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Improving the Efficiency of a Freight Forwarding Company in the Organization of International Road Cargo Transportation

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Abstract
The object of the study is the process of work of a freight forwarding company in the organization of international road cargo transportation. The article proposes a simulation model of the work of a freight forwarding company in customer service in the GPSS World simulation automation package. As a result of simulation modeling of the work of a freight forwarding company, the values of efficiency indicators are determined. Methodology has been developed to determine the optimal structure of a freight forwarding company in the organization of international road cargo transportation. The developed simulation model and methodology for determining the optimal structure of a freight forwarding company can be used to improve the efficiency of providing freight forwarding services when organizing international road cargo transportation.

Keywords: Freight Forwarding Company, Queuing System, Simulation Modeling, Optimal Structure

1. Introduction

Transport provides full satisfaction of the needs of national economy and population in transportation. More than half of the volume of traffic is carried out road transport, since it is the most mobile and maneuverable. It also allows the delivery of goods from places of production to places of consumption.

In order to increase the volume of cargo transportation by road, it is important to provide high-quality freight forwarding services to potential customers, since at present the object of research of the transport market is the customer and his needs. The more profitable the transportation is, the more interested the customer is.

The most common aspects that are usually subject to constant reforms in freight forwarding companies operation are workforce and material-and-technical capacity management. Potential measures that are considered to optimize the staffing level to provide complex and timely freight forwarding service provision, as well as derive economic benefits from the operation are the assessment of costs, revenues, and profits generated from the activity [1].

The purpose of the work is to determine the optimal structure of a freight forwarding company to improve the efficiency of providing freight forwarding services in the organization of international road cargo transportation.

For this purpose, it is necessary:

- To create a simulation model for the provision of freight forwarding services, which allows conducting research and determining the values of the company's performance indicators;
- To develop methodology for determining the optimal structure of a freight forwarding company in the organization of international road cargo transportation.

2. Simulation model of freight forwarding services by a company

Simulation model has been developed to evaluate the activity of a freight forwarding company and determine its optimal structure.

The input parameters of model *X* are:

- Incoming flow λ_j of receipt of requests for transportation depending on the type of customers and directions of cargo delivery;

- The time of completion of the work $m_j \pm \sigma_j$ for processing the application by the freight forwarder, depending on the type of customers and the direction of delivery of the cargo;
- Priority Pr_j in servicing the incoming flow of requests for transportation from customers of different types and directions of cargo delivery;
- The number of freight forwarders *n* working with different clients;
- The processing time of the application on the exchange $a_j \pm b_j$.

The output characteristics – responses of model *Y* are the modeling statistics:

- The average time of service by the freight forwarder (preparatory operations) depending on the type of customers and the direction of cargo delivery (tp_j);
- The average time of cargo delivery, taking into account preparatory operations, depending on the type of customers and the direction of cargo delivery (ts_j);
- The average length of the queue to the freight forwarder for processing the application (η_k)
- The average waiting time for the client in the queue to the freight forwarder (w_k),
- The number of applications denied service (φ_k);
- The proportion of applications served without downtime in the queue (ν_j);
- Freight forwarder load factor (ψ_k).

As performance indicators that determine the goals of modeling – choosing the optimal structure for organizing the work of a freight forwarding company, the output characteristics *Y*.

The limitations of the simulation model are related to:

- The conditions imposed on the incoming flow of incoming applications (it is assumed to be the simplest, there are no repeated applications),
- The absence of phenomena that change the patterns of application service time (failures and failures of equipment, etc.).

To justify the choice of the optimal structure of the company and optimize the processing of incoming applications, a mathematical model of queuing system is proposed.

The mathematical model of processing incoming streams is shown in Fig 1.

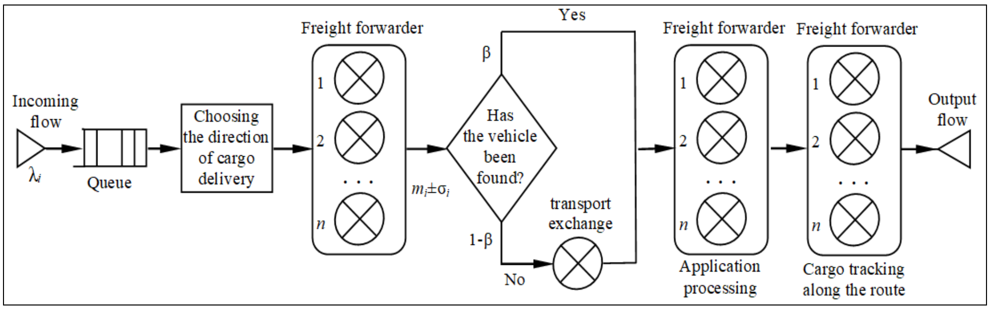

Fig 1: The scheme of modeling the processing of incoming application flows

The proposed model for the provision of freight forwarding services was created in the GPSS World simulation automation package [9-11].

Five variants of the freight forwarding company (FFC_j, $j=\overline{1,5}$) structure were used as input information *X* for the developed simulation model.

According to the reports obtained because of modeling the processing of incoming requests, the main indicators of the simulation results were determined, and the amount of time lost for requests for service in queues was calculated (Table 1).

Table 1: The main indicators of modeling results

Output parameters	FFC_1	FFC_2	FFC_3	FFC_4	FFC_5
The average time of service by the manager (preparatory operations), min (tp_j)	88,9	105,7	210,8	58,4	154,9
The average time of cargo delivery, considering preparatory operations, hour (ts_j)	112,2	125,4	175,6	110,5	156,5
The average length of the queue for processing the application (η_j)	0,222	0,353	0,260	0,199	0,333
The average waiting time for a client in the queue to the manager, min (w_j)	6,468	18,824	35,633	7,546	26,786
The number of applications that received a denial of service, % (φ_j)	9	17	22	11	19
The proportion of applications served without downtime in the queue, % (ν_j)	16	12	8	17	7
Freight forwarder load factor (ψ_j)	0,77	0,76	0,91	0,78	0,85

Analyzing the simulation results obtained, we see that the "bottleneck" for this flow is the number of freight forwarders working with clients, the increase of which will allow serving more clients, reducing customer service time, and reducing the number of applications entering the exchange.

3. Methodology for determining the optimal structure of a freight forwarding company in the organization of international road freight transportation

The assessment of the activity of a freight forwarding company is carried out based on various indicators.

On the one hand, the task of determining the composition of these indicators is to ensure that they consider the content and characteristics of the object of assessment as much as possible. On the other hand, indicators should unambiguously define the goals of modeling – determining the optimal structure of a freight forwarding company.

The groups of indicators that are allocated to assess the structure of a freight forwarding company are called local criteria.

Both quantitative and qualitative indicators have different

units of measurement, varying degrees of influence (weight) and different directions of influence on the final performance indicator (generalized criterion) of choosing the optimal structure of the company.
Local criteria have different directions of influence on the final performance indicator:

- Indicators of the first group have the property of backward orientation to the generalized integral criterion,
- Indicators of the second group have the property of direct orientation to the generalized integral criterion.

To bring the indicators of the second group to the indicators of the first group, it is necessary to find the values inverse to the data (raise their values to the degree of "minus one").
Since local criteria have varying degrees of influence (weight) on the final performance indicator, it is necessary to rank them according to the significance of the impact on the final generalized performance indicator.
Thus, all performance indicators will be ranked according to the significance of the impact and have a single reverse orientation to the final generalized performance indicator.
For each group of factors, a matrix of indicators is formed, ranked by importance and having a single inverse orientation to the final generalized efficiency indicator of the evaluated structure of the freight forwarding company FFC_j (Table 2).

Table 2: 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.
To determine the parameters of the optimal structure of a freight forwarding company, the minimum value of indicators is selected for each group of factors:

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

As a result, a vector with the parameters of the optimal structure of the freight forwarding company will be formed for each group of factors:

$$X^* = \{X_1^*, X_2^*,\ldots, X_j^*, \ldots, X_n^*\}.$$

Since performance indicators have different units of measurement, the initial data must be reduced to the range [0,.., 1] by normalizing the data by dividing the optimal indicator X_i^* by the indicators X_{ij} characterizing FFC_j (Table 3).

Table 3: Relational matrix of performance indicators of freight forwarding company

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

The significance of each factor is determined by the weighting coefficient W_i, which reflects the contribution of each factor to the integral criterion for each group.
The generalized indicator of economic efficiency for the assessment of FFC_j is determined by the formula:

$$FC_j = \sum_{i=1}^{n} W_i \cdot \frac{X_i^*}{X_{ij}}, \quad j = (\overline{1, m}).$$

The generalized efficiency indicator for the optimal structure of a freight forwarding company is defined as:

$$FC^* = \sum_{i=1}^{n} W_i \cdot \frac{X_i^*}{X_i^*} = \sum_{i=1}^{n} W_i, \quad j = (\overline{1, m}).$$

The integral efficiency indicator is determined by comparing the generalized efficiency indicator for the optimal structure of the freight forwarding company with the generalized indicator of the estimated FFC_j:

$$C_j = FC^* - FC_j, \quad j = (\overline{1, m}).$$

The lower the absolute value of the integral indicator of the effectiveness of evaluating the structure of a freight forwarding company, the higher the efficiency of the estimated FFC_j, i.e. the closer the efficiency of the estimated FFC_j is to the optimal one.

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 time of service by the freight forwarder (preparatory operations) depending on the type of customers and the direction of cargo delivery (tp_j);
F_2 - the average time of cargo delivery, taking into account preparatory operations, depending on the type of customers and the direction of cargo delivery (ts_j);
F_3 - the average length of the queue to the freight forwarder for processing the application (η_j);
F_4 - the average waiting time for the client in the queue to the freight forwarder (w_j);
F_5 - the number of applications denied service (φ_j);
F_6 - the proportion of applications served without downtime in the queue (ν_j);
F_7 - freight forwarder load factor (ψ_j).

Indicator F_6 has a direct impact on the final performance indicator. Indicator F_6 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 taken into account in the calculations.

Table 4: Matrix of performance indicators of freight forwarding company

Indicators		FFC_1	FFC_2	FFC_3	FFC_4	FFC_5	Optimal indicators
F_1	tp_j	88,9	105,7	210,8	58,4	154,9	58,4
F_2	ts_j	112,2	125,4	175,6	110,5	156,5	110,5
F_3	η_j	0,222	0,353	0,260	0,199	0,333	0,199
F_4	w_j	6,468	18,824	35,633	7,546	26,786	6,468
F_5	φ_j	9	17	22	11	19	9
F_6	ν_j	0,063	0,083	0,125	0,059	0,143	0,059
F_7	ψ_j	0,77	0,76	0,91	0,78	0,85	0,76

Since performance indicators have different units of measurement, the initial data are reduced to the range [0,.., 1] by data normalization (Table 5). Generalized and integral performance 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	FFC_5	Optimal indicators
F_1	tp_j	0,657	0,553	0,277	1,000	0,377	1
F_2	ts_j	0,985	0,881	0,629	1,000	0,706	1
F_3	η_j	0,896	0,564	0,765	1,000	0,598	1
F_4	w_j	1,000	0,344	0,182	0,857	0,241	1
F_5	φ_j	1,000	0,529	0,409	0,818	0,474	1
F_6	ν_j	0,937	0,711	0,472	1,000	0,413	1
F_7	ψ_j	0,987	1,000	0,835	0,974	0,894	1
FC_j		6,462	4,581	3,569	6,650	3,703	7
C_j		0,538	2,419	3,431	0,350	3,297	0

Having ranked FFC_j in descending order of integral performance indicators, the following results were obtained: FFC_4, FFC_1, FFC_2, FFC_5, FFC_3. The lower the absolute value of the integral indicator of the effectiveness of evaluating the structure of a freight forwarding company, the higher the efficiency of FFC_5, i.e. the closer the efficiency of the evaluated FFC_5 is to the optimal one.

5. Conclusions

The developed simulation model and methodology for determining the optimal structure of a freight forwarding company can be used to improve the efficiency of providing freight forwarding services when organizing international road freight transportation.

In determining the optimal number of employees to work with service consumers, a company's management should take into account the quantitative and qualitative indicators of their activities, but the most important aspect of any freight forwarding organization`s operation is, of course, financial indicators.

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