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INCREASING THE EFFICIENCY OF TECHNICAL OPERATION OF VEHICLES BY OPTIMIZING THE ORGANIZATIONAL AND PRODUCTION STRUCTURE OF SERVICE ENTERPRISES

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A B S T R A C T

The article examines the management of the technical operation of vehicles at automobile transport enterprises. Effective management requires the integration of planning, organization, motivation and control functions. Production organization is determined through the enterprise's production structure, which reflects the main production units, and the organizational structure, which governs and coordinates production processes. The system of technical operation is influenced by external factors, including the annual number of customer vehicle visits, the distribution of maintenance and repair work along different technological routes, and the uneven flow of technical service requests. The paper investigates how these factors affect the choice of an optimal production and organizational structure of road transport enterprises. Parameters describing different production structures are given. Methods of system analysis, simulation modeling, graph theory and process mining were used. Simulation experiments involving four production structure variants under varying conditions were conducted, resulting in recommendations for choosing the optimal enterprise structure.

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1. INTRODUCTION

In the structure of costs included in the cost price of transportation (work, services) in automobile transport, a significant share is occupied by the costs of maintaining fixed production assets in working order and restoring their serviceability. For automobile transport enterprises, fixed assets are vehicles that generate profit. These processes at the system level are ensured by the technical operation of vehicles (Zakharov et al., 2019). One of the ways to improve the technical operation of vehicles at a motor transport enterprise is a system for organizing and managing the maintenance and repair of rolling stock (Kozin, 2023).

The organization of production for the maintenance and repair of automobiles is understood as a set of production and organizational structures that interact with each other as part of the implementation of management goals (Denisov et al., 2013).
The production structure describes the composition of the main and auxiliary units and the relationships between

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them, and the organizational structure establishes the system of mutual subordination, job tasks and responsibility of performers. The model of functioning of organizational and production structures from the point of view of implementing the main business process of the organization – the production of technological influences to maintain and restore the performance of cars – is described by the functional scheme of the enterprise. The functional scheme describes the logic of the vehicle movement through production areas and sections. In some sources, it is also called the organizational form of technological processes of technical maintenance, diagnostics and current repair of cars at the motor transport enterprise (Maltseva et al., 2025). In concepts of queuing theory, the elements of a functional scheme can be represented as channels (or links) of various types which an application passes through in accordance with the established sequence of actions on it to ensure the conditions for its successful exit from the system (Kozin, 2023). Consequently, the task of organization of production is to develop a functional scheme for the interaction of the organizational and production structure of the enterprise, taking into account external and internal factors that influence the achievement of the goals of the system.

Production management consists of converting information about factors influencing the system into a set of specific management actions (Nikulina et al., 2022). The ideal of the managing any production, economic and organizational system, related to the type of the complex systems, is its approach to the technical system and the implementation of management influences within the framework of existing automatic control schemes. However, many researchers note the complexity of the mathematical description of such systems, due to human-machine interaction and the presence of weakly predictable situations (Aizerman, 2016). In such conditions, they draw on the simulation modeling and identifying statistical relationships between the system elements (Xuejun & Shiyuan, 2024). In general, production management consists of several typical stages: determining the goals of the system, obtaining and processing information about the current state of the system, making a management decision in the case of a discrepancy between the desired and actual state, implementing the decision and assessing its effectiveness (feedback) (Van Der Aalst, 2012).

At the same time, the list of tasks, their detail and planning horizon differ at different levels of management. Within the framework of top executive management, a strategic business plan and a corresponding Sales and Operation Plan (SOP) are established. At the level of department heads and functional managers, a Master Production Schedule (MPS) and a Material Requirements Planning (MRP) are developed. And the line managers ensure the implementation of operational tasks (Shop Floor Control – SFC). Moreover, the degree of detail of tasks is inversely proportional to the management level (Nyulászsiová & Paľová, 2020). It is obvious that when forming the optimal organizational and production structure of an enterprise, it is necessary to take into account different levels of management.

It should be noted that solving the problem of the organization of production is one of the four functions of enterprise management (Eisenberg, 2009). In addition to this, within the framework of an integrated approach, it is also necessary to solve the problems of planning, motivation and control (Tilley & Rosenblatt, 2017). However, due to its considerable size, solving only the first of four problems will be considered in this study. Organization of production is one of the functions of management, therefore, in the framework of solving the first problem, it would be more correct to speak not about organization and production management as related concepts, but only about the organization.

The solution to the problem of the organization of production lies in determining the organizational and production structure of the enterprise. The set of links, the functions they perform and the relationships between them constitute the production structure of the enterprise. If we focus only on the main business process of the enterprise, then the production structure, with some degree of simplification, can be understood as a functional production circuit. The problem of finding an optimal functional circuit belongs to the type of problems of dynamic programming and combinations theory.

The set of administrative units and their relationship with the elements of the production structure (through linkage to the functions of the business process) constitutes the organizational structure of the enterprise. The organizational structure is a superstructure over the technological graph that describes the implementation of the main business process of the organization (functional circuit). The problem of finding an optimal organizational structure is a type of hierarchy problem over a technological graph (Grassa & Bocanet, 2023). Both problems can be solved using simulation modeling methods.

Currently, insufficient attention is paid to the formation of a rational organizational and production structure of motor transport enterprises. Existing scientific research on the organization and management of production for vehicle maintenance and repair considers various types of organizational charts of motor transport enterprises depending on their capacity, expressed in the list number and the average annual distance run of vehicles. However, the choice of a complicated version of the organizational chart for more powerful motor transport enterprises is discrete, and the number of selection options is limited to 4-5 circuits. Despite the fact that all the circuits are presented in order of increasing the number of links and complicating the relationships between them, the patterns and principles underlying the

addition of a new functional area, zone, or specialization of existing ones are not disclosed. At the same time, many studies were carried out in old economic conditions that did not take into account the commercial business trend, and the list of recommendations is mainly presented for motor transport enterprises, but not for service stations and dealership centers. In addition, existing approaches to the formation of indicators for assessing and classifying the organizational and production structures are represented either by economic indicators for assessing the activities of the enterprise as a whole, or by indicators characterizing the management and administration system of the enterprise, or by generalized expert assessments (Bartuševičienė & Šakalytė, 2013; Kim, 2007). The above approaches do not take into account the technical features of the functional schemes of production organization, as well as a number of factors that determine the work of the technical service of the enterprise, for example, the capacity or number of vehicle entries, as well as the distribution of applications included in the system by the work types. All this speaks to the relevance of research aimed at determining the optimal organizational and production structure for managing an enterprise for the maintenance and repair of automobiles, taking into account the external factors.

As the main conceptual position of this study, the following can be defined: for a certain level of flow of incoming requirements for maintaining and restoring the vehicles serviceability, the enterprise has its own optimal version of the functional circuit of production for maintenance and repair, which is determined by a number of classification criteria.

2. MATERIALS AND METHODS

The paper uses methods from the theory of management the organizational systems (Gurianova & Mechtcheriakova, 2015), system analysis (Peng & Bao, 2023) and operations research (Carter et al., 2018), which are based on methodology of technological and economic calculation of motor transport enterprises (Tushman & Smith, 2017), supplemented by modern approaches to determining the economic indicators of enterprise activities (Doroshin & Kazaryan, 2022). The methodology integrates a discrete-event simulation model based on the SimPy framework, which allows us to simulate the operation of a car service station as a queuing system. This takes into account the probabilistic characteristics of the flow of requests entering the system, the performance of service channels, as well as the output parameters of the queuing system. The presented approach allows us to connect minute-by-minute simulation modeling of the work of a service station and an economic model that calculates capital and current costs for the organization and operation of an enterprise for a given time period, and also takes into account the profit from production activities. To form functional operation charts, the work uses methods of research and optimization the business processes (Vaičiūtė et al., 2019). The data flow diagrams (DFG – Data Flow Graph) presented in the paper are based on the theoretical principles of graph theory and enterprise business process modeling notation (BPMN notation), and are implemented using the framework pm4py. To describe the elements of functional production management diagrams for vehicle maintenance and repair, the provisions of the theory of automatic control were used, which is based on the theory of system analysis when describing complex systems (Zakharov & Makarova, 2019), it should be noted that the issue of the quality of transport services largely depends on regional characteristics (Zelenina et al., 2022). The latter was used to define the boundaries of the system, describe its structure, and also to formalize the efficiency criterion (Liao et al., 2023).

The object of the study was the structure of the system of a passenger car service and repair station. The purpose of the system is to increase the efficiency of its functioning (Kang et al., 2023). Net profitability of the business was used as the main indicators of the system efficiency (NPM – Net Profit Margin), (ROI – Return On Investment), определяемые по формулам also taking into account losses from lost benefits associated with inefficient organization of the system, and return on investment (ROI – Return On Investment), determined by the formulas:

$$NPM = \frac{NI}{R} \cdot 100\% \tag{1}$$

where NPM is net profit margin, %,
NI is net profit, thousand rubles,
R is income, thousand rubles:

$$ROI = \frac{NRI}{CI} \cdot 100\% \tag{2}$$

where ROI is return on investment, %,
NRI is net return on investment, thousand rubles.
CI is cost of investment, thousand rubles.

The use of two performance indicators is due to the fact that the first indicator (NPM) takes into account the efficiency of the current production activities without taking into account capital costs for the construction and equipment of the enterprise, and the second indicator (ROI) takes into account the initial investments and their payback period due to the profit received from operating activities. Obviously, an enterprise can show positive dynamics in terms of the first indicator, but at the same time it will not be able to recover the initial investment, or it may require a long period of time to do this. Therefore, for the management of an enterprise, it may be important to evaluate the efficiency of the enterprise using the two given indicators at once (Malone et al., 1993). In addition, the use of these low capital investments (quick entry to the market with low scaling prospects) or a focus on a specific niche market with significant investments in the production base.

The boundaries of the system under study and the structural relationships between its elements are shown in Figure 1.

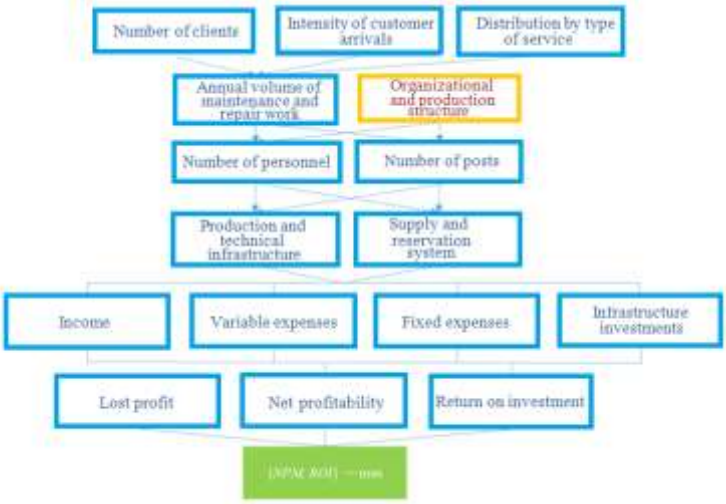


Figure 1. Structure of the system under study. Controlled factor: "Organizational and production structure" and the target function are highlighted in separate colors

The following were considered as input factors determining the behavior of the system: the total annual number of vehicle visits to the service station, the intensity of customer arrivals at the station by day of the week and during the work shift, the type of request (maintenance, repair, cleaning and washing work, other additional services), as well as the process flow of the application. The main controlled factor and object under study is the organizational and production structure of the enterprise, expressed in various functional operation charts. The objective function is aimed at maximizing the indicators given in the formulas above.

A description of the developed mathematical model of the operation of a car service enterprise is shown below. The model is based on the operating principle of a queuing system. An enterprise is a queuing system where applications are received, processed for some time, and then exited from the system, which makes it possible to evaluate its efficiency indicators, usually consisting of the number of processed applications and the total length of the queue. However, an original superstructure has been proposed above this principle, which is as follows.

Each application entering the system has a set of parameters: type of work, labor intensity of the work, the required process flow for processing the application, the need for a separate specialized area or equipment. However, what is important for the system is not so much the parameters of each specific application, but the total distribution of all incoming applications according to the presented indicators. For example, there is an obvious difference between managing a system with an incoming applications flow of low-labor intensity of the same type and a system that processes a flow of diverse applications with high implementation labor intensity.

All production sites are formed according to the following principle. The minimum necessary organizational and production structure, which in principle allows the acceptance and processing of applications, is mandatory. The structure element is a link. According to Kessler (2013), a link is an organizationally separate, independent management body that performs certain management functions. A link can be a post or an administrative unit. It can perform business functions (hereinafter referred to as functions) corresponding to the implementation of the main business process of the enterprise – the provision of services to the client (car maintenance and repair). That is, the starting point for building an enterprise management structure is the main business process. A business process is a directed graph (Harmer & Oshurko, 2020). Business functions may include technological operations for vehicle maintenance and repair. At the same time, when forming the management structure of the decision maker, it is necessary to solve the problem of selecting the main technological operations (or services) that will be included in the business functions. For example, by far not every car service center sells the entire existing list of services for vehicle maintenance and repair; it selects only some services from all possible ones. Functions can be combined at one link, which, obviously, can lead to an increase in the period of work, or distributed over several links. All functions are subordinated to ensuring the possibility of implementing the stages of passing an application through the system (the main business process). They can be listed: answering calls, reception, sending clients to the service, technical assistance, spare parts, issuing a car to the client. To use uniform terminology, the set of business functions of the main process, taking into account some assumptions, will be called a functional process chart in the future. From the point of view of the technology of

work performance within the framework of the "technical influences" sub-process, each link can be specialized in performing certain types of work, with or without specialized equipment or tools. Or it can be a universal link at which any type of work is performed, including or excluding specialized ones. The system model diagram is presented in Figure 2.

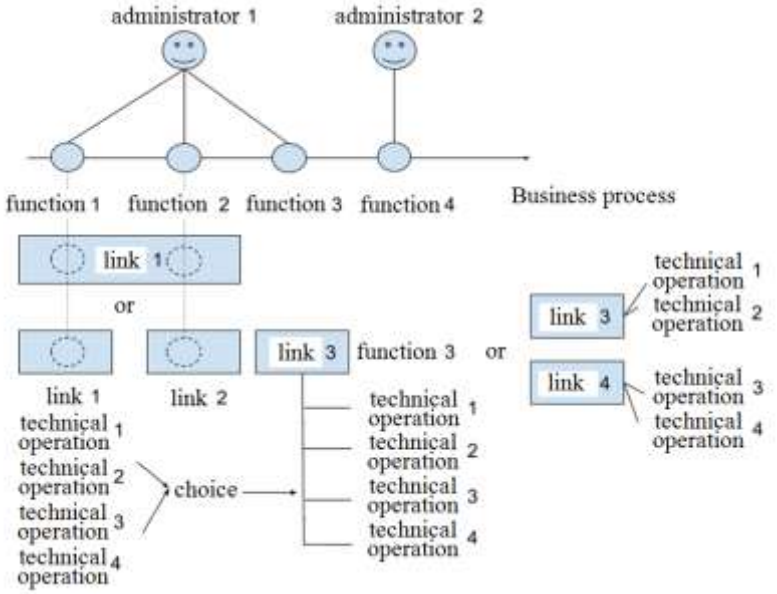


Figure 2. System model chart

Taking into account all of the described above, the production structure is a set of links, the functions they perform and the relationships between them. The organizational structure is a set of administrative units and their relationship with elements of the production structure (through reference to the functions of the business process).

The indicators of net profitability and return on investment are determined as output indicators of the system.

The operation of the system can be realized under the following controllable factors:

a) different production structure
b) different organizational structure

The goal of the system is to select such values of controlled factors that would allow achieving a global optimum. The optimization task is to maintain or transfer the system to a state with extreme values of characteristics under given conditions and restrictions (Gambella et al., 2021).

A variant of a simple functional scheme of a medium-sized car service station is presented in Figure 3 and can be characterized by a number of indicators.

The client arrives at the service station (arrive) and gets to the first link x_1 – to the service receptionist (receipt), who serves him for a given time t_1. At the same time, within the specified time, the service receptionist can perform several actions: directly accept the client's car a_1^1 with the labor intensity t_1^1, receive calls a_1^2 with the labor intensity t_1^2, or order spare parts for clients a_1^3 with labor intensity t_1^3.

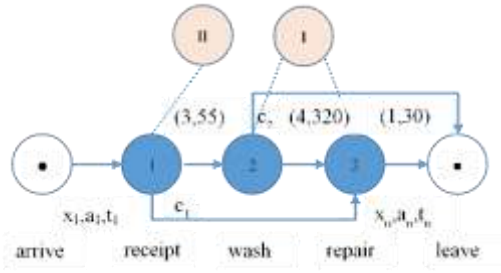


Figure 3. Functional and organizational chart of a service station, presented as a directed graph

The model considers only enlarged types of actions within the main business process, each of which can be performed either by a separate specialist or combined in the responsibilities of one employee. Further, depending on the type of application, it can be sent to the area of cleaning and washing work (wash) or another type of additional work – to the second link x_2, or immediately to the third link x_3 – a post for maintenance and repair (repair). This is the first branch c_1 in the functional scheme under consideration, corresponding to one of two process flows. After the washing zone, the car can be immediately issued to the client at the fourth level x_4

(leave) or sent to the repair area. This is the second branch c_2. Similar to the first, each of the presented links is characterized by its number of actions a_y and the complexity of these actions t_n. At the end, the time the client leaves the enterprise is recorded (leave). The arrive and leave blocks are not links. They are needed to record the time of arrival and departure of an application from the system. The numbers in brackets between the links characterize a certain "value" of the link and show the number of functions performed by the link and the total labor intensity of these functions.

Thus, the functional scheme can be considered in the form of a directed graph and characterized by the following indicators: the number of links x_n that implement the main business process of the enterprise; the number of actions per link a_y / x_n; the labor intensity actions per link t_y / x_n; number of branches c_Σ; coefficient of variation of the number of actions per link σ_a; coefficient of variation of labor intensity of actions per link σ_t. The last two indicators can be considered a quantitative and qualitative balance of the functional scheme, the number of links and branches can characterize the complexity of the functional scheme, and the number and labor intensity of actions per link can characterize the level of specialization of the enterprise functional scheme.

The task of forming an organizational structure for the given graph will be to create a structure that would control the flows between the individual elements of the technological graph (Gould, 2012). For short, such a structure is called an organization. That is, the goal is to create a superstructure over the technological graph in the form of a tree, which "upper" nodes will be supervising managers (administrative apparatus), and the "lower" nodes will be the vertices of the technological graph.

Figure 3 shows a management system where the subordinates of node I are all the mechanics who directly carry out cleaning and washing work as well as vehicle maintenance and repair operations, and the service receptionist reports to another boss II. In this case, node I controls a total of 5 functions, and node II controls 3 functions. Obviously, other options for administering the graph presented in Figure 3 are possible, for example, with one boss who will control all 5 functions of the business process.

Evaluation of different options for organizing the control tree is carried out according to the criterion of minimizing the total cost of the graph. The cost of the graph consists of the costs of maintaining the nodes of the organization's graph and the costs of operating one node. The first cost component depends on the number of control nodes (managers), and the second one – on the number of functions controlled by one node. It should be noted, however, that the practical search for an optimal organizational structure using the simulation modeling method is the task of a separate scientific study, so below we will present the results for optimizing the production (or functional) structure of a motor transport enterprise.

Possible combinations of options for various functional schemes for implementing the main business process of an enterprise were modeled using a simulation model developed for this purpose.

The general structure of the developed simulation model is presented in Figure 4.

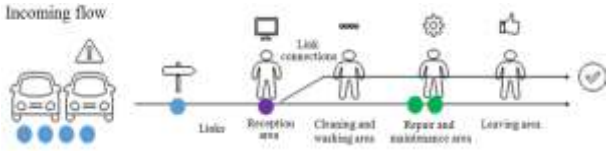


Figure 4. Structure of the simulation model

The flow of applications entering the system has the following parameters: total quantity for a period of time; flow rate; ratio of applications by type; application route. The organization and management of production in the model is determined by two parameters: links, which are channels of different types; a functional scheme that defines the connections between links and the number of branches c_Σ. Each link has the following attributes: quantity *n*; number of actions *y*; and labor intensity of the action *t*. The links also have the following methods: program delay; program interruption; flow redirection. The output parameters of the model are the number of applications served; average waiting time in queue; economic indicators of the channel efficiency and the system as a whole. The model on each link generates an event log, which records the application number, the link type and the current model time (Olkiewicz et al., 2023). This data is used to construct business process charts within the framework of process mining theory in BPMN notation. The first few columns of such a log are presented in Table 1.

Table 1. Register of records (log) generated by the model for processing applications by the link type

Entry No.	Client's number	Action	Time
…			
951	18	leave	2024-02-05 18:26:00
952	19	carwash	2024-02-05 18:33:00
953	19	delivery	2024-02-05 18:53:00
954	20	arrive	2024-02-05 18:59:00
955	20	reception	2024-02-05 18:59:00

The developed simulation model operates with probabilistic values of the receipt and servicing of applications, and also makes it possible to determine parameter values averaged over a given number of iterations.

3. RESULTS AND DISCUSSION

Four options of functional schemes of a car service station were selected as initial data for conducting an experiment on a simulation model. The options are characterized by the sequential addition of the number of links and the complication of the relationships between them.

All presented options correspond to real enterprises and can be defined as a "small garage workshop" – scheme 1; "garage workshop" – scheme 2; "small service station" – scheme 3; "service station" – scheme 4. Within the framework of the scheme 1, the main technological operations for maintenance and repair and additional services (cleaning and washing work, diagnostics, tire fitting, etc.) are performed by one unit (at a universal post(s)); within the framework of the scheme 2, the work of performing maintenance and repair as well as additional services are divided into two different units (that is, posts for the implementation of additional services are added to the universal posts); according to the scheme 3, a separate link is added for issuing the car to the client; according to the scheme 4, in addition to the previous one, a separate specialist for spare parts (warehouse) is involved. The list of links, the actions they perform and their labor intensity used in the modeling are presented in Table 2.

Table 2. Initial data for modeling functional schemes: types of links, actions performed by links, and their corresponding complexity

No.	Actions (a_y)	Labor intensity (t_y), minutes	Links (x_n)
1	Receiving calls	5	1 – service receptionist; 2 –post for additional work/services; 3 –post for performing basic maintenance and repair work; 4 – spare parts master; 5 – car issuing post.
2	Car reception	15	
3	Work	90	
4	Spare parts	20	
5	Additional services (washing, diagnostics)	30	
6	Car issuing	15	

For each of the four schemes considered, the following distribution of types of actions a_y across links x_n was modeled:

- scheme 1: $\{a_1, a_2, a_4, a_6\} \in x_1$, $\{a_3, a_5\} \in x_2$;
- scheme 2: $\{a_1, a_2, a_4, a_6\} \in x_1$, $\{a_3\} \in x_2$, $\{a_5\} \in x_3$;
- scheme 3: $\{a_1, a_2, a_4\} \in x_1$, $\{a_3\} \in x_2$, $\{a_5\} \in x_3$, $\{a_6\} \in x_4$;
- scheme 4: $\{a_1, a_2\} \in x_1$, $\{a_3\} \in x_2$, $\{a_5\} \in x_3$, $\{a_6\} \in x_4$, $\{a_4\} \in x_5$.

Changes in the indicators of all four simulated functional schemes as they become more complex are presented graphically in Figure 5 a and b.

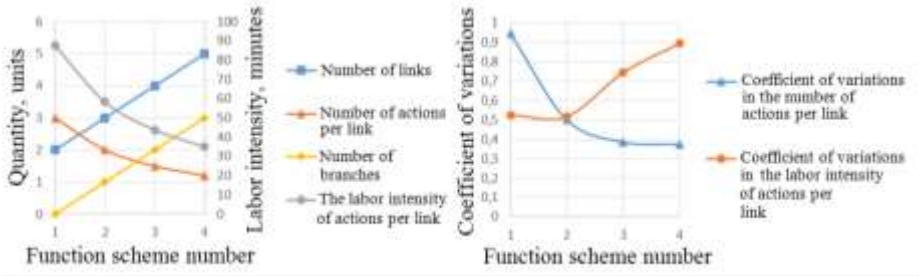


Figure 5. Changes in indicators of functional schemes 1-4 a) quantitative indicators and average labor intensity of operations per link for various schemes b) coefficient of variation for various schemes

As the type of functional scheme becomes more complex, the number of links and the number of branches or options for production routes for cars increases. At the same time, such relative indicators as the number of actions per link and the average labor intensity of operations per link decrease, which may indicate an increase in the links specialization to perform certain technological operations. This conclusion is also confirmed by an increase in the coefficient of variation in the labor intensity of actions per link and a decrease in the coefficient of variation in the number of actions per link. That is, each link, as the scheme becomes more complex, performs fewer actions, but the complexity of these actions can vary greatly for different types of links.

Visualization of the considered options for functional schemes in the form of a business process diagram obtained using the pm4py framework is presented in Figure 6.

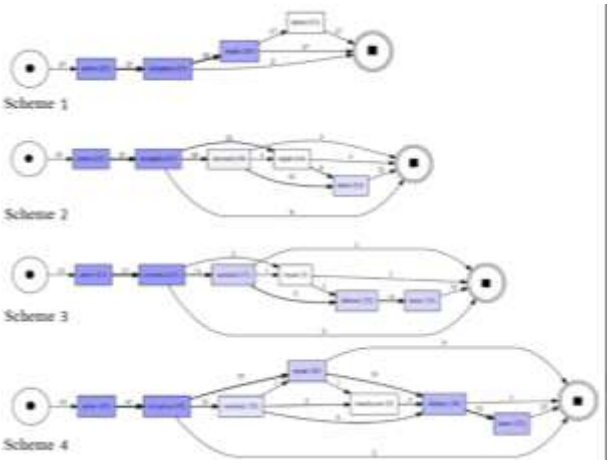


Figure 6. Initial options of functional schemes for simulation modeling

The numbers on the arrows and in brackets inside the blocks correspond to the number of applications that passed through the links based on the results of one modeling cycle. After determining the options for functional schemes and their parameters, the operation of a car service station was simulated within the framework of each scheme. During the simulation, the influence of the input factors indicated in Figure 1 on the system efficiency indicators was assessed. The results of assessing the impact of the total annual number of clients on the optimal variant of the production management structure are shown below.

The annual number of service station clients varied from 1,000 to 15,000 units in increments of 3,000 customers, which roughly corresponds to a range of values from 1 visit every three hours to 1 visit every 15 minutes. The ratio of types of work during modeling was as follows: 70% – maintenance and repair work, 20% – additional services, 10% – a full cycle of work with the application passing through all elements of the functional scheme. For each value of vehicle visits, the optimal number of posts for vehicle maintenance and repair was determined according to the criterion of achieving maximum values of the NPM and ROI efficiency indicators.

During the simulation, for each incoming customer value N, the optimal number of posts according to the selected efficiency criteria was determined. Figure 7 for functional scheme number 2 shows the change in net profitability depending on the number of posts for three different values of N, equal to 3000, 12000 and 15000 units respectively (Figure 7).

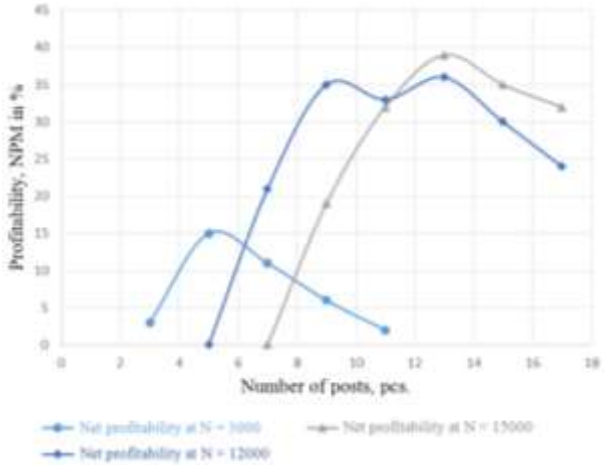


Figure 7. Change in the NPM indicator depending on the number of posts for vehicle maintenance and repair with different annual number of clients N

Based on the graphs shown in Figure 7, we can conclude that stations with a certain number of posts are advisable to use only with a certain number of clients: large stations with over 10 posts are advisable to use when the incoming flow N exceeds 10,000 clients; with a smaller number of clients they will be unprofitable. The opposite situation is observed for service stations with a small number of posts – they are effective only with an annual number of clients not exceeding 6,000 units. Similar patterns were constructed for all four functional schemes under consideration.

In existing methods, the main element of the production and technical base for the maintenance and repair of vehicles at an enterprise, as a rule, is a post equipped with repair personnel and equipment for carrying out work. However, in the presence of several links (or phases) which the application passes through when determining the optimal parameters of the system, the links associated with posts should also be considered which may limit the intensity of the receipt of applications for them. Such links may include a service receptionist. Based on this, modeling of the system operating parameters was carried out taking into account the proportional increase in the number of posts in the number of service receptionists at the rate of 1 specialist per 3,000 clients per year, and also without taking into account their increase at the rate of 2 service receptionists per enterprise. The second scheme loses its effectiveness as the number of clients increases and exhausts itself after 9,000 clients per year. This is due to the emergence of queues at the car acceptance link. The first scheme with an increase in service receptionists shows its effectiveness also with a further increase in the annual number of clients. The graph constructed based on the modeling results for functional scheme number 3, presented in Figure 8, can be used to determine the required number of service receptionists at a service station (Figure 8).

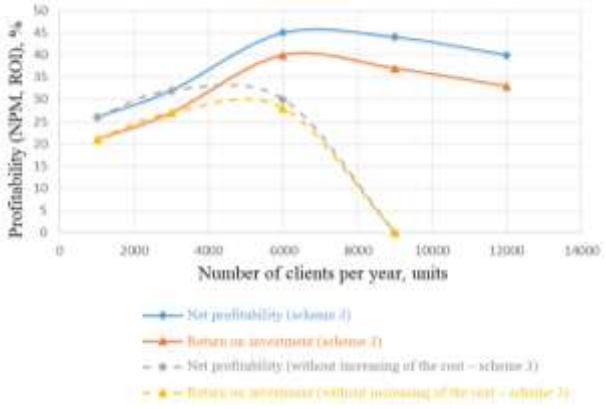


Figure 8. Changes in profitability indicators with an increase in the number of service receptionists (solid lines) and without increasing their number (dashed lines) for functional scheme number 3

Moreover, after 13,000 clients per year, an increase in the number of service receptionists does not lead to a further increase in the efficiency of the enterprise for the current version of functional scheme number 3. In this regard, for the scheme under consideration, the pattern of relationship between the number of service receptionists $N_{м.п.}$ and the annual number of customers of a service station N can be described by a logarithmic curve with the following approximation equation (3):

$$N_{м.п..} = 1{,}57 \cdot \ln(N) - 10{,}12 \quad (3)$$

Similar patterns have been identified for other functional schemes. As a result, the optimal number of posts was determined for each functional scheme for a different annual number of clients. After this, the values of the net profitability indicator corresponding to the optimal number of posts for the selected *N* were plotted on the graph. This made it possible to evaluate the effectiveness of using functional scheme options for various station work levels. It was revealed that scheme 1 with a small number of links is advisable to use in the range of up to 7000 clients. Schemes 2 and 3 have approximately the same extreme points, corresponding to 9,000 clients per year, but scheme 3 shows its effectiveness over a wider range of values. Scheme 4 with a larger number of links and options for process flows becomes most effective when the number of clients exceeds 10,000 units. A graphical representation of the conclusions made is shown in Figure 9.



Figure 9. Dependence of the efficiency of using functional scheme 1-4 on the annual number of clients of a car service station

The pattern of changes in the ROI performance indicator follows the NPM, so it was not presented in the graphs.

Next, models were developed for patterns of changes in indicators (presented in Figure 5 and in the description below) of functional schemes of organization and production management depending on the incoming number of clients *N*:

for the number of links x_n implementing the main business process of the enterprise:

$$x_n = 4.40 \cdot \ln(N) - 36.10 \quad (4)$$

for the number of actions per link a_y / x_n:

$$a_y / x_n = 168339 \cdot N^{-1.27} \quad (5)$$

for the labor intensity of actions per link t_y / x_n:

$$t_y / x_n = 5000000 \cdot N^{-1.27} \quad (6)$$

for the number of branches c_Σ:

$$c_\Sigma = 4.40 \cdot \ln(N) - 38.10 \quad (7)$$

for the coefficient of variation of the number of actions per link σ_a:

$$\sigma_a = 12659 \cdot N^{-1.124} \quad (8)$$

for the coefficient of variation of the labor intensity of actions per link σ_t.

$$\sigma_t = 0.627 \cdot \ln(N) - 4.98 \quad (9)$$

4. CONCLUSIONS

The resulting graphs and models of patterns can be interpreted as follows. As the number of clients *N* increases, schemes with a larger number of links and process flows (branches) will be more efficient. However, as *N* increases, the rate of increase in efficiency slows down, and to increase the effect, qualitatively new actions will obviously be required. For a larger number of clients, functional schemes with lower labor intensity of actions per link and with fewer actions per link are required. That is, when the number of clients grows, it will be more effective to reduce the number of tasks per employee and balance the labor intensity between all functional links: the transition to a quantitative and qualitative balance of the functional scheme. The complication of functional schemes leads to specialization of links: with a decrease in the number of actions per link, the coefficient of their variation also decreases, however, the gap between the labor intensity of actions for different links, expressed by the coefficient of variation of labor intensity, grows. That is, an individual employee may be specialized in performing one or two operations that take significantly less time than another technological operation of his colleague. At the same time, for a small number of clients such schemes will, on the contrary, be redundant and ineffective. For such conditions, it is advisable to use universal posts and combine operations between participants in the technological process.

The presented patterns can be used by enterprise management to make management decisions on adapting the work of service stations to changes in external factors. For example, to increase the efficiency of the functional scheme when the incoming flow of clients increases, you can increase the number of units involved in processing the incoming flow of clients, or specialize them to perform specific technological operations. The advantage of indicators used as performance criteria is that they are relative, and the nature of their changes can be maintained even if the absolute values of the factors included in them change, for example, prices for specific goods and services.

Based on the above, it is possible to formulate a methodology for determining the optimal management structure of a service station, which consists of several steps: determining options for organizational and management structures (OMS) for vehicle maintenance

and repair; determining the relationship between the organizational and management structure and the indicator characterizing the flow of requirements for maintenance and repair work; determining of a set of classification characteristics for each organizational and management structure; modeling the functioning of an enterprise with a selected option of organizational and management structure with different values of the incoming flow of requirements for maintenance and repair; determining the value of the efficiency indicator of the organizational and management structure at different values of the requirements flow; determining of changes in the classification indicators of the organizational and management structure with different values of the requirements flow for maintenance and repair.

Thus, in the course of the study the following results were achieved, constituting the elements of its scientific novelty, namely:

1. The parameters for the classification of organizational and management structures for vehicle maintenance and repair have been determined, the main ones of which include the number of links, the number of actions for each link, the labor intensity of the actions, as well as the degree of their variation.
2. Models of the influence of the annual number of clients on the optimal structure of organization and production management have been determined.
3. The conditions for using each functional scheme of organization and production management with different numbers of clients have been determined, as well as actions to improve the efficiency of the scheme currently used by the enterprise.

The direction of further research is to check the adequacy of the simulation model and its results using data from a real enterprise. It is also planned to decompose solutions by moving away from functional schemes and separately considering the production and organizational structure of the enterprise. The conclusions presented in the work are an approach to solving only one of the four problems associated with production management for vehicle maintenance and repair; therefore, in the future it is planned to solve the problems of planning, motivation and control.

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