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Optimization of the Organizational Structure of a Freight Forwarding Company Based on Multicriteria Analysis and Simulation Modeling

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Abstract

The article is devoted to the development of a methodology for determining the optimal organizational structure of a freight forwarding company based on the integrated application of simulation modeling and multicriteria optimization methods.

To solve this problem, methods of system analysis, simulation modeling in the GPSS World environment and methods of multi-criteria decision-making were used. A simulation model has been developed that reproduces the process of processing applications for international road transport. To aggregate heterogeneous indicators (service time, queue length, staff workload, failure rate, etc.), a formalized approach was applied with data standardization and calculation of an integral efficiency criterion.

Based on the data generated by the simulation model for four alternative structures, a multi-criteria analysis was performed. By calculating generalized and integral indicators, the optimal variant of the structure was determined, which showed the smallest deviation from the reference values according to a set of key criteria.

The developed methodology makes it possible to objectively and quantitatively justify the choice of organizational structure, transferring it from the field of subjective assessments to the plan of data analysis. The practical significance of the work is to provide company managers with a tool for modeling structural changes, assessing their impact on KPIs, and making informed decisions to optimize resources and business processes to reduce costs and improve the quality of services. The results are applicable in the practical activities of logistics companies and in the educational process.

Keywords: Freight Forwarding Company, Organizational Structure, Multi-Criteria Optimization, Simulation Modeling, GPSS World, Key Performance Indicators (KPIs)

1. Introduction

In the context of the growth of international trade, the efficiency of logistics chains is becoming a critical factor of competitiveness. Freight forwarding companies face structural problems (suboptimal resource allocation, flow imbalance, long service time), which leads to economic losses. Traditional empirical management methods do not allow quantifying the impact of structural changes on key performance indicators (KPIs).

The topic of enhancing the efficiency of freight forwarding companies, particularly in international road transport, is widely covered in international academic literature. The research focuses on various aspects: from process modeling and structural optimization to digital transformation and sustainability.

Simulation modeling remains a core method for analyzing and optimizing logistics systems. Research often employs discrete-event simulation (like GPSS, Arena, AnyLogic) to model cargo flows, warehouse operations, and transport networks.

H. Ghiani, G. Laporte, R. Musmanno (2013) in [4] provide a foundational overview of using simulation to evaluate logistics performance, including queueing systems and resource allocation – directly relevant to modeling manager workload and request queues.

J. Banks, J. Carson, B. Nelson (2017) in [2] detail methodological principles for creating credible simulation models, including input data analysis and output interpretation, which supports the technical validity of the approach described in the article.

Lebid E. *et al*. (2024) in [19] use simulation to optimize vehicle routing and fleet management, a key sub-process for a freight

forwarder.

Sedláček M. (2017) in [25] demonstrates the practical application of simulation modeling to optimize the internal procedures of a freight forwarding company (for warehouse or administrative processes). This confirms the relevance and effectiveness of the tools selected in the article (GPSS World) for solving similar problems.

Improving the efficiency of a freight forwarding company is closely related to the search for an optimal organizational structure, where personnel are the key element.

Luzhanska N.O. *et al*. (2020) in [21] focus on evaluating the efficiency of using freight forwarding company personnel. Their approach, based on an analysis of workload and productivity indicators, serves as a methodological basis for selecting such local criteria in the proposed model as the "manager load factor" and "average service time".

Wasielewska-Marszałkowska I. (2015) in [28] analyzes the transformation of the role of a freight forwarder from a simple intermediary to an integrator of logistics services. The work highlights the need to adapt the freight forwarding company's organizational structure to new requirements, such as risk management, coordination of complex supply chains, and implementation of digital solutions.

Abdulla M.F., Musa H. (2022) in [1] consider freight forwarding companies as part of a broader service value chain. Their model shows how the internal factors of the company (which can include the organizational structure) through the quality of logistics services, they influence the final business results, justifying the importance of internal optimization.

Hyland M.F. *et al*. (2016) in [7] use analytical and simulation models to decompose the operational and economic advantages of a particular type of service. This example of a deep analysis of cause-and-effect relationships in the transport system is methodologically close to the purpose of building an imitation model in the article.

Manuj I., Sahin F. (2011) in [22] propose a conceptual model for analyzing the complexity of supply chains. Their ideas can be used to justify the choice of multidirectional criteria for evaluating the structure of a freight forwarding company operating in a complex international transportation environment.

Yang N. *et al*. (2022) in [30] present an example of hybrid modeling combining agent modeling and system dynamics. The article confirms the trend towards using simulation modeling to analyze interactions in logistics systems and serves as a guideline for the possible development of the proposed model.

Lebid E. *et al*. (2023) in [17] conduct a study aimed at modeling cargo delivery in international road transport, considering the efficiency of the entire logistics chain. This work directly intersects with the object of research in this article and can be considered as a related study, where the focus is shifted to the delivery chain.

The purpose of the research is to develop a methodology for determining the optimal structure of freight forwarding companies based on simulation modeling and multicriteria optimization methods.

To achieve **this goal**, the following tasks are being solved:

- Analysis of the work process of a freight forwarding company in the organization of international road transportation and identification of key parameters affecting efficiency.
- Development of a simulation model for processing incoming customer requests in the GPSS World environment, which allows evaluating various scenarios of the company's work.
- Formation of a system of interrelated performance indicators (local criteria) reflecting various aspects of the freight forwarding company's activities.
- Creation of a methodology for bringing heterogeneous indicators to a comparable form, ranking them and integrating them into a generalized criterion for comparative evaluation of alternative structures.
- Testing of the proposed approach using the example of modeling structural variants and determining the optimal one.

2. Simulation model of the company's freight forwarding activities

To objectively assess the effectiveness of various organizational structures of a freight forwarding company and identify "bottlenecks" in its work, an imitation model of key business processes has been developed [9]. The model is implemented in the GPSS World simulation automation environment [6, 16, 26] and reproduces the logic of customer request service in the organization of international road transport.

The purpose of the simulation of the company's freight forwarding activities is to obtain quantitative estimates of the company's performance indicators in various variants of its organizational structure, which is the basis for the subsequent selection of the optimal structure.

The input parameters of the model (*X*) include:

- the incoming flow λ_r of applications for the provision of freight forwarding services for the organization of road freight transportation in the *r*-th direction (Republic of Belarus, Russian Federation, European Union, Republic of Kazakhstan);
- an estimate of the average time $m_{ij} \pm \sigma_{ij}$ of performing the *j*-th work W_{ij} of the *i*-th stage of ST_i for processing the application by the manager;
- the number of N_k managers working with clients;
- the probability γ_l of choosing the movement of the application depending on the verification of the condition.

The output characteristics of the model (*Y*), representing the statistics of the simulation:

- the average freight forwarding service time for the organization of road freight transportation in the *r*-th direction (Republic of Belarus, Russian Federation, European Union, Republic of Kazakhstan) (t_r);
- the average length of the queue to the manager for processing the application (η_k);
- the average waiting time for the client in the queue to the manager (w_k);
- the proportion of applications served without downtime in the queue (ν_k);
- probability of denial of service (q_k);
- manager load factor (ψ_k);
- the average number of managers loaded (ρ_k).

These indicators were chosen as **local performance criteria** for subsequent multi-criteria analysis and determination of the optimal company structure.

The description and implementation of the simulation model of the company's freight forwarding activities are presented

in the article [9].

During the simulation experiments, four alternative organizational structures of the freight forwarding company (FFC_1 - FFC_4) were tested.

As a result of the simulation, the average service time for incoming requests is shown in Table 1.

Table 1: The results of modeling the average service time (t, min)

Freight forwarding company options	Republic of Belarus	Russian Federation	European Union	Republic of Kazakhstan
FFC_1	175	218	294	260
FFC_2	194	229	307	273
FFC_3	144	181	257	223
FFC_4	205	244	319	285

Based on the reports obtained because of the simulation, the main indicators of four alternative organizational structures of the freight forwarding company (FFC_1 – FFC_4) have been determined (Table 2).

Table 2: The results of modeling the process of providing freight forwarding services

Freight forwarding company options	Indicators	Customer Service Manager	Transport Manager	Operational Logistician	The value of the generalized indicator
FFC_1	w_k	17,1	11,8	2,6	31,5
	η_k	3,6	1,7	1,2	2,17
	v_k	30	26	76	44,00
	N_k	3	1	12	16
	ρ_k	2,36	0,71	7,70	10,77
	ψ_k	0,79	0,71	0,64	0,71
FFC_2	w_k	28,8	19,0	4,6	52,4
	η_k	6,0	2,7	2,2	3,63
	v_k	22	17	64	34,3
	N_k	4	1	10	15
	ρ_k	2,52	0,80	7,62	10,94
	ψ_k	0,84	0,80	0,76	0,80
FFC_3	w_k	6,7	9,5	1,4	17,6
	η_k	1,4	1,4	0,7	1,17
	v_k	56	28	81	55
	N_k	4	1	12	17
	ρ_k	2,40	0,70	7,98	11,08
	ψ_k	0,60	0,70	0,67	0,66
FFC_4	w_k	17,4	21,1	3,9	42,4
	η_k	3,7	3,2	1,9	2,93
	v_k	35	13	63	37
	N_k	4	1	10	15
	ρ_k	3,01	0,86	8,04	11,91
	ψ_k	0,75	0,86	0,80	0,80

Thus, the simulation model serves as a tool for generating objective source data, which, within the framework of the developed methodology, are used to select the best organizational structure for a freight forwarding company.

3. Methodology for determining the optimal structure of a freight forwarding company

Assessment of the efficiency of a freight forwarding company and the choice of its optimal organizational structure are based on a system of interrelated indicators (criteria) F_i.

The formation of this system must meet two main requirements:

- completeness of the reflection of the specifics of the company's activities in the field of international road transport;
- an unambiguous focus on achieving the goal of modeling – determining the optimal structure of the company.

The set of indicators used for evaluation is grouped into groups called **local criteria**. These criteria can be both quantitative and qualitative, have different units of measurement, different significance (weight) and a multidirectional influence on the final generalized performance indicator.

According to the direction of the impact on the generalized integral criterion, local indicators are divided into two groups:

- **reverse orientation indicators**, increasing the values of which reduces overall efficiency (for example, service time, queue length);
- **direct targeting indicators**, increasing the values of which increases overall efficiency (for example, the proportion of applications serviced without downtime).

To ensure comparability, all indicators should be brought to a **single focus** – the reverse. Forward-looking indicators are transformed by taking the inverse value (exponentiation -1).

Since local criteria have different importance, they are ranked in importance and weighted coefficients W_i are assigned, reflecting the contribution of each indicator to the integral assessment.

Based on the formed groups of indicators for each of the considered variants of the FFC_j company structure, a matrix is constructed (Table 3), in which for each criterion its value for the corresponding variant of the structure is fixed.

Table 3: Matrix of performance indicators of freight forwarding company

Performance indicators	FFC_1	FFC_2	…	FFC_j	…	FFC_m	Optimal indicators
F_1	X_{11}	X_{12}	…	X_{1j}	…	X_{1m}	X_1^*
F_2	X_{21}	X_{22}	…	X_{2j}	…	X_{2m}	X_2^*
…	…	…	…	…	…	…	…
F_i	X_{i1}	X_{i2}	…	X_{ij}	…	X_{im}	X_i^*
…	…	…	…	…	…	…	…
F_n	X_{n1}	X_{n2}	…	X_{nj}	…	X_{nm}	X_n^*

where X_{ij} is the value of the i–th performance indicator for the j-th variant of the structure of a freight forwarding company.

The optimal values of the indicators are determined by selecting the minimum value for each criterion among all possible structures.:

$$X_i^* = \min_j \{X_{ij}\}.$$

As a result, a vector of optimal parameters is formed: $X^* = \{X_1^*, X_2^*, \ldots, X_n^*\}$.

Data standardization is carried out to eliminate the influence of heterogeneity of measurement units. Standardization brings the values of all indicators to a single range of values. There are various ways to standardize the source data.

To standardize the source data, the corresponding optimal value X_i^* is divided by each value X_{ij}, which brings all indicators to a dimensionless form in the range (0, 1]:

$$R_{ij} = \frac{x_i^*}{x_{ij}}.$$

Based on the standardized matrix and the weighting coefficients, a **generalized efficiency indicator** is calculated for each variant of the FFC_j structure.:

$$FC_j = \sum_{i=1}^{n} W_i \cdot R_{ij}.$$

For the optimal (reference) structure, the generalized indicator is:

$$FC^* = \sum_{i=1}^{n} W_i.$$

The integral efficiency indicator C_j is defined as the difference between the generalized indicator of the optimal structure and the generalized indicator of the evaluated option.:

$$C_j = |FC^* - FC_j|.$$

The lower the value of the integral indicator C_j, the closer the efficiency of the evaluated structure FFC_j is to the optimal one. Thus, ranking the options in ascending order C_j allows us to objectively choose the best organizational structure of a freight forwarding company.

The proposed method is a flexible tool that allows us to adapt the system of criteria and weighting factors to specific conditions and strategic priorities of the company.

4. Determining the optimal structure of a freight forwarding company

As a result of simulation modeling of the work of a freight forwarding company, the values of efficiency indicators are determined:

F_1 – the average freight forwarding service time for the organization of road freight transportation to the Republic of Belarus (t_{1j});

F_2 – the average freight forwarding service time for the organization of road freight transportation to the Russian Federation (t_{2j});

F_3 – the average freight forwarding service time for the organization of road freight transportation to the European Union (t_{3j});

F_4 – the average freight forwarding service time for the organization of road freight transportation to the Republic of Kazakhstan (t_{4j});

F_5 – the average waiting time for the client in the queue to the manager (w_k),

F_6 – the average length of the queue to the manager for processing the application (η_k)

F_7 – the proportion of applications served without downtime in the queue (ν_k);

F_8 – the number of managers working with clients (N_k);

F_9 – manager load factor (ψ_k);

F_{10} – the average number of managers loaded (ρ_k).

Indicator F_7 has a direct impact on the final performance indicator. Indicator F_7 is given to indicators that have a reverse impact on the final performance indicator.

The indicators have the same importance of influencing the final performance indicator, therefore, the W_j weighting coefficients are equal and are not considered in the calculations.

Table 4: Matrix of performance indicators of freight forwarding company

Indicators		FFC$_1$	FFC$_2$	FFC$_3$	FFC$_4$	Optimal indicators
F_1	t_{1j}	175	194	144	205	144
F_2	t_{2j}	218	229	181	244	181
F_3	t_{3j}	294	307	257	319	257
F_4	t_{4j}	260	273	223	285	223
F_5	w_k	31,5	52,4	17,6	42,4	17,6
F_6	η_k	2,17	3,63	1,17	2,93	1,17
F_7	ν_k	0,023	0,029	0,018	0,027	0,018
F_8	N_k	16	15	17	15	15
F_9	ρ_k	10,77	10,94	11,08	11,91	10,77
F_{10}	ψ_k	0,71	0,80	0,66	0,80	0,66

Since performance indicators have different units of measurement, the initial data are reduced to the range (0, 1] by standardizing the data (Table 5). Generalized and integral efficiency indicators for the optimal structure of a freight forwarding company are shown in Table 5.

Table 5: Relational matrix of performance indicators of freight forwarding company

Indicators		FFC$_1$	FFC$_2$	FFC$_3$	FFC$_4$	Optimal indicators
F_1	t_{1j}	0,823	0,742	1,000	0,702	1
F_2	t_{2j}	0,830	0,790	1,000	0,742	1
F_3	t_{3j}	0,874	0,837	1,000	0,806	1
F_4	t_{4j}	0,858	0,817	1,000	0,782	1
F_5	w_k	0,559	0,336	1,000	0,415	1
F_6	η_k	0,539	0,322	1,000	0,399	1
F_7	ν_k	0,800	0,624	1,000	0,673	1
F_8	N_k	0,938	1,000	0,882	1,000	1
F_9	ρ_k	1,000	0,984	0,972	0,904	1
F_{10}	ψ_k	0,930	0,825	1,000	0,825	1
FC_j		8,150	7,278	9,854	7,249	10
C_j		1,850	2,722	0,146	2,751	0

Having ranked FFC$_j$ in descending order of integral performance indicators, the following results were obtained: FFC$_3$, FFC$_1$, FFC$_2$, FFC$_4$.

As a result, the optimal structure of a freight forwarding company FFC$_3$ was determined from the four options considered. The selection criterion was the minimum integral efficiency indicator $C_3^* = 0{,}146$, calculated based on the simulation results.

This option is characterized by the lowest average service times in all directions, the minimum waiting time and queue length, as well as the most balanced staff workload.

5. Conclusions

In this study, an urgent applied task was solved – the development and testing of a scientifically sound methodology for determining the optimal organizational structure of a freight forwarding company specializing in international road transport.

The main scientific and practical results of the work are as follows:

A comprehensive methodological approach has been developed that integrates simulation modeling tools and multicriteria optimization methods. This approach makes it possible to transfer the process of structural design from the field of subjective expert assessments to the field of objective quantitative analysis based on data.

A simulation model of the company's key business processes has been created in the GPSS World environment. The model reproduces the logic of processing client

requests, the work of managers of various specializations and the formation of queues. It serves as an effective tool for generating initial data and conducting multivariate experiments to optimize the structure without risks for real business.

A system of criteria has been formed and applied to evaluate the effectiveness of organizational structures. The system includes interrelated local indicators (service time, queue length, staff workload, percentage of applications served, etc.) that comprehensively reflect various aspects of the forwarding company's activities. An algorithm is proposed for bringing heterogeneous and multidirectional indicators to a comparable form through standardization procedures.

The optimal company structure (FFC_3) has been determined and quantified. Four alternative structures were compared using the developed methodology based on the calculation of generalized and integral performance indicators. The FFC_3 variant demonstrated the smallest deviation from the conditional standard (integral indicator $C_3^* = 0{,}146$), which confirms its advantage in terms of a set of key parameters: minimum average service time, shortest waiting time for customers and the most balanced workload of managers.

The scientific novelty of the research lies in the complex adaptation and application of the multi-criteria decision-making apparatus to the problem of structural optimization in freight forwarding activities based on simulation data.

The practical significance of the work lies in the fact that the developed model and methodology provide the management of freight forwarding companies with a specific tool for:

- analyzing "bottlenecks" in the existing organizational structure;
- assessment of the impact of changes in the number and specialization of staff on key performance indicators;
- informed management decision-making aimed at reducing costs, reducing maintenance time and improving the quality of service.

The proposed approach contributes to the development of modeling and management methods in logistics and can be used both in the practical activities of companies and in the educational process when training specialists in the field of logistics and supply chain management.

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