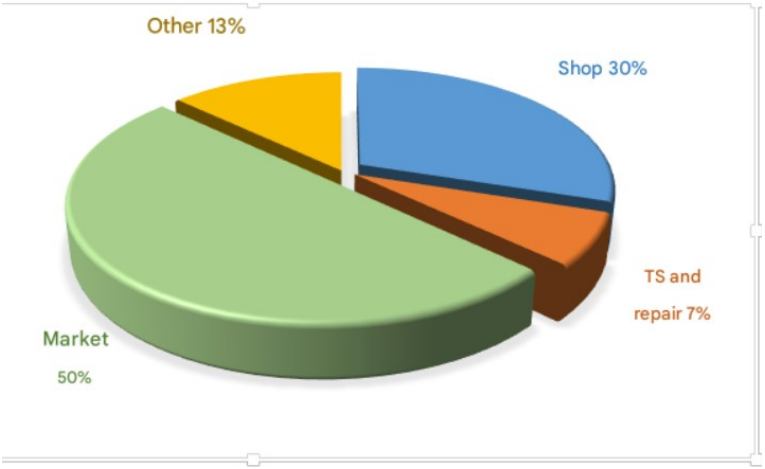

Figure 1. Distribution of spare parts consumption among the enterprise's departments.

Here, Q — the mathematical expectation (mean) of the distribution; z — the standard score (z-value) representing the number of standard deviations from the mean;

σ\sigmaσ — the standard deviation.

Given a probability PPP, the value of zzz satisfying the following condition is determined [7]:

$$\frac{1}{\sqrt{2\pi}} \int_{0}^{z} e^{\frac{-e^2}{2}} dt = P. \qquad (5)$$

The required quantity of spare parts of the necessary designation:

$$Q_{do'k} = \mathrm{Q} + \mathrm{z}\sigma, \qquad (6)$$

Here, Q and σ\sigmaσ are the mathematical expectation (mean) and standard deviation, respectively.

When considering the consumption of spare parts in auto service enterprises as consisting of two components, the following difficulties may arise:

- An increase in the volume of calculations required for demand estimation;
- Lack of separate statistical data on spare parts consumption for individual departments;
- The separately collected statistics on spare parts consumption by departments may not fully reflect the movement of spare parts from supplier to end user.

For example, spare parts purchased by an auto service enterprise from an auto parts store may be installed on a vehicle in the technical service department of the same enterprise. Alternatively, due to limited capabilities of the technical service, the technician may recommend the customer replace the parts themselves, in which case the customer buys them from the store and has them installed at another enterprise.

Thus, within the scope of this study, it is necessary to analyze the spare parts consumption statistics separately for the technical service department and the auto parts store. This allows for identifying the patterns of consumption changes and selecting the mathematical apparatus that ensures the highest accuracy in forecasting the demand for spare parts.

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