Methodology for Optimizing the Headcount Based on Simulation Modeling

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Abstract. The article discusses the advantages of simulation modeling of the number of sales personnel in order to increase the economic efficiency of the organization. Headcount optimization aims to generate savings while meeting the organization's goals. This example considers the activities of one of the leading players in the regional food market. In accordance with the general structure of the processes of receiving and servicing customers in the organization, their simulation model was developed in the GPSS World software environment. The obtained conclusions are economically substantiated.

1 Introduction

The relevance of the study presented in this article is due to the importance of the sales staff of organizations engaged in wholesale and retail trade in food and agricultural products in order to increase the economic efficiency of their activities. In the new economic realities, characterized by instability and unpredictable institutional transformations taking place in the external environment, employees of enterprises are the resource (in quantitative and qualitative aspects), on which the quality of the implementation of competitive technologies depends. Cost optimization of business entities is one of the effective ways to improve business sustainability and requires the use of modern techniques based on economic and mathematical modeling. Competitive strategies of enterprises are focused on attracting new and retaining existing customers. At the same time, as experts determine, the cost of engaging each new customer is estimated to be 6 times higher than the cost of increasing the loyalty of existing ones. It takes 25 times more funds to return a dissatisfied customer who leaves, for example, due to an insufficiently effective service organization. This may be due to long waiting in line, denial of service, etc.). To minimize these negative effects, the queuing theory can be applied [1].

2 Materials and Methods

The article proposes a method for planning the number of sales and operational personnel of the company store of the JSC Agrocomplex named after N.I. Tkachev. Among
supermarkets and hypermarkets, competitors are Magnit, Pyaterochka, Dixy, Auchan, Perekrestok, Karusel, Lenta and Okay.

In most cases, the structure of a small enterprise is a multi-channel queuing system (QMS), the value of the main characteristics of which is difficult to obtain by analytical methods. In the conditions of uncertainty of the external environment and the presence of many non-formalizable or difficult-to-formalize factors, simulation modeling allows solving this problem. The GPSS (General Purpose Simulation System) language, created in 1962 by J. Gordon and based on the GPSS World software product, facilitates the process of creating simulation programs. GPSS system models can be written as flowcharts or presented as a sequence of program lines equivalent to a flowchart. In different versions of the language, the number of blocks for creating simulation programs varies and is about 40. The GPSS modeling language includes special tools for describing the dynamic behavior of systems through changing states at discrete points in time, that is, the simulation time varies randomly from event to event. The most detailed construction technique is presented in [2].

It is determined that in any elementary act of service, two main components can be distinguished: the expectation of service by the application and the actual service of the application. Let $N_i$ be the $i$-th service device consisting of a storage of applications $N_i$, in which $l_i = (0, L_i^H)$ can simultaneously be located applications, where $L_i^H$ is the capacity of the $i$–th drive, and the service channel $K_i$ [3]. Each element of the service device receives streams of events: to the accumulator $H_i$ – a stream of requests $w_i$, to the channel $K_i$ – a stream of services $u_i$. The described process can be depicted in the form of a Q–diagram (Figure 1).

![Q-diagram](Image)

**Fig. 1. Maintenance device**

Q-diagrams of the processes of receiving and servicing applications at a small enterprise, allow you to graphically depict these processes graphically, as well as implement them in the GPSS World environment. On this methodological basis methods of mathematical modeling based on the software environment GPSS World are used. A methodology has been developed for assessing the quantitative composition of the personnel of an organization engaged in retail trade using simulation modeling, for the first time using a module that allows you to set the structure of the organization as an exogenous variable, which makes it possible to substantiate the optimal number of employees in each structural unit of the company in the future. The authors, in contrast to the generally accepted methods for assessing the effectiveness of personnel activities, take into account the indicators of customer service of the organization.
3 Results

The general scheme for receiving and serving clients fits into the general scheme for the operation of a multi-phase queuing system (QS) [4, 5, 6, 7] (Figure 2). The flows of buyers are indicated by arrows, above which the intensities of these flows are signed ($\lambda$, $\lambda_1$, $\lambda_2$, ..., $\lambda_r$ – number of buyers (customers) per unit of time). The client can refuse the services of the store in the future ($p_i$ - the probability of refusal) [2].

Fig. 2. The general scheme of the process of receiving and servicing customers in a trade and retail enterprise [compiled by the authors taking into account]

The authors, in accordance with the general structure of the process of receiving and servicing customers in the organization, developed a simulation model of these processes in the GPSS World software environment. In order to facilitate the perception of the algorithm indicated in Figure 3, in Figure 4, in general, a Q-diagram of the processes under consideration was constructed for an arbitrary i-th phase of the QMS. Here I is the source of applications in the i-th phase, Ni is the queue in the i–th phase, Kj is the service personnel in the i-th phase, $i=1, ..., r$, j is the employee number $j=1, ..., l$. 
The incoming parameters of the model are the values $x_i$ – the number of employees of the $i$-th department of the company, the laws of distribution of the incoming ZAKON customer flow $(1, 0, 1/\lambda)$ and the law of distribution of the service time of one customer in the $i$-th department of ZAKON $(1, 0, 1/\mu_i)$, where $\lambda, \mu_i$ – the intensity of flows. Note that the laws of the distribution of the incoming flow and the service time set in the simulation model can be any, unlike the laws used in mathematical models of the processes of receiving and servicing applications.

**Fig. 3.** Simulation model of application acceptance and service processes at the enterprise (compiled by the authors)
The input parameters of the model are: values $x_i$ - the number of employees of the $i$-th phase of the store, the laws of distribution of the flow of customers and the law of distribution of the service time of one client in the $i$-th phase of the company, where $\lambda_i$, $\mu_i$ are the intensity of the flows.

The outputs of the model contain the values of the quantities $a_{ki}$, $k = 2, \ldots, 8$, $i = 1, \ldots, r$, characterizing customer service and representing:

- $a_{2i}$ - average time utilization ratio of the sales staff in the $i$-th phase;
- $a_{3i}$ - average number of sales personnel in the $i$-th phase;
- $a_{4i}$ - maximum queue length in the $i$-th phase;
- $a_{5i}$ - average queue length in the $i$-th phase;
- $a_{6i}$ - average number of buyers in the $i$-th phase;
- $a_{7i}$ - average time spent by buyers in the queue of the $i$-th phase;
- $a_{8i}$ - average residence time in the $i$-th phase;

It is necessary to have $n$ such that $f_i^n$ reaches its minimum, i.e. solve an optimization problem:

$$f_i^n = \sum_{k=1}^{8} a_{ki}(n) \cdot \lambda_{ki} \rightarrow \min_n$$  \hspace{1cm} (1)

On the basis of the developed methodology, the author assessed the number of sales and operational personnel of the company store of the JSC Agrocomplex named after N.I. Tkachev.

The store can be conditionally divided into two phases (departments): trading floor, cash center. All of these divisions interact and each of them participates in the trading activities of the organization. The general scheme of the processes of receiving and servicing customers in the store is shown in Figure 5.

The experts of the organization found $\lambda_{ki}$, $k = 1, \ldots, 8$, $i = 1, \ldots, 4$, for $f_i$ (2).

Shopping room:
\[ f_1 = \frac{1}{16}a_1 + \frac{3}{16}a_2 + \frac{1}{32}a_3 + \frac{1}{16}a_4 + \frac{1}{8}a_5 + \frac{1}{32}a_6 + \frac{1}{32}a_7 + \frac{1}{32}a_8; \]  
\[ (2) \]

Settlement and cash department:

\[ f_2 = \frac{1}{12}a_1 + \frac{2}{15}a_2 + \frac{1}{12}a_3 + \frac{3}{15}a_4 + \frac{2}{15}a_5 + \frac{1}{24}a_6 + \frac{1}{24}a_7 + \frac{1}{6}a_8; \]  
\[ (3) \]

Fig. 5. The general scheme of the processes of receiving and servicing customers of the company store of the company Agrocomplex named after N.I. Tkachev Source: [8]

In order to substantiate recommendations on the optimal, from the point of view of the developed methodology, the number of employees of the enterprise, it is necessary to solve the optimization problem (2). For this purpose, let’s calculate \( a_{k1}(n) \), with the values of \( n \) (the number of employees of the first phase) and compare the results. For this purpose, we use the developed simulation model (Table 1).

<table>
<thead>
<tr>
<th>Index</th>
<th>Number of employees</th>
</tr>
</thead>
<tbody>
<tr>
<td>The total salary of the sales staff of the department, thousand rubles</td>
<td>52,4 78,6 104,8</td>
</tr>
<tr>
<td>Employee utilization rate</td>
<td>0,75 0,5 0,375</td>
</tr>
<tr>
<td>Average number of employees, pers.</td>
<td>2,0 2,8 3,1</td>
</tr>
<tr>
<td>Maximum queue length, pers.</td>
<td>15 10 4</td>
</tr>
<tr>
<td>Average queue length, pers.</td>
<td>13,2 5,6 2,2</td>
</tr>
<tr>
<td>The average number of buyers in the department, pers.</td>
<td>34,2 17,3 15,4</td>
</tr>
<tr>
<td>Average time spent by a customer in the queue, hours</td>
<td>0,64 0,08 0,015</td>
</tr>
<tr>
<td>Average time spent by a customer in the department, hours</td>
<td>1,14 0,37 0,12</td>
</tr>
</tbody>
</table>

Table 1. \( a_{k1} \) parameter values of the shopping room. Source: [8]
Using the table data, we calculate:
\[ f_1^2(52, 4; 0, 75; 2; 15; 13, 2; 34, 2; 0, 64; 1, 14) = 7, 2; \]
\[ f_1^2(78, 6; 0, 5; 2, 8; 10; 5, 6; 17, 3; 0, 08; 0, 37) = 7, 06; \]
\[ f_1^2(104, 8; 0, 375; 3, 1; 4, 2; 2; 15, 4; 0, 015; 0, 12) = 7, 67. \]

Therefore, at this stage it is advisable to reduce the number of employees to three. As shown above, the optimal number of jobs on the trading floor (first phase) \( n = 3 \).

Based on the results of modeling the cash settlement department given in Table 2, we calculate the values of \( f_2 \):
\[ f_2^2(27, 2; 0, 733; 1; 15; 13, 2; 16, 3; 0, 324; 0, 58) = 8, 14; \]
\[ f_2^2(55, 6; 0, 367; 1, 5; 7; 4, 4; 8, 2; 0, 012; 0, 16) = 7, 15; \]
\[ f_2^2(83, 4; 0, 245; 1, 6; 2; 1, 1; 3, 5; 0, 001; 0, 05) = 7, 81. \]

Table 2. Values of the parameter \( a_{k2} \) of the settlement and cash department. Source [8]

<table>
<thead>
<tr>
<th>Index</th>
<th>Number of employees</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>The total salary of the sales staff of the department, thousand rubles</td>
<td>27,8</td>
</tr>
<tr>
<td>Employee utilization rate</td>
<td>0,733</td>
</tr>
<tr>
<td>Average number of employees, pers.</td>
<td>1,15</td>
</tr>
<tr>
<td>Maximum queue length, pers.</td>
<td>15</td>
</tr>
<tr>
<td>Average queue length, pers.</td>
<td>13,2</td>
</tr>
<tr>
<td>The average number of buyers in the department, pers.</td>
<td>16,3</td>
</tr>
<tr>
<td>Average time spent by a customer in the queue, hours</td>
<td>0,324</td>
</tr>
<tr>
<td>Average time spent by a customer in the department, hours</td>
<td>0,58</td>
</tr>
</tbody>
</table>

Expression (3) takes the minimum value on the set at \( k=2 \), therefore, the number of cashiers should be reduced to two.

Thus, from the point of view of the methodology of the optimal number of sales personnel developed by the author, it is advisable to reduce the sales staff in the store by two people (one employee of the trading floor and one cashier). Savings from the implementation of this technique will amount to 54 thousand rubles per month.

The methodology developed by the authors for optimizing the labor resources of small enterprises makes it possible to carry out their quantitative analysis in various departments and determine the optimal amount that allows minimizing wage costs while maintaining the highest possible quality of service. The approbation of the presented methodology at 40 enterprises of the Krasnodar Territory made it possible to conduct a thorough analysis of the processes of reception and customer service and draw the following conclusion. In more than 85% of enterprises, labor resources were distributed inefficiently, which necessitates
the implementation of appropriate changes. The quality of service at the same time can increase by more than 15%, and revenue – by 5%. This positive trend persists even in the case of an increase in the number of personnel, despite the increase in labor costs. The representativeness of the sample allows us to conclude that this technique can be applied in the conditions of enterprises of various industries and spheres of activity.

4 Conclusions

An urgent task of trade management is to choose the most effective ways of organizing and managing activities that allow interacting with the external environment, as well as optimizing the allocation of human resources to increase customer satisfaction. On the basis of the presented results of calculations, it can be concluded that savings in enterprise resources have been achieved. An economically justified strategy for planning the quantitative and qualitative composition of the sales staff of a company store of an agricultural company, which includes a methodology for assessing the quantitative composition of personnel using simulation modeling, for the first time using a module that allows you to set the structure of the organization as an exogenous variable, as well as a system of measures for training the specifics of labor activity personnel of the organization during the adaptation period, which will allow to substantiate for the future the optimal number of competent employees in each structural unit of the company. The proposed methodology can be used as an element of benchmarking and replicated at other enterprises.

References

8. E.E. Takaho, V.I. Gaiduk, N.V. Gaiduk, Improving the strategic planning of wholesale and retail trade in food and agricultural products (Krasnodar, 2022)