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STUDY OF THE DEMAND LEVEL FOR SPARE PARTS IN AUTO SERVICE ENTERPRISES

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Abstract
The article presents the results of modeling the need for spare parts using adaptive mathematical models for the formation of the need for spare parts of car service enterprises, the emergence, randomness, and distribution patterns of the need for spare parts during maintenance and repair of vehicles, and forecasting.

Keywords: Car service enterprises, spare parts, mathematical models, technical service, repair, demand, need, time, operational factors, spare parts store, mathematical expectation of distribution, coefficient of relative significance, factor, expert methods, probabilitys.

Introduction

One of the hallmarks of high-quality auto service is the proper organization of its production and technical base. In this regard, many tasks of material and technical support are highlighted, the most important of which are: optimal reserves of spare parts and materials, as well as their constant supply in the warehouse and improvement of the processes of ordering, purchasing, and supplying components. If these listed tasks are performed unsatisfactorily:
- complicates the operation of the production zone of maintenance stations;
- Larger areas are required for storing cars waiting for repair or maintenance;
- waiting time for vehicle maintenance and repair increases;
- decrease in the level of competitiveness of the enterprise in domestic and foreign markets;
-can lead to a decrease in the popularity of certain car brands.
Solving these problems allows for the creation of a scientifically based system for managing spare parts inventories at the maintenance station.

Evaluation of factors influencing the demand for spare parts using expert methods

Experience shows that when assessing the degree of significance of each factor influencing the need for spare parts, the main result can be determined by an expert survey conducted among specialists working in the field of providing the enterprise with spare parts.

In order to assess the degree of influence of factors affecting the need for spare parts, a questionnaire was compiled and an assessment of the influence of 33 factors was proposed. These factors, in turn, are combined into seven groups:
- control;
- age composition of the serviced vehicle fleet;
- operating conditions;
- employees;
- organization of maintenance and repair;
- production and technical base;
- organization of logistical support.

37 specialists were involved in the survey related to the supply and sale of spare parts at car service enterprises. Of these, 25 are employees of the "UZAVTEXXIZMAT-F" LLC enterprise, and the remaining 12 are specialists from other enterprises.

Survey participants were offered to assess the degree of influence of factors according to a five-point system: the most influential factor was given 5 points, and the least significant (almost non-influential) factor - 1 point.

X_{ij} from the obtained grades, a matrix of participants' answers was compiled:

$$X_{11}\ \ X_{12}\ \ X_{13}\ \ldots.X_{1,33}$$
$$X_{21}\ \ X_{22}\ \ X_{23}\ \ldots.X_{2,33}$$

....

$$X_{37,1}\ \ X_{37,2}\ \ X_{37,3}\ \ldots.X_{37,33}$$

X_{ij} where - assessment of the factors under consideration (from 1 to 5);

i = 1,..., 37 - serial number of experts (participants in the survey);

j = 1,...,33 - serial number of the studied factor.

X_{ij} In order to directly assess the degree of influence of each factor, the relative significance coefficient of the individual factor is calculated for each person participating in the survey:

$$X_{ij} = \frac{x_{ij}}{\sum_{j=1}^{33} x_{ij}}, i = 1, \ldots, 37. \qquad (1)$$

After calculating this coefficient for each participant in the survey, based on the assessments given by all participants, we determine the average relative significance of each factor:

$$X_j = \frac{\sum_{j=1}^{33} X_{ij}}{37}, \qquad (2)$$

X_j where - coefficient of relative significance of the j-th factor.

According to the survey results, experts believe that the following factors have the greatest influence on the demand for spare parts (Table 1): age composition of the serviced vehicle fleet. About 85% of respondents believe that these factors have the greatest impact on the demand for spare parts.

Factors included in the "operational conditions" group, such as operational intensity, transport, road, and natural-climatic conditions, according to 55% of specialists, have the greatest impact on the need for spare parts. Among the remaining group of factors, experts separately identified the "Management" group of factors. About 80% of respondents believe that the level of prices for spare parts and services, the presence of regular customers, and advertising have a strong influence on the needs of a car service enterprise for spare parts.

Table 1

Factors	**Group number**	**Place in an ordered series**	**Significance ratios**
Age composition of the enterprise	2	1	0.0511
Usage intensity	3	2	0.0507
Method for calculating the need for spare parts	7	3	0.0487
Transport, road, and natural-climatic operating conditions	3	4	0.0467
Composition of vehicles based on the distance traveled since the beginning of operation	2	5	0.045
Maintenance capacity	6	6	0.0446
Advertisement	1	7	0.044
Prices for spare parts and services	1	8	0.0431
Quality of spare parts and materials	7	9	0.043
Customers	1	10	0.0429
Model line	2	11	0.0419
Sales volume of new cars	1	12	0.0412
Spare parts delivery speed	1	13	0.0411
Reliability	2	14	0.0405
Number of vehicles in use	1	15	0.0387
Specialization of maintenance	6	16	0.0356
Optimal reserve amount	7	17	0.0350
Methods of replenishing reserves	7	18	0.0347
Volume of spare parts sales in previous years	1	19	0.0327
Equippedness	6	20	0.031
Quality of maintenance and repair	4	21	0.0285
Warehouse system	1	22	0.0263
Qualification of production and technical personnel	5	23	0.0205
Driver's Qualification	3	24	0.0185
Volume of maintenance and repair (spare parts consumption) for previous years	1	25	0.0163
Optimal warehouse utilization	7	26	0.0161
Methods of maintenance and repair	4	27	0.0152
Rate of fulfilling maintenance requirements (waiting period)	1	28	0.0144
Level of personnel training	5	29	0.0133
Complaints	4	30	0.013
Unification (Unification)	2	31	0.0126
Device complexity	2	32	0.0118
Losses due to defective products	7	33	0.0113
			1.0000

According to 67% of experts, among the factors related to the organization of maintenance, the need for spare parts is strongly influenced by material and technical support. The complexity of the structure, defective losses, the degree of unification, and the number of complaints, according to experts, have little effect on the need for spare parts (55-60%). Experts also included the optimal use of warehouses among the least influencing factors. This is due to the fact that the task of efficient use of these warehouses is mainly assigned to spare parts warehouse employees who did not participate in the survey.

Survey participants were also asked to name factors that are not included in the specified list, but, in their opinion, significantly affect the demand for spare parts.

Summarizing the definitions of the experts' answers, we will highlight factors not included in the specified list, in particular: the possibility of extending the service life or restoring worn-out spare parts, as well as the popularity of the car brand and the reputation of the maintenance point. These factors will also need to be studied in further research.

Results of mathematical modeling of spare parts consumption.

Adaptive models for forecasting.

Using the adaptive forecasting model, we conduct a modeling of the consumption of spare parts for a single nomenclature of parts.

At the initial stage of the modeling process, it is necessary to enter the initial data into Table 2 or import them from the databases available at the enterprise. For the creation of the model, we will use experimental data on the consumption of digital steering rods in the catalog 45503-05020 for 12 months of 2024.

Table 2 Assessment of initial model parameters

t	**Y (t)**	$(\mathbf{t}-\mathbf{t}_{o\prime rt})^2$	$\mathbf{Y}_{o\prime rt}$**Y (t) -**	$\mathbf{t}-\mathbf{t}_{o\prime rt}$	$\mathbf{t}-\mathbf{t}_{o\prime rt}\mathbf{Y}_{o\prime rt}$**() (Y (t) -)**
1	2	3	4	5	6
1	18	4	-1	-2	3
2	24	1	5	-1	-5
3	17	0	-2	0	0
4	16	1	-3	1	-3
5	22	4	3	2	5

The serial numbers of the time series points (from 1 to 5) are entered in column 1. The first five values of spare parts consumption for the previous period (T=12 months) are recorded in column 2. The values in columns 4-6 are calculated automatically.

At the next stage of the modeling process, Table 3 is compiled. Spare parts consumption volumes for the entire period of 2024 will be included in the table.

Based on the first five points of the series, the initial values of the model parameters A_0 and A_1 are estimated using the least squares method for linear approximation: $Y_p(t) = A_0 + A_1 \cdot k\ (t = 1, 2, \dots 5)$. Using the obtained values of the parameters A_0 and A_1, we calculate the prediction one step ahead (k = 1):

$$Y_p(t,k) = A_0(t) + A_1(t) \cdot k. \qquad (3)$$

The calculated value of the need for spare parts is compared with its actual value, and the difference (error) between them is determined.

When k = 1, we have: e (t + 1) = Y (t + 1) - $Y_p(t, 1)$. According to this value, the model parameters are adjusted. Modification will be performed as follows:

$$A_0(t) = A_0(t-1) + A_1(t-1) + \alpha^2 e(t);$$

$A_1(t) = A_1(t-1) + \alpha^2 e(t),$ (4)

α where - is a smoothing parameter, the optimal value of which is determined by a repeated method, i.e., it is found by repeatedly constructing the model and selecting the best one for different values of;

e (t) - *Y (t)* prediction error of the level *(t-1)* one step forward at a time moment.

It should be noted that the indicated method should ensure good results in cases where the principle of constant change in the consumption of spare parts is close to a linear dependence.

Table 3 Evaluation of model parameters.

t	Y (t)	A_0	A_1	Y_p(t)	e (t)
0		19,400	0.000		
1.	18.	19.176	-0.224	19,400	-1.400
2.	24.	19,796	0.620	18,728	5,272
3.	17.	19,670	-0.125	21.654	-4.654.
4.	16.	19.038	-0.632	19.170	-3.170
5.	22.	19,386	0.347	15,877	6.123
6.	13.	18,378	-1.008	21,470	-8,470
7.	12.	17,478	-0.900	11.323	0.677
8.	14.	17.174	-0.305	10.282	3,718
9.	22.	18.080	0.906	14.432	7.568
10.	30.	19,443	1.363	27.143	2.857
11.	27.	19,616	0.173	34,441	-7.441.
12.	24.	20.159	0.542	21,690	2.310

$Y_p,\ A_0\ and\ A_1$ The values of, and are calculated using relations (3) and (4).

The model obtained at the next stage of forecasting looks like this:

$Y_p = 20{,}16 + 0{,}542k,$ (5)

where k is the prediction step.

$A_0\ and\ A_1$The model should provide the best result at the first stage of forecasting, and at subsequent stages, it will be necessary to recalculate the coefficients and.

The results of mathematical modeling of the consumption of other parts using actual consumption values for 2024 are presented in Table 4.

Table 4

Name of the part	Directory number	Prediction model
Fuel filter	23300-19535	U=28.52+0.2k
Air filter	17801-02050	Y=67.60+0.2k
High-voltage wires	90919-22400	Y=16.8-0.09k
Spark candle	90919-01164	Y=122-0.38k
Oil filter	90915-10003	Y=97.13+0.45k
GTM Ribbon	13568-09020	Y=21.89-0.49k

To assess the accuracy of the constructed models, it is necessary to conduct calculations and compare the projected values of the need for spare parts with the actual consumption of parts.

Conclusion

Currently, it is necessary to develop a legislative framework and regulatory legal documents regulating the activities of the auto service sector at the level of demand, based on the constant need of dealer points supplying spare parts and materials to existing auto service enterprises.

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