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# SELECTING A TRANSPORT AND FORWARDING COMPANY FOR MEETING A CUSTOMER'S NEEDS WHEN ORGANIZING INTERNATIONAL ROAD CARGO TRANSPORTATION

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***The object of this study is the process of planning the work of a manufacturing enterprise that needs transport and forwarding services when exporting goods to counterparties in different countries of the world.***

***The problem being solved is predetermined by the need to devise recommendations for choosing a transport and forwarding company when serving an individual customer, based on its individual needs and conditions of cooperation.***

***A simulation model for the selection of a transport and forwarding company was constructed and implemented to meet the customer's needs when exporting goods, applying the GPSS World simulation automation package.***

***The model provides for the optimization of the choice of a transport and forwarding company for servicing counterparties based on the assessment of their activity indicators over previous periods of cooperation.***

***When building the model, the types of commercial conditions of the exporter's cooperation with the transport and forwarding company, indicators of the quality assessment of the basic level of service and the duration of service at all stages of the foreign trade operation were taken into account. The application of the constructed model in practice will enable exporters and importers to choose a transport and forwarding company depending on the individual needs of customers in the delivery of goods. The simulation results reflect the performance indicators of the provision of transport and forwarding services by various specialized enterprises. This will make it possible to involve in the transport and forwarding service of a separate counterparty an organization that will meet all the requirements of goods buyer in accordance with the terms of the international economic contract. At the same time, the duration of choosing and agreeing the terms of cooperation could be reduced by 12–15 % while the efficiency of transport and forwarding services would increase by 13–16 %***

***Keywords: transport and forwarding service, simulation model, intermediary services, international transportation***

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## 1. Introduction

The effectiveness of export-import trade operations has a significant impact on the level of trust in exporters in the international market of goods and services. When concluding international economic contracts, an important aspect is the distribution of responsibilities between the buyer and seller of the goods regarding responsibility for the delivery of the goods.

The main range of services related to the organization of international transportation is performed by transport and forwarding companies (TFCs). Planning the delivery of goods by the exporter involves the selection of an intermediary organization capable of rendering a full range of necessary services in compliance with the terms of the commercial agreement.

Depending on the demand for goods, the exporter can involve one or more TFCs in cooperation. The interaction between the customer and contractor can be based on such forms as bidding, contract, auction, reduction, and general conditions. The key features of choosing a form of cooperation with TFC are the frequency of the counterparty's requests and the level of satisfaction with the quality of service.

The list of works carried out by TFCs when exporting goods has a clear sequence. However, the quality and duration of service is closely related to the company's available resources and readiness to process the order in accordance with the exporter's needs. Significant differences in the performance of enterprises are related to the direction of transportation, namely searches for rolling stock in partner organizations (in case of lack of free own); preparation of customs, transportation, and commercial documents. An important aspect is compliance with the requirements for international transportation through the territory of the countries of departure, destination, and transit. In turn, depending on the chosen form of cooperation, there may be differences in priority and time characteristics of service.

Scientific research into this area is important because under the conditions of competition on the market of transport and forwarding services, the choice of an enterprise that will provide the necessary range of services is relevant for customers. Due to the fact that each enterprise is characterized by significant differences in technical, technological, and organizational support, this has an impact on the duration and quality of service. Accordingly, it is in the interests of the customer to choose a transport and forwarding company that is able to satisfy its individual requirements for the delivery of goods in international communication. It is possible to achieve this goal by automating the processes of organizational and management activities of production and trade enterprises and other stakeholders.

The results of such studies are needed in practice because the application of software packages in the activities of subjects of international economic activity will contribute to the formation of stable partnership relations. In turn, this will make it possible to optimize the duration of choosing a business entity and direct service, as well as provide the required level of service. Based on the assessment of qualitative and quantitative indicators of the effectiveness of service provision, it will be possible to plan international trade operations over long-term periods.

## 2. Literature review and problem statement

In work [1], a study of problems and factors that affect cargo transportation in transport and forwarding organizations engaged in forwarding and servicing of shippers was carried out. The study identifies and analyzes a number of problems faced by freight forwarders with carriers, as well as companies and individual clients. But this study concerns those processes that take place already after the selection of TFC and does not show how the customer chooses this or that enterprise for transportation.

In work [2], the directions for improving the transport and logistics service of international freight transportation are considered. The study showed that the comprehensive rendering of transport and logistics services by the company is one of the most priority directions. A significant number of TFCs operate in each country, among which the customer must choose the one that will most fully meet its requirements. However, the cited paper does not consider the issue of choosing a TFC by the customer, although it is of significant importance in the organization of cargo transportation in international traffic.

Paper [3] notes the importance of selecting a servicing TFC and provides certain recommendations for its selection. The authors emphasize that when choosing a TFC, it is necessary to pay attention to the level of specialists, the availability of own rolling stock, the cost and quality of the offered services, and reviews of other organizations. However, the work does not provide an algorithm for selecting TFCs, and there is no study of the influence of each of the criteria on the selection results.

In work [4], authors investigated the influence of the quality of the provision of transport services on customer satisfaction. The research results allowed them to conclude that customer loyalty is one of the main goals of TFC. Therefore, transport companies need to devise strategic measures that can involve improving each component of service quality to increase customer satisfaction. That is, the work indicates the importance of high-quality customer service, but no recommendations are given as to how the client should choose one or another company for transportation.

Simulation models of transport processes and systems are the main tool for research and solving many problems in the field of their management.

Thus, in work [5], authors built a model that makes it possible to study the process of transportation planning by freight forwarders through the involvement of third-party carriers. The implementation of subcontracting extends the traditional routing of own vehicles to integrated operational transportation planning, which simultaneously constructs execution plans with the lowest total cost, using own fleet and vehicles of subcontractors. The results of the calculations show a significant reduction in costs when using the proposed approach to planning. However, the given model is related to the optimization of TFC work and does not take into account the interests of the customer regarding the choice of the carrier.

In work [6], authors modeled transport processes in a transport forwarding agency, using Business Process Modeling tools and methodology. The transportation process with all the stages associated with it was modeled in specialized software in order to identify bottlenecks, overloads, uneven distribution of workload, excessive time, money, etc. This model cannot be applied in the study of the choice of TFC to meet the customer's needs.

In work [7] it is indicated that the interconnectedness of various participants in freight transportation has turned it into a large complex system. It is difficult to conduct research analysis in such a system. This work presents a four-stage model of freight transportation. But it does not provide for the possibility of choosing TFC by the customer.

Work [8] considers the possibility of optimizing the processes of TFC, which provides services for international road transportation. For research, a simulation model built in the SIMUL8 environment was used, which provides the possibility of dynamic discrete modeling of the company's processes. But this model is limited only to the functioning of the company's warehouse, un which the sequence of loading and unloading operations of vehicles is carried out and possible downtimes are investigated. Such a model cannot be used to study the process of TFC selection in transportation planning.

In [9], authors devised and implemented a simulation model of the work of a transport-forwarding company when serving customers. The model provides for the optimization of organizational and management processes in cooperation with customers of transport and forwarding services. The application of the developed model provides an opportunity for owners of transport and forwarding companies to plan the number of staff of forwarders and the duration of service provision under different conditions of interaction with customers. This IM makes it possible to improve the quality of customer service but does not provide an opportunity to investigate the process of choosing a TFC by the customer to meet its needs in the organization of international road transportation of goods.

In work [10], authors performed a critical analysis of the existing optimization models of the process of interaction of transport market subjects. A mathematical model of the choice of rational strategies of behavior in the strategic planning of the activities of transport market entities with an orientation on the commercial efficiency of the customer is suggested. The proposed mathematical model provides an opportunity to consider the maximum number of alternative delivery participants among the representatives of each delivery element and take into account the amount of external additional profit from the cooperation of participants. This model is focused on the study of interaction between participants of the transportation process and cannot be used to study the process of choosing a TFC by the client.

The above models consider the activity of TFC and methods of improving its functioning. This is important because providing quality service attracts new and keeps customers. But it is also necessary to understand how the initial process takes place – choosing TFC as a client.

Therefore, there is a need for the development of IM, which will allow researching the procedure for choosing TFC based on the assessment of quantitative and qualitative indicators of the business entity's work, taking into account the previous experience of cooperation.

## 3. The aim and objectives of the study

The purpose of our study is to devise a procedure for selecting TFC that most fully satisfies the needs of the customer in the organization of international road transportation, taking into account quantitative and qualitative indicators of work.

To achieve the goal, the following tasks were set:

– to formalize the TFC activity model;

– to develop and carry out a verification of the adequacy of the IM of TFC activities;

– to perform an evaluation of the simulation results;

– to devise a methodology for determining the optimal TFC;

– to determine the optimal transport and forwarding company, taking into account the interests of the counterparties.

## 4. The study materials and methods

The object of our study is the process of choosing TFC when exporting goods along various transportation routes and forms of commercial interaction between the customer and contractor.

The research hypothesis assumes that the construction of a simulation model for the selection of TFC will enable exporters to make rational management decisions about the feasibility of cooperation based on the assessment of qualitative and quantitative indicators of service.

When performing the research, the activity of a manufacturing enterprise that is an exporter of goods to different countries of the world is considered. Cooperation of the exporter with counterparties is carried out on the basis of various Incoterms delivery conditions. In accordance with this, an international economic contract is concluded, which registers the division of responsibilities between the buyer and seller of the goods in accordance with the agreed terms of delivery. In the event that the seller is entrusted with the organization of the delivery of goods, the production company faces the task of choosing a TFC capable of meeting the needs of the counterparty and providing the necessary range of services. Cooperation with TFCs with which the exporter had previous work experience is under consideration. In the structure of the studied business entities, forwarding, customs brokerage and transport departments function, that is, within the scope of the enterprise, the customer can receive a set of services necessary for the organization of an international flight. The exporter interacts with each TFC on the basis of such commercial forms as: bidding, contract, auction, reduction, and general conditions. Depending on the volume of goods supplied to a particular counterparty, the direction of transportation and the individual requirements of the buyer, various TFCs and forms of cooperation may be involved.

When building the simulation model, the list of types of activities performed by the TFC when exporting goods was taken into account, namely:

1. Agreement on terms of cooperation.
2. Approval of the cost of the work.
3. Choice of vehicle.
4. Preparation of commercial documents.
5. Preparation of transport documents.
6. Preparation of customs documents.
7. Execution of warehouse work.
8. Loading of rolling stock.
9. Fulfillment of customs formalities in the country of departure.
10. Completion of documentary formalities in the country of destination.
11. Execution of financial calculations for the services provided.

In order to detail the activities of the manufacturing enterprise, during the construction of the model, cooperation with five counterparties carrying out economic activities in Poland, Spain, Italy, the Netherlands, and Germany was considered. Accordingly, each of the buyers of the product is characterized by a different intensity of incoming orders per year. In order to comply with the conditions of cooperation with counterparties, the exporter evaluates the qualitative and quantitative indicators of TFC for each international trade operation.

Thus, when modeling the choice of TFC to meet the needs of the exporter, it is necessary to take into account the direction of transportation of goods and the priority of service depending on the chosen form of commercial cooperation between the customer and contractor.

The IM considers a generalized list of works performed by TFC when organizing the export of goods and performed within the limits of one business entity. Each counterparty receives a different number of supply orders.

The following parameters are registered as the results of IM work:

– duration of the feasibility study of each individual counterparty, taking into account the individual requirements for the delivery of goods and the form of commercial cooperation;

– waiting time in the queue for the feasibility study of each individual counterparty, taking into account the individual requirements for the delivery of goods and the form of commercial cooperation;

– length of the queue for the feasibility study of each individual counterparty in cooperation with various business entities;

– the share of applications for the feasibility study of each individual counterparty, which was served without downtime in the queue when cooperating with various business entities;

– load factor of freight forwarders when servicing individual counterparties by various business entities;

– load factor of customs brokers when serving individual counterparties by various business entities.

Simulation methods were used to analyze the activity of TFC in the organization of international road transportation of goods.

Multi-criteria (vector) optimization methods were used to devise a methodology for determining the optimal TFC.

Various indicators are used to evaluate the activity of TFC – local criteria of optimality, which are components of a generalized criterion, which will be key when choosing TFC to meet the needs of an individual customer.

Local criteria have different measurement units, which makes their direct comparison difficult. To solve this issue, local criteria were normalized, that is, they were reduced to single units of measurement.Another task is related to the need to take into account the degree of importance (priority) of local criteria. This requires the use in the model of a vector of weighting factors that make it possible to establish (determine) the importance of local criteria. The requirements of the simultaneous maximum and minimum of local criteria are also incompatible, which requires bringing them to one kind of extremum.

Thus, in order to determine the optimal TFC, a procedure of transition from the problem of vector optimization according to local criteria to a specially constructed scalar function, which is termed a generalized criterion, was devised. The generalized criterion depends on local criteria that have different weights and units of measurement, as well as different directions of influence on the generalized criterion.

The goal is to build the IM of TFC activities in the organization of international road transportation of goods to determine the following parameters:

– determination of the average duration of feasibility studies by each investigated enterprise;

– determination of the characteristics of the investigated TFC.

Many factors influence the process of operation of TFC. Let's divide the factors into known $A=\{a_1, a_2, ..., a_m\}$, which cannot be influenced, and controlled $X=\{x_1, x_2, ..., x_k\}$.

We denote by the set $Y=\{y_1, y_2, ..., y_n\}$ the initial parameters that depend in a certain way on the vectors $A$ and $X$, i.e., $Y$ is some function $Y=\Phi(A; X)$.

In general, the model of operation of TFC activities in the organization of international road transportation of goods can be represented by the following structure:

$$Y=\begin{Bmatrix} a_1, a_2, ..., a_m \\ x_1, x_2, ..., x_k \end{Bmatrix}. \tag{1}$$

The controlled $X$ factors of the model are:

– intensity $\lambda$ of receiving orders from the $k$-th counterparty for the export of goods;

– conditions of cooperation (bidding, contract, auction, reduction, general conditions) $PR_j$ with $j$-th TFC, which determine priority in service;

The uncontrollable factors $A$ of the model are:

– estimation of the average time $m_{ij}\pm\sigma_{ij}$ of the $i$-th work $W_i$ at each stage of feasibility study by the $j$-th company;

– the number of forwarders $M_j$ working at the $j$-th enterprise;

– estimate of the average time $a_{ij}\pm b_{ij}$ of the $i$-th job $W_i$ at each stage of customs brokerage service by the $j$-th company;

– the number of customs brokers $L_j$, working at the $j$th enterprise;

– the number of vehicles $V_j$ on the company's balance sheet;

– estimation of the average time $c_j\pm d_j$ of searching for vehicles by the $j$-th company (if the company has no free vehicles).

The processing of an application in TFC represents the performance of works (Table 1), which must be completed before it finalizes the service. The duration of each operation is considered as a random variable with a given distribution law. The parameters necessary for modeling a random variable are established as a result of statistical processing of field research data. FIFO (first-in, first-served) order is adopted as the main order of service of applications.

## 5. Results of research on the choice of a transport and forwarding company in the organization of international road transportation of goods

### 5. 1. Formalization of the activity model of the transport and forwarding enterprise

The work of TFC in the organization of international road transportation of goods is considered. Customers of transport and forwarding services receive a stream of orders from counterparties for the export of goods.

Customers of transport and forwarding services have different conditions of cooperation with TFC: bidding, contract, auction, reduction, general conditions.

Table 1

Types of feasibility study operations during cargo export

| No. | Task identifier | Types of operations |
|---|---|---|
| 1 | $W_1$ | Agreement on terms of cooperation |
| 2 | $W_2$ | Approval of the cost of the work |
| 3 | $W_3$ | Choice of vehicle |
| 4 | $W_4$ | Preparation of commercial documents |
| 5 | $W_5$ | Preparation of transport documents |
| 6 | $W_6$ | Preparation of customs documents |
| 7 | $W_7$ | Execution of warehouse work |
| 8 | $W_8$ | Loading of rolling stock |
| 9 | $W_9$ | Fulfillment of customs formalities in the country of departure |
| 10 | $W_{10}$ | Completion of documentary formalities in the country of destination |
| 11 | $W_{11}$ | Performing financial calculations for the services rendered |

The output factors-feedback $Y$ of the model are:

– the average duration of feasibility study ($t_{kj}$) by the $j$-th enterprise of the $k$-th counterparty;

– the average waiting time in the queue for the feasibility study ($w_{kj}$) by the $j$-th enterprise of the $k$-th counterparty;

– the average length of the queue for feasibility study ($\eta_{kj}$) by the $j$-th enterprise of the $k$-th counterparty;

– the share of applications ($\nu_{kj}$) from the $k$-th counterparty, which are served by the $j$-th company without downtime in the queue;

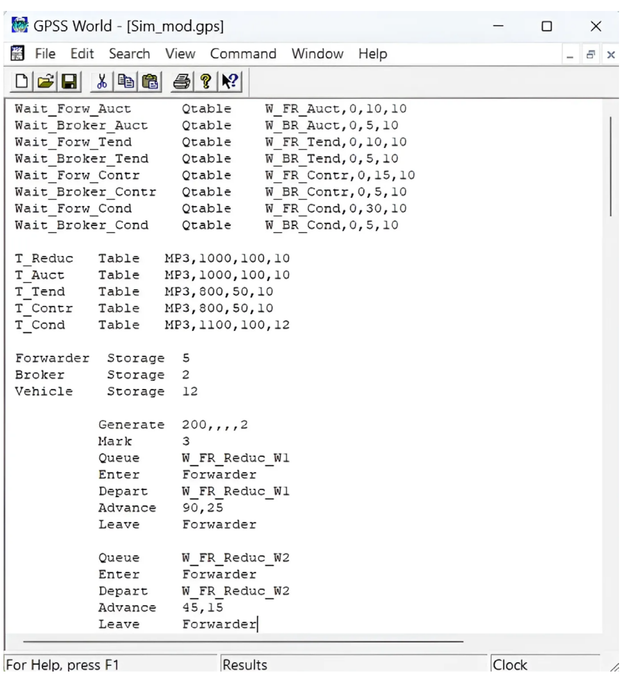
– loading factor of forwarders ($\psi_{kj}$) of the $j$-th enterprise when serving the $k$-th counterparty;

– load factor of brokers ($\rho_{kj}$) of the $j$-th enterprise when servicing the $k$-th counterparty.

As performance indicators that determine the goals of modeling – the choice of the optimal TFC when exporting goods, the feedback of the $Y$ model is considered. The limitations of IM are related to the conditions imposed on the incoming flow of export supplies that require TFC (it is assumed that it is the simplest, i.e., there are no urgent applications), as well as there are no phenomena that change the regularity of the duration of feasibility study (failures and failures of equipment, etc.).

**5. 2. Devising and implementing the verification of adequacy of the simulation model of the transport and forwarding enterprise**

The activity of the investigated TFCs is represented in the form of a mass service system. The proposed mass service model is implemented in the GPSS World simulation automation package [11]. An example of the text of IM of the activity of TFC in GPSS World is shown in Fig. 1.


```
Wait_Forw_Auct      Qtable    W_FR_Auct,0,10,10
Wait_Broker_Auct    Qtable    W_BR_Auct,0,5,10
Wait_Forw_Tend      Qtable    W_FR_Tend,0,10,10
Wait_Broker_Tend    Qtable    W_BR_Tend,0,5,10
Wait_Forw_Contr     Qtable    W_FR_Contr,0,15,10
Wait_Broker_Contr   Qtable    W_BR_Contr,0,5,10
Wait_Forw_Cond      Qtable    W_FR_Cond,0,30,10
Wait_Broker_Cond    Qtable    W_BR_Cond,0,5,10

T_Reduc    Table   MP3,1000,100,10
T_Auct     Table   MP3,1000,100,10
T_Tend     Table   MP3,800,50,10
T_Contr    Table   MP3,800,50,10
T_Cond     Table   MP3,1100,100,12

Forwarder   Storage   5
Broker      Storage   2
Vehicle     Storage   12

           Generate   200,,,,2
           Mark       3
           Queue      W_FR_Reduc_W1
           Enter      Forwarder
           Depart     W_FR_Reduc_W1
           Advance    90,25
           Leave      Forwarder

           Queue      W_FR_Reduc_W2
           Enter      Forwarder
           Depart     W_FR_Reduc_W2
           Advance    45,15
           Leave      Forwarder
```


Fig. 1. Partial program listing of the simulation model that we implemented in GPSS World

The application of GPSS for the construction of IM for the analysis of TFC activity in the organization of international road transportation of goods is characterized by the following possibilities:

– GPSS uses an extensive user interface for IM construction. This is provided by visualization capabilities of the modeling process, as well as built-in elements of statistical data processing;

– GPSS has an interactive ability to debug the model, which makes it possible to set control points in the model, step-by-step debugging, and the ability to determine the parameters of service requests during the simulation experiment;

– GPSS makes it possible to evaluate the characteristics of the system at certain time points at different levels of its detail.

Verification of the adequacy of IM to the real object was carried out for the case when it is possible to determine the value of the system responses during field tests. To check the adequacy of the model, the hypothesis about the closeness of the average values of each response of the model to the known average value of the response of the real object $\bar{Y}^*$ was tested. $N_1=5$ experiments were conducted on a real object and a sample of values $\{Y_i^*\}$, $i=\overline{1,5}$ was formed. $N_2=5$ experiments were conducted with the help of IM, samples of $i=\overline{1,5}$ values were obtained based on the feedback of the model.

Estimates of the mathematical expectation and variance of the model and system responses (Table 2) were determined by the samples using the following ratios:

$$\bar{Y}^*_{Q_n}=\frac{1}{N_1}\sum_{k=1}^{N_1}Y^*_{Q_{nk}};$$

$$D^*_n=\frac{1}{N_1-1}\sum_{k=1}^{N_1}\left(Y^*_{Q_{nk}}-\bar{Y}^*_{Q_n}\right)^2;$$

$$\bar{Y}_n=\frac{1}{N_2}\sum_{k=1}^{N_2}Y_{nk};$$

$$D_n=\frac{1}{N_2-1}\sum_{k=1}^{N_2}\left(Y_{nk}-\bar{Y}_n\right)^2. \quad (2)$$

The basis for testing the hypothesis is the difference $E_n=(\bar{Y}_n-\bar{Y}^*_{Q_n})$, the estimate of the variance of which will be:

$$D_{an}=\frac{(N_1-1)D_n+(N_2-1)D^*_n}{N_1+N_2-2}. \quad (3)$$

The calculated estimates of variance $D_{an}$ are given in Table 2.

$E_n$ and $D_{an}$ values are independent statistics, so you can use $t$-statistics:

$$t_n=\left(\bar{Y}_n-\bar{Y}^*_{Q_n}\right)\sqrt{\frac{N_1N_2}{D_{an}(N_1+N_2)}}. \quad (4)$$

With the number of degrees of freedom $\nu=N_1+N_2-2=8$ and the significance level $\alpha=0.05$, the critical value ($t_{cr}=1.85$) was determined according to Student's distribution tables. Comparing each of the $t$-statistic values in Table 2 with $t_{cr}$ ($t_n\le t_{cr}$), the hypothesis about the closeness of the average values of the responses of the model and the real object is accepted. Thus, we can talk about the adequacy of IM and the real object.

To determine the error of IM responses regarding TFC activity, 10 simulation experiments were conducted at the midpoint of the IM parameter values. At the same time, in the $l$-th simulation experiment, the IM parameters were not changed, but only the initial values of the basic generator algorithms were modified. As a result of the simulation experiment, samples with a volume of $N=10$ of each $k$-th IM response $\{Y_{nk}\}$ were formed.

Table 2

Checking the adequacy of the simulation model

| Re-sponse | Value of sample components | | | | | Average response value $\overline{Y}_n, \overline{Y}^*_n$ | Response variance score $\overline{D}_n, \overline{D}^*_n$ | Variance of difference $D_{an}$ | $t$-statistics $t_n$ |
|---|---|---|---|---|---|---|---|---|---|
| | $j$=1 | $j$=2 | $j$=3 | $j$=4 | $j$=5 | | | | |
| $t_{1j}$ | 1,116 | 1,120 | 1,100 | 1,128 | 1,090 | 1,110.8 | 239.2 | 256.850 | 1.302 |
| $t^*_{1j}$ | 1,130 | 1,128 | 1,095 | 1,137 | 1,130 | 1,124 | 274.5 | | |
| $w_{1j}$ | 80 | 82 | 79 | 80 | 110 | 86.2 | 178.2 | 148.700 | 0.648 |
| $w^*_{1j}$ | 73 | 77 | 75 | 81 | 100 | 81.2 | 119.2 | | |
| $\eta_{1j}$ | 1.2 | 3 | 1 | 3.5 | 2.8 | 2.3 | 1.27 | 1.235 | 0.711 |
| $\eta^*_{1j}$ | 1 | 1 | 1 | 3 | 3 | 1.8 | 1.2 | | |
| $\psi_{1j}$ | 0.66 | 0.68 | 0.69 | 0.65 | 0.69 | 0.674 | 0.00033 | 0.000 | 1.510 |
| $\psi^*_{1j}$ | 0.65 | 0.65 | 0.67 | 0.66 | 0.67 | 0.66 | 0.0001 | | |
| $\rho_{1j}$ | 0.82 | 0.88 | 0.83 | 0.89 | 0.885 | 0.861 | 0.001105 | 0.004 | 1.307 |
| $\rho^*_{1j}$ | 0.71 | 0.88 | 0.75 | 0.85 | 0.87 | 0.812 | 0.00592 | | |

Based on these samples, mathematical expectation estimates and sample variances of model responses $(\overline{Y}_n, \overline{D}_n)$ were calculated according to formula (2). The resulting values of errors $dY_n$ in percentages for IM, calculated from formula (5), are given in Table 3:

$$dY_n = \frac{t_{0.05}}{\overline{Y}_n}\sqrt{\frac{\overline{D}_n}{N-1}} \cdot 100\,\%. \tag{5}$$

The accuracy of simulation is determined by the formula:

$$d_{SM} = \max_n \left\{ dY_n \right\}. \tag{6}$$

During the trial simulation experiment, it was established that the upper limit of the simulation error is equal to $d_{SM}$=2.8 % with a permissible 3 %. Thus, the simulation error is insignificant for this study.

Table 3

Estimation of the error of simulating the responses of the simulation model

| Re-sponse | Simulation error $dY_n$ % | Re-sponse | Simulation error $dY_n$ % | Re-sponse | Simulation error $dY_n$ % |
|---|---|---|---|---|---|
| $t_{11}$ | 2.5 | $t_{12}$ | 2.3 | $t_{13}$ | 2.8 |
| $w_{11}$ | 1.3 | $w_{12}$ | 1.6 | $w_{13}$ | 2.1 |
| $\eta_{11}$ | 1.8 | $\eta_{12}$ | 1.7 | $\eta_{13}$ | 1.9 |
| $\nu_{11}$ | 2.1 | $\nu_{12}$ | 1.9 | $\nu_{13}$ | 2.2 |
| $\psi_{11}$ | 1.2 | $\psi_{12}$ | 1.5 | $\psi_{13}$ | 1.7 |
| $\rho_{11}$ | 1.4 | $\rho_{12}$ | 1.3 | $\rho_{13}$ | 1.6 |

**5. 3. Assessment of modeling results**

According to the reports obtained as a result of simulating the activities of TFC when exporting goods from the $k$-th counterparty (at $k$=1 – to Poland, $k$=2 – to Spain, $k$=3 – to Italy, $k$=4 – to the Netherlands, $k$=5 – to Germany) we obtained the results given in Table 4. The activity of five TFCs with different conditions of cooperation (bidding, contract, auction, reduction, general conditions) was considered.

Table 4

Feasibility study simulation results

| Enterprise | TFC 1 | TFC 2 | TFC 3 | TFC 4 | TFC 5 |
|---|---|---|---|---|---|
| Cooperation conditions | Reduction | Bidding | Bidding | Contract | General conditions |
| Poland ($k$=1) | | | | | |
| $t_{1j}$, min | 1,539.9 | 1,596.2 | 1,116.0 | 1,198.4 | 1,859.3 |
| $w_{1j}$, min | 234.9 | 208.2 | 73.0 | 128.4 | 335.3 |
| $\eta_{1j}$ | 2.6 | 3.2 | 1.2 | 1.8 | 4 |
| $\nu_{1j}$, % | 70 | 69 | 83 | 78 | 56 |
| $\psi_{1j}$ | 0.83 | 0.72 | 0.65 | 0.75 | 0.92 |
| $\rho_{1j}$ | 0.84 | 0.82 | 0.71 | 0.79 | 0.89 |
| Spain ($k$=2) | | | | | |
| $t_{2j}$, min | 1,506.5 | 1,703.5 | 1,330.4 | 1,337.5 | 1,867.5 |
| $w_{2j}$, min | 240.5 | 247.5 | 163.4 | 174.45 | 373.5 |
| $\eta_{2j}$ | 2.8 | 3.5 | 1.3 | 2.0 | 4.4 |
| $\nu_{2j}$, % | 76 | 75 | 89 | 85 | 61 |
| $\psi_{2j}$ | 0.77 | 0.67 | 0.62 | 0.70 | 0.86 |
| $\rho_{2j}$ | 0.81 | 0.79 | 0.68 | 0.76 | 0.85 |
| Italy ($k$=3) | | | | | |
| $t_{3j}$, min | 1,618.4 | 1,642.7 | 1,223.8 | 1,276.8 | 1,851.3 |
| $w_{3j}$, min | 258.4 | 238.7 | 140.8 | 156.8 | 358.3 |
| $\eta_{3j}$ | 2.5 | 3.1 | 1.2 | 1.7 | 3.9 |
| $\nu_{3j}$, % | 69 | 67 | 81 | 76 | 55 |
| $\psi_{3j}$ | 0.81 | 0.71 | 0.63 | 0.74 | 0.89 |
| $\rho_{3j}$ | 0.81 | 0.80 | 0.70 | 0.77 | 0.87 |
| The Netherlands ($k$=4) | | | | | |
| $t_{4j}$, min | 1,424.4 | 1,517.5 | 1,212.2 | 1,255.5 | 1,595.2 |
| $w_{4j}$, min | 227.4 | 220.5 | 110.2 | 134.5 | 329.2 |
| $\eta_{4j}$ | 2.8 | 3.4 | 1.3 | 1.9 | 4.3 |
| $\nu_{4j}$, % | 78 | 74 | 92 | 83 | 62 |
| $\psi_{4j}$ | 0.80 | 0.69 | 0.62 | 0.72 | 0.88 |
| $\rho_{4j}$ | 0.83 | 0.81 | 0.70 | 0.78 | 0.88 |
| Germany ($k$=5) | | | | | |
| $t_{5j}$, min | 1,452.6 | 1,574.4 | 1,074.6 | 1,209.6 | 1,696.3 |
| $w_{5j}$, min | 221.6 | 205.4 | 79.6 | 129.6 | 339.3 |
| $\eta_{5j}$ | 3.0 | 3.7 | 1.4 | 2.1 | 4.6 |
| $\nu_{5j}$, % | 74 | 72 | 85 | 82 | 59 |
| $\psi_{5j}$ | 0.87 | 0.76 | 0.67 | 0.79 | 0.98 |
| $\rho_{5j}$ | 0.88 | 0.85 | 0.73 | 0.83 | 0.95 |

The simulation results indicate that for all studied product delivery directions, TFC No. 3, which is serviced on a bidding basis, achieves optimal performance. In turn, TFC No. 5, with which cooperation is carried out on general terms, is characterized by the worst indicators. In addition, service indicators for different transportation routes have differences related to the terms of preparation of transport and customs documents, as well as the duration of delivery.

**5. 4. Devising the methodology for determining the optimal transport and forwarding company**

TFC activity is evaluated on the basis of various qualitative and quantitative indicators. The task of determining the composition of these indicators boils down to the fact that, firstly, they maximally take into account the composition and features of the object of evaluation. Secondly, the objectives of the modeling were clearly defined, that is, the choice of TFC that would satisfy the customer's needs for cargo delivery.

For the comparative evaluation of TFC, groups of indicators or factors (local criteria) characterizing different levels of technical, technological, and organizational support of the enterprise are distinguished.

Both quantitative and qualitative indicators have different units of measurement, different degrees of influence (weight) and different directionality of influence on the final performance indicator (generalized criterion) for choosing the optimal TFC for the customer.

It is possible to distinguish two groups of indicators that have a direct and inverse influence on the final performance indicator. In order to bring the indicators of one group to the indicators of another, it is necessary to find the inverse values of the data.

For each group of factors, a matrix of indicators $F_i$ $(i=\overline{1,n})$, is formed, which have the same orientation to the final generalized indicator of the efficiency of TFC, which is evaluated (Table 5). The significance of indicators $F_i$ is determined by weighting coefficients $W_i$, $(i=\overline{1,n})$, which reflect the contribution of each indicator to the generalized criterion for each group of factors. In Table 5, the following designations are adopted:

– $W_i$ $(i=\overline{1,n})$ is the weight of the $i$-th efficiency indicator;

– $I_{ij}$ $(i=\overline{1,n};\ j=\overline{1,m})$ is the value of the $i$-th efficiency indicator for the $j$-th TFC.

Table 5

TFC performance indicator matrix

| Indicator | Weight | $TFC_1$ | $TFC_2$ | ... | $TFC_j$ | ... | $TFC_m$ | Optimal indicator |
|---|---|---|---|---|---|---|---|---|
| $F_1$ | $W_1$ | $I_{11}$ | $I_{12}$ | ... | $I_{1j}$ | ... | $I_{1m}$ | $I_1^*$ |
| $F_2$ | $W_2$ | $I_{21}$ | $I_{22}$ | ... | $I_{2j}$ | ... | $I_{2m}$ | $I_2^*$ |
| ... | ... | ... | ... | ... | ... | ... | ... | ... |
| $F_i$ | $W_i$ | $I_{i1}$ | $I_{i2}$ | ... | $I_{ij}$ | ... | $I_{im}$ | $I_i^*$ |
| ... | ... | ... | ... | ... | ... | ... | ... | ... |
| $F_n$ | $W_n$ | $I_{n1}$ | $I_{n2}$ | ... | $I_{nj}$ | ... | $I_{nm}$ | $I_n^*$ |

For each factor, the minimum value of performance indicators (PI) is selected:

$$I_i^* = \min_j \{I_{ij}\}. \quad (7)$$

Since PIs have different units of measurement, the output data must be brought to a certain range ([0, ..., 1]), by performing data normalization by dividing the optimal indicator $I_i^*$ by indicators $I_{ij}$ characterizing $TFC_j$ (Table 6).

For the comparative assessment of TFC, taking into account the weighting factors $W_i$, the generalized efficiency indicator $TFC_j$ is determined:

$$FG_j = \sum_{i=1}^{n} W_i \cdot \frac{I_i^*}{I_{ij}},\ j=\left(\overline{1,m}\right). \quad (8)$$

The generalized PI for optimal TFC is:

$$FG^* = \sum_{i=1}^{n} W_i \cdot \frac{I_i^*}{I_i^*} = \sum_{i=1}^{n} W_i,\ j=\left(\overline{1,m}\right). \quad (9)$$

The integral PI is determined by comparing the generalized PI for the optimal TFC with the generalized $TFC_j$ indicator, which is estimated:

$$IG_j = FG^* - FG_j,\ j=\left(\overline{1,m}\right). \quad (10)$$

The smaller the integral indicator of the TFC efficiency, the higher the evaluated TFC efficiency, i.e., the closer the given TFC is to the optimal one.

Table 6

TFC matrix of relations of performance indicators

| Indicator | Weight | $TFC_1$ | $TFC_2$ | ... | $TFC_j$ | ... | $TFC_m$ | Optimal indicator |
|---|---|---|---|---|---|---|---|---|
| $F_1$ | $W_1$ | $I_1^*/I_{11}$ | $I_1^*/I_{12}$ | ... | $I_1^*/I_{1j}$ | ... | $I_1^*/I_{1m}$ | $I_1^*/I_1^*=1$ |
| $F_2$ | $W_2$ | $I_2^*/I_{21}$ | $I_2^*/I_{22}$ | ... | $I_2^*/I_{2j}$ | ... | $I_2^*/I_{2m}$ | $I_2^*/I_2^*=1$ |
| ... | ... | ... | ... | ... | ... | ... | ... | ... |
| $F_i$ | $W_i$ | $I_i^*/I_{i1}$ | $I_i^*/I_{i2}$ | ... | $I_i^*/I_{ij}$ | ... | $I_i^*/I_{im}$ | $I_i^*/I_i^*=1$ |
| ... | ... | ... | ... | ... | ... | ... | ... | ... |
| $F_n$ | $W_n$ | $I_n^*/I_{n1}$ | $I_n^*/I_{n2}$ | ... | $I_n^*/I_{nj}$ | ... | $I_n^*/I_{nm}$ | $I_n^*/I_n^*=1$ |
| $FG_j$ | | $\sum_{i=1}^{n} W_i \cdot \frac{I_i^*}{I_{i1}}$ | $\sum_{i=1}^{n} W_i \cdot \frac{I_i^*}{I_{i2}}$ | ... | $\sum_{i=1}^{n} W_i \cdot \frac{I_i^*}{I_{ij}}$ | ... | $\sum_{i=1}^{n} W_i \cdot \frac{I_i^*}{I_{im}}$ | $\sum_{i=1}^{n} W_i$ |

Let $L$ groups of indicators that characterize $TFC_j$ be selected for comparative evaluation of TFC. The integral $IG_{lj}$ PI is determined by the $l$th group of factors. The generalized integral indicator of efficiency $TFC_j$ which is evaluated, is determined as follows:

$$I_j = \sum_{l=1}^{L} IG_{lj}. \quad (11)$$

Ranking of $TFC_j$ according to the decrease of integral $IG_j$ PI or generalized integral indicators $I_j$ will allow choosing a TFC that can satisfy the needs of the customer in the organization of international road transportation of goods.

**5. 5. Determining the optimal transport and forwarding company, taking into account the interests of counterparties**

In order to evaluate the efficiency of TFC and the customer's choice $TFC_j$, which meets the needs of the customer in the organization of international road transportation of goods, two groups of indicators have been identified:

– quantitative indicators, which are the results of simulation modeling of feasibility studies when exporting goods to Poland, Spain, Italy, the Netherlands, and Germany (Table 4);

– qualitative indicators of evaluation of cooperation with TFC.

As a result of simulation modeling of the operation of five TFCs, the values of TFC efficiency indicators were determined (Table 7):

– the average duration of feasibility study of the $k$-th counterparty ($F_{k1}$);

– the average waiting time in the queue for the feasibility study of the $k$-th counterparty ($F_{k2}$);

– the average length of the queue at the feasibility study of the $k$-th counterparty ($F_{k3}$);

– the share of applications from the $k$-th counterparty, which were served without downtime in the queue ($F_{k4}$);

– load factor of forwarders when serving the $k$-th counterparty ($F_{k5}$);

– load factor of brokers when serving the $k$-th counterparty ($F_{k6}$).

Table 7

TFC matrix of performance indicators

| Indicator | | $TFC_1$ | $TFC_2$ | $TFC_3$ | $TFC_4$ | $TFC_5$ | Optimal indicator |
|---|---|---|---|---|---|---|---|
| Poland | | | | | | | |
| $F_{11}$ | $t_{1j}$ | 1,539.9 | 1,596.2 | 1,116.0 | 1,198.4 | 1,859.3 | 1,116 |
| $F_{12}$ | $w_{1j}$ | 234.9 | 208.2 | 73.0 | 128.4 | 335.3 | 73 |
| $F_{13}$ | $\eta_{1j}$ | 2.6 | 3.2 | 1.2 | 1.8 | 4 | 1.2 |
| $F_{14}$ | $\nu_{1j}$ | 0.014 | 0.014 | 0.012 | 0.013 | 0.018 | 0.012 |
| $F_{15}$ | $\psi_{1j}$ | 0.83 | 0.72 | 0.65 | 0.75 | 0.92 | 0.65 |
| $F_{16}$ | $\rho_{1j}$ | 0.84 | 0.82 | 0.71 | 0.79 | 0.89 | 0.71 |
| Spain | | | | | | | |
| $F_{21}$ | $t_{2j}$ | 1,506.5 | 1,703.5 | 1,330.4 | 1,337.5 | 1,867.5 | 1,330.4 |
| $F_{22}$ | $w_{2j}$ | 240.5 | 247.5 | 163.4 | 174.45 | 373.5 | 163.4 |
| $F_{23}$ | $\eta_{2j}$ | 2.8 | 3.5 | 1.3 | 2.0 | 4.4 | 1.3 |
| $F_{24}$ | $\nu_{2j}$ | 0.013 | 0.013 | 0.011 | 0.012 | 0.016 | 0.011 |
| $F_{25}$ | $\psi_{2j}$ | 0.77 | 0.67 | 0.62 | 0.70 | 0.86 | 0.62 |
| $F_{26}$ | $\rho_{2j}$ | 0.81 | 0.79 | 0.68 | 0.76 | 0.85 | 0.68 |
| Italy | | | | | | | |
| $F_{31}$ | $t_{3j}$ | 1,618.4 | 1,642.7 | 1,223.8 | 1,276.8 | 1,851.3 | 1,223.8 |
| $F_{32}$ | $w_{3j}$ | 258.4 | 238.7 | 140.8 | 156.8 | 358.3 | 140.8 |
| $F_{33}$ | $\eta_{3j}$ | 2.5 | 3.1 | 1.2 | 1.7 | 3.9 | 1.2 |
| $F_{34}$ | $\nu_{3j}$ | 0.014 | 0.015 | 0.012 | 0.013 | 0.018 | 0.012 |
| $F_{35}$ | $\psi_{3j}$ | 0.81 | 0.71 | 0.63 | 0.74 | 0.89 | 0.63 |
| $F_{36}$ | $\rho_{3j}$ | 0.81 | 0.80 | 0.70 | 0.77 | 0.87 | 0.7 |
| The Netherlands | | | | | | | |
| $F_{41}$ | $t_{4j}$ | 1,424.4 | 1,517.5 | 1,212.2 | 1,255.5 | 1,595.2 | 1,212.2 |
| $F_{42}$ | $w_{4j}$ | 227.4 | 220.5 | 110.2 | 134.5 | 329.2 | 110.2 |
| $F_{43}$ | $\eta_{4j}$ | 2.8 | 3.4 | 1.3 | 1.9 | 4.3 | 1.3 |
| $F_{44}$ | $\nu_{4j}$ | 0.013 | 0.014 | 0.011 | 0.012 | 0.016 | 0.011 |
| $F_{45}$ | $\psi_{4j}$ | 0.80 | 0.69 | 0.62 | 0.72 | 0.88 | 0.62 |
| $F_{46}$ | $\rho_{4j}$ | 0.83 | 0.81 | 0.70 | 0.78 | 0.88 | 0.7 |
| Germany | | | | | | | |
| $F_{51}$ | $t_{5j}$ | 1,452.6 | 1,574.4 | 1,074.6 | 1,209.6 | 1,696.3 | 1,074.6 |
| $F_{52}$ | $w_{5j}$ | 221.6 | 205.4 | 79.6 | 129.6 | 339.3 | 79.6 |
| $F_{53}$ | $\eta_{5j}$ | 3.0 | 3.7 | 1.4 | 2.1 | 4.6 | 1.4 |
| $F_{54}$ | $\nu_{5j}$ | 0.014 | 0.014 | 0.012 | 0.012 | 0.017 | 0.012 |
| $F_{55}$ | $\psi_{5j}$ | 0.87 | 0.76 | 0.67 | 0.79 | 0.98 | 0.67 |
| $F_{56}$ | $\rho_{5j}$ | 0.88 | 0.85 | 0.73 | 0.83 | 0.95 | 0.73 |

The $F_{k4}$ indicator has a direct impact on the final PI. The $F_{k4}$ indicator is reduced to indicators that have the opposite direction of influence on the final PI. The indicators have the same significance of influence on the final PI; therefore, the weighting coefficients $W$ are equal and are not taken into account in the calculations.

The resulting efficiency indicators show that the optimal values for different directions of transportation were achieved when the customer cooperated with TFC No. 3 on a bidding basis. A key feature of the decision to cooperate with TFC is the possibility of service without downtime in queues or reducing this indicator to a minimum. Thus, there are reasons to assert that the activity of TFC No. 3 has clearly structured business processes since the value of the studied indicator has slight differences when serving different counterparties. On the basis of the proposed methodology, it becomes possible to obtain not only information about the service of an individual counterparty but also to carry out a comparative characteristic based on key performance indicators.

Since PIs have different units of measurement, the output data are reduced to the range [0, .., 1] by data normalization (Table 8). Generalized TFC efficiency indicators $FG_{kj}$ $(k=\overline{1,5};\ j=\overline{1,5})$ and optimal TFC efficiency indicators $FG_k^*$ are calculated according to formulas (8) and (9) and are given in Table 8.

Based on the data of the ratio matrix of TFC efficiency indicators, generalized indicators of TFC efficiency were determined under various conditions of cooperation with counterparties. This will allow the exporter to receive recommendations for the selection of TFC taking into account individual service conditions, as well as to determine the optimal values among the studied ones.

In addition, it becomes possible to prioritize the establishment of partnership relations with TFC based on our research results.

Integral PI $IG_{kj}$ $(k=\overline{1,5};\ j=\overline{1,5})$ of TFC when exporting goods to Poland, Spain, Italy, the Netherlands, Germany were calculated according to formula (10) and are given in Table 9.

According to our results from the study of quantitative indicators of cooperation with TFCs, it was established that in various directions of transportation, cooperation with $TFC_3$ and $TFC_4$ is the most effective, and the lowest indicators are characteristic of $TFC_5$. Thus, it can be asserted that the exporter's interaction with TFC on a bidding and contractual basis provides significantly higher PI of service to various counterparties, unlike other conditions of cooperation. However, before making the transition to such service conditions, it is important to make sure that all the necessary components are available to ensure high PI of goods delivery in international communication.

By ranking $TFC_j$ according to the decrease of integral PIs $IG_{kj}$ according to the first group of indicators, the following results were obtained:

– Poland: $TFC_3$, $TFC_4$, $TFC_2$, $TFC_1$, $TFC_5$;
– Spain: $TFC_3$, $TFC_4$, $TFC_1$, $TFC_2$, $TFC_5$;
– Italy: $TFC_3$, $TFC_4$, $TFC_1$, $TFC_2$, $TFC_5$;
– The Netherlands: $TFC_3$, $TFC_4$, $TFC_1$, $TFC_2$, $TFC_5$;
– Germany: $TFC_3$, $TFC_4$, $TFC_2$, $TFC_1$, $TFC_5$.

Table 10 gives quality indicators of the service evaluation that were provided to the client as a result of cooperation with TFCs.

Table 8

TFC matrix of ratios of efficiency indicators

| Indicator | | $TFC_1$ | $TFC_2$ | $TFC_3$ | $TFC_4$ | $TFC_5$ | Optimal value |
|---|---|---|---|---|---|---|---|
| Poland | | | | | | | |
| $F_{11}$ | $t_{1j}$ | 0.725 | 0.699 | 1 | 0.931 | 0,600 | 1 |
| $F_{12}$ | $w_{1j}$ | 0.311 | 0.351 | 1 | 0.569 | 0,218 | 1 |
| $F_{13}$ | $\eta_{1j}$ | 0.462 | 0.375 | 1 | 0.667 | 0,300 | 1 |
| $F_{14}$ | $\nu_{1j}$ | 0.857 | 0.857 | 1 | 0.923 | 0,667 | 1 |
| $F_{15}$ | $\psi_{1j}$ | 0.783 | 0.903 | 1 | 0.867 | 0,707 | 1 |
| $F_{16}$ | $\rho_{1j}$ | 0.845 | 0.866 | 1 | 0.899 | 0,798 | 1 |
| $FG_{1j}$ | | 3.98 | 4.05 | 6 | 4.85 | 3.29 | 6 |
| Spain | | | | | | | |
| $F_{21}$ | $t_{2j}$ | 0.883 | 0.781 | 1 | 0.995 | 0,712 | 1 |
| $F_{22}$ | $w_{2j}$ | 0.679 | 0.660 | 1 | 0.937 | 0,437 | 1 |
| $F_{23}$ | $\eta_{2j}$ | 0.464 | 0.371 | 1 | 0.650 | 0,295 | 1 |
| $F_{24}$ | $\nu_{2j}$ | 0.846 | 0.846 | 1 | 0.917 | 0,688 | 1 |
| $F_{25}$ | $\psi_{2j}$ | 0.805 | 0.925 | 1 | 0.886 | 0,721 | 1 |
| $F_{26}$ | $\rho_{2j}$ | 0.840 | 0.861 | 1 | 0.895 | 0,800 | 1 |
| $FG_{2j}$ | | 4.52 | 4.44 | 6 | 5.28 | 3.65 | 6 |
| Italy | | | | | | | |
| $F_{31}$ | $t_{3j}$ | 0.756 | 0.745 | 1 | 0.958 | 0,661 | 1 |
| $F_{32}$ | $w_{3j}$ | 0.545 | 0.590 | 1 | 0.898 | 0,393 | 1 |
| $F_{33}$ | $\eta_{3j}$ | 0.480 | 0.387 | 1 | 0.706 | 0,308 | 1 |
| $F_{34}$ | $\nu_{3j}$ | 0.857 | 0.800 | 1 | 0.923 | 0,667 | 1 |
| $F_{35}$ | $\psi_{3j}$ | 0.778 | 0.887 | 1 | 0.851 | 0,708 | 1 |
| $F_{36}$ | $\rho_{3j}$ | 0.864 | 0.875 | 1 | 0.909 | 0,805 | 1 |
| $FG_{3j}$ | | 4.28 | 4.28 | 6 | 5.25 | 3.54 | 6 |
| The Netherlands | | | | | | | |
| $F_{41}$ | $t_{4j}$ | 0.851 | 0.799 | 1 | 0.966 | 0,760 | 1 |
| $F_{42}$ | $w_{4j}$ | 0.485 | 0.500 | 1 | 0.819 | 0,335 | 1 |
| $F_{43}$ | $\eta_{4j}$ | 0.464 | 0.382 | 1 | 0.684 | 0,302 | 1 |
| $F_{44}$ | $\nu_{4j}$ | 0.846 | 0.786 | 1 | 0.917 | 0,688 | 1 |
| $F_{45}$ | $\psi_{4j}$ | 0.775 | 0.899 | 1 | 0.861 | 0,705 | 1 |
| $F_{46}$ | $\rho_{4j}$ | 0.843 | 0.864 | 1 | 0.897 | 0,795 | 1 |
| $FG_{4j}$ | | 4.26 | 4.23 | 6 | 5.14 | 3.58 | 6 |
| Germany | | | | | | | |
| $F_{51}$ | $t_{5j}$ | 0.740 | 0.683 | 1 | 0.888 | 0,633 | 1 |
| $F_{52}$ | $w_{5j}$ | 0.359 | 0.388 | 1 | 0.614 | 0,235 | 1 |
| $F_{53}$ | $\eta_{5j}$ | 0.467 | 0.378 | 1 | 0.667 | 0,304 | 1 |
| $F_{54}$ | $\nu_{5j}$ | 0.857 | 0.857 | 1 | 1.000 | 0,706 | 1 |
| $F_{55}$ | $\psi_{5j}$ | 0.770 | 0.882 | 1 | 0.848 | 0,684 | 1 |
| $F_{56}$ | $\rho_{5j}$ | 0.830 | 0.859 | 1 | 0.880 | 0,768 | 1 |
| $FG_{5j}$ | | 4.02 | 4.05 | 6 | 4.90 | 3.33 | 6 |

Table 9

TFC integral performance indicators

| Country of cargo delivery | Integral indicator | $TFC_1$ | $TFC_2$ | $TFC_3$ | $TFC_4$ | $TFC_5$ |
|---|---|---|---|---|---|---|
| Poland | $IG_{1j}$ | 2.02 | 1.95 | 0 | 1.15 | 2.71 |
| Spain | $IG_{2j}$ | 1.48 | 1.56 | 0 | 0.72 | 2.35 |
| Italy | $IG_{3j}$ | 1.72 | 1.72 | 0 | 0.75 | 2.46 |
| The Netherlands | $IG_{4j}$ | 1.74 | 1.77 | 0 | 0.86 | 2.42 |
| Germany | $IG_{5j}$ | 1.98 | 1.95 | 0 | 1.1 | 2.67 |

In addition to quantitative indicators, it is advisable to use qualitative indicators of the effectiveness of cooperation with TFC. First of all, given the previous experience of interaction with TFC and assessment of the level of satisfaction with the range of services provided, this will provide an opportunity to receive additional recommendations on the selection of cooperation conditions. Evaluation indicators can be formed by each exporter separately, taking into account its requirements for the delivery of goods and corporate values.

Table 10

Qualitative indicators of evaluation of cooperation with TFC

| Indicator | | Weight | $TFC_1$ | $TFC_2$ | $TFC_3$ | $TFC_4$ | $TFC_5$ |
|---|---|---|---|---|---|---|---|
| $F_1$ | Environmental friendliness in communications | 0.2 | 0.13 | 0.124 | 0.3 | 0.26 | 0.18 |
| $F_2$ | Simplifying the way to purchase a service | 0.1 | 0.082 | 0.062 | 0.12 | 0.12 | 0.14 |
| $F_3$ | Prompt processing of appeals | 1.0 | 0.14 | 0.14 | 0.13 | 0.22 | 0.18 |
| $F_4$ | Knowledge of your audience and the specifics of delivery of various categories of goods | 0.8 | 0.17 | 0.18 | 0.04 | 0.08 | 0.06 |
| $F_5$ | All channels of interaction in a centralized system | 0.4 | 0.15 | 0.17 | 0.06 | 0.06 | 0.12 |
| $F_6$ | Personalization | 0.6 | 0.11 | 0.14 | 0.14 | 0.1 | 0.13 |
| $F_7$ | Loyalty | 0.1 | 0.12 | 0.13 | 0.12 | 0.11 | 0.1 |
| $F_8$ | Seamless communication | 0.1 | 0.098 | 0.094 | 0.09 | 0.05 | 0.09 |

Since the indicators $F_1$–$F_8$ have a direct influence on the final PI, the values inverse to them were found (Table 11).

Table 11

TFC matrix of performance indicators

| Indicator | Weight | $TFC_1$ | $TFC_2$ | $TFC_3$ | $TFC_4$ | $TFC_5$ | Optimal value |
|---|---|---|---|---|---|---|---|
| $F_1$ | 0.2 | 7.69 | 8.06 | 3.33 | 3.85 | 5.56 | 3.33 |
| $F_2$ | 0.1 | 12.20 | 16.13 | 8.33 | 8.33 | 7.14 | 7.14 |
| $F_3$ | 1.0 | 7.14 | 7.14 | 7.69 | 4.55 | 5.56 | 4.55 |
| $F_4$ | 0.8 | 5.88 | 5.56 | 25.00 | 12.50 | 16.67 | 5.56 |
| $F_5$ | 0.4 | 6.67 | 5.88 | 16.67 | 16.67 | 8.33 | 5.88 |
| $F_6$ | 0.6 | 9.09 | 7.14 | 7.14 | 10.00 | 7.69 | 7.14 |
| $F_7$ | 0.1 | 8.33 | 7.69 | 8.33 | 9.09 | 10.00 | 7.69 |
| $F_8$ | 0.1 | 10.20 | 10.64 | 11.11 | 20.00 | 11.11 | 10.20 |

Assigning weight to a separate indicator ensures consideration of individual needs of the exporter as a whole or requirements for delivery of goods to the specified counterparty. Our data make it possible to determine the optimal values for each of the studied indicators under the condition of service by one of the proposed enterprises. Thus, it becomes possible to form a list of requirements for the quality of service in accordance with the needs of stakeholders.

The initial data were normalized (Table 12). Generalized TFC efficiency indicators $FG_j\ (j=\overline{1,5})$ and optimal TFC efficiency indicators $FG_k^*$ taking into account the weighting factors $W_i$, integral PIs $IG_j\ (j=\overline{1,5})$ were re calculated according to formulas (8) to (10) and are given in Table 12.

Table 12

Matrix of ratios of generalized and integrated performance indicators of TFCs

| Indicator | Weight | $TFC_1$ | $TFC_2$ | $TFC_3$ | $TFC_4$ | $TFC_5$ | Optimal value |
|---|---|---|---|---|---|---|---|
| $F_1$ | 0.2 | 0.43 | 0.41 | 1.00 | 0.87 | 0.60 | 1 |
| $F_2$ | 0.1 | 0.59 | 0.44 | 0.86 | 0.86 | 1.00 | 1 |
| $F_3$ | 1.0 | 0.64 | 0.64 | 0.59 | 1.00 | 0.82 | 1 |
| $F_4$ | 0.8 | 0.94 | 1.00 | 0.22 | 0.44 | 0.33 | 1 |
| $F_5$ | 0.4 | 0.88 | 1.00 | 0.35 | 0.35 | 0.71 | 1 |
| $F_6$ | 0.6 | 0.79 | 1.00 | 1.00 | 0.71 | 0.93 | 1 |
| $F_7$ | 0.1 | 0.92 | 1.00 | 0.92 | 0.85 | 0.77 | 1 |
| $F_8$ | 0.1 | 1.00 | 0.96 | 0.92 | 0.51 | 0.92 | 1 |
| $FG_j$ | | 2.55 | 2.76 | 1.98 | 2.32 | 2.31 | 3.30 |
| $IG_j$ | | 0.75 | 0.54 | 1.32 | 0.98 | 0.99 | 0.00 |

Generalized and integrated PIs of TFCs allow us to determine the expediency of cooperation with a business entity taking into account the requirements for the quality of service and to compare them with quantitative indicators during the delivery of goods.

Taking into account the two groups of PIs that characterize $TFC_j$, the generalized integral PIs $I_k$ ($k=\overline{1,5}$) of feasibility study when exporting goods to Poland, Spain, Italy, the Netherlands, and Germany were calculated according to formula (11) and are shown in Table 13.

Table 13

Generalized integrated TFC performance indicators

| Country of cargo delivery | Integrated indicator | $TFC_1$ | $TFC_2$ | $TFC_3$ | $TFC_4$ | $TFC_5$ |
|---|---|---|---|---|---|---|
| Poland | $IG_{1j}$ | 2.77 | 2.49 | 1.32 | 2.13 | 3.7 |
| Spain | $IG_{2j}$ | 2.23 | 2.1 | 1.32 | 1.7 | 3.34 |
| Italy | $IG_{3j}$ | 2.47 | 2.26 | 1.32 | 1.73 | 3.45 |
| The Netherlands | $IG_{4j}$ | 2.49 | 2.31 | 1.32 | 1.84 | 3.41 |
| Germany | $IG_{5j}$ | 2.73 | 2.49 | 1.32 | 2.08 | 3.66 |

The following results were obtained after ranking $TFC_j$ according to the decrease in generalized integral PIs $I_k$ for two groups of indicators:

– Poland: $TFC_3$, $TFC_4$, $TFC_2$, $TFC_1$, $TFC_5$;
– Spain: $TFC_3$, $TFC_4$, $TFC_2$, $TFC_1$, $TFC_5$;
– Italy: $TFC_3$, $TFC_4$, $TFC_2$, $TFC_1$, $TFC_5$;
– The Netherlands: $TFC_3$, $TFC_4$, $TFC_2$, $TFC_1$, $TFC_5$;
– Germany: $TFC_3$, $TFC_4$, $TFC_2$, $TFC_1$, $TFC_5$.

Thus, taking into account the quantitative and qualitative PIs, it is advisable to plan cooperation with $TFC_3$ and $TFC_4$, which will satisfy the complex requirements for the delivery of goods in international communication.

These results indicate the expediency of applying IM and scientific approaches in the practical activities of manufacturing enterprises that are exporters of goods to different countries of the world. The proposed technological advancement will make it possible to justify the decision regarding the choice of TFC when delivering goods to a separate counterparty, taking into account the terms of the international economic contract. This will make it possible, on the basis of the IM built, to analyze the performance indicators of TFC when serving individual contractors, taking into account their individual requirements for the delivery of goods. The simulation results will ensure the formation of reliable partnership relations between exporters and their counterparties, as well as contribute to the effective fulfillment of the terms of international trade contracts. In addition, a high level of trust in the business entity will be achieved due to the involvement of TFCs in the product delivery process, which, according to their qualitative and quantitative indicators of cooperation evaluation, meet the requirements of the customer. Thus, the application of the proposed model will provide an opportunity for manufacturing enterprises to secure a separate TFC contractor that is able to provide all requirements for the delivery of goods along the necessary route. As a result of this implementation, Ukrainian exporters will gain competitive advantages among other suppliers of goods due to the possibility of clearly planning the terms of delivery of goods and fulfilling the terms of international trade contracts.

## 6. Discussion of results of simulating the model for the selection of a transport and forwarding company to meet the needs of the customer

The results of simulation allow us to analyze the quantitative performance indicators of the studied TFCs (Table 4) under the condition of using various types of cooperation. This will make it possible to carry out a comparative analysis and formulate recommendations for the exporter to make a decision on cooperation with a separate business entity. The simulation model makes it possible to determine the optimal values (Table 7), which will become the basis for choosing a TFC capable of meeting the needs of the counterparty regarding the organization of international transportation.

Our results of modeling the provision of transport and forwarding services (Table 8) from the involvement in the delivery of goods on different routes of five business entities show significant differences in efficiency indicators. At the same time, the conditions of cooperation, which determine the priority of order processing in the event of the employment of specialists and the formation of a queue, have a significant impact on the service process. The presence of previous agreements on cooperation or interaction on a bidding basis indicates significant improvements in all service indicators studied.

Integral performance indicators (Table 9) ensure the formation of the priority of selection and the establishment of partnership relations with the studied TFCs, taking into account the results of modeling. In general, there is a general trend regarding the effectiveness of the provision of TFC services, which have a clear strategy for building internal and external policies for ensuring business processes.

Based on the qualitative indicators of cooperation with TFC (Table 10), a matrix of performance indicators was formed (Table 11), which allows determining the optimal values and justifying the choice of TFC based on the requirements for the level of service. Thus, each exporter can form a list of indicators and their weight, which will have an impact on the planning of interaction with TFC.

By analogy with the quantitative indicators, our work defines integral and general indicators of the efficiency of TFCs (Table 12), which provide justification for the expediency of cooperation with the studied TFCs and plan the conditions of cooperation with them.

In addition, PIs were compared according to two groups of indicators (Table 13) and a strategy of cooperation with TFC was formulated in serving contractors who need to deliver goods by different routes.

In this study, it was possible to construct a simulation model of TFC selection in the organization of road transport, which will allow planning the work of a manufacturing enterprise that exports goods. It provides for the possibility of determining the performance indicators of the TFC that correspond to the terms of the international economic contract when delivering the goods to a separate counterparty. Thus, it becomes possible to organize the cooperation of the exporter with TFC when delivering the goods to a specific counterparty, taking into account the transportation route.

The results of the calculations, which are given in Table 13, testify to the significant influence of the transportation route and the conditions of cooperation on the duration of the feasibility study, which includes organizational and preparatory measures and the process of providing the service.

The IM built provides for the definition and substantiation of qualitative and quantitative indicators of the efficiency of TFC under various conditions of cooperation depending on the territorial location of the buyer of a product.

Unlike the existing ones, the proposed IM provides for a comparative analysis of TFC performance indicators when organizing the delivery of goods by different routes. Thus, it becomes possible to establish approximate terms of service and other indicators of cooperation for planning further actions to develop strategies for establishing sustainable partnership relations. This aspect will make it possible to choose optimal conditions of cooperation with the executor and ensure the fulfillment of all necessary legal formalities. The provision of services on general terms, auction and reduction requires more time spent on agreeing the terms of cooperation at the initial stage compared to contractual and bidding terms.

In contrast to [5], which considers options for planning cargo transportation by involving own or hired rolling stock. However, the duration of organizational and preparatory measures for the preparation of transport and customs documents for the execution of an international trade operation is not taken into account. This becomes possible owing to the determination of the load factors of freight forwarders and customs brokers who will perform their duties within the scope of the investigated enterprise.

So, for example, in [6], the simulation of the processes taking place in a transport and forwarding agency was carried out. But the approach does not take into account the interests of other stakeholders, in particular customers. To solve this task, the model built takes into account the possibility of evaluating the performance indicators of the enterprise when serving the customer under study, rather than the general flow of consumers.

In [7], the system of interrelationships between the subjects of the transport services market involved in the transportation process was investigated. However, this does not make it possible to take into account the individual requirements of the customer. And when applying the model that we proposed, it becomes possible to plan the duration of an international trade transaction and inform the counterparty about it with minimal error.

The advantages of this study are the possibility to shorten the duration of the selection of TFC to meet the conditions of an international economic contract with a separate counterparty, as well as to directly optimize the process of providing transport and forwarding services.

Our solutions allow taking into account the specificity of the organization of the delivery of goods to a separate counterparty, taking into account the transportation route. The direct feasibility study procedure is characterized by a clear sequence of actions and operations, the only significant difference is the duration of service provision due to the different personnel and material and technical support of each business entity. It was established that the duration of organizational preparatory work, which is related to the competence of specialists and the available resources of the enterprise, as well as the duration of the rolling stock's stay on the flight during the delivery of the goods, which requires control by the forwarder, has a significant impact on the time component of the feasibility study. In particular, the duration of service provision within the scope of activities of different transport and forwarding services will differ.

The main limitations of IM include the need to adjust incoming information about changes in the staffing of a potential partner enterprise and their impact on qualitative and quantitative performance indicators.

The disadvantages of IM are that it does not take into account the specific characteristics of the types of cargo that can be provided by individual exporters for transportation and provides for the delivery of goods only by road transport.

The development of this research has prospects in the following directions:

– the possibility of determining the performance indicators of TFC when transporting dangerous, oversized, and perishable goods along various routes;

– provision of recommendations regarding the expediency of involving individual TFCs when importing goods;

– construction of IM for the selection of TFC when transporting goods by sea, rail, and air transport.

## 7. Conclusions

1. The model of TFC selection has been formalized to meet the needs of customers when exporting goods to counterparties conducting their economic activities in different countries of the world. The essence of the model is the possibility of planning the cooperation of the exporter with various TFCs when organizing the delivery of goods to a separate counterparty, taking into account the individual requirements of the international economic contract. The model built provides for the possibility of performing a comparative analysis of the performance indicators of feasibility studies by various business entities when supplying goods, taking into account the individual requirements of counterparties. In addition, the model provides a comparative analysis of the application of various conditions of commercial cooperation, which affects the priority of service.

2. The IM of TFC activity was constructed for the organization of international road transportation of goods in the service of counterparties that need to organize the delivery of goods to different countries of the world. The proposed model provides an opportunity to study the interaction of the exporter with TFC under the conditions of auction, reduction, bidding, contract, and general conditions. Our model makes it possible to investigate and optimize TFC performance indicators under the condition of standardization of types of work performed by various business entities.

IM makes it possible to evaluate the qualitative and quantitative characteristics of the work of TFC, which are based on previous experience of cooperation with the organization and are formed into integral performance indicators through machine processing. The verification of the adequacy of IM showed that the upper limit of the simulation error during the trial experiment is $d_{SM}$=2.8 % with a permissible 3 %. Accordingly, the proposed IM of choosing a TFC to ensure the delivery of goods to counterparties reproduces the real conditions of international trade operations.

3. The results of simulation modeling indicate that, in the case of significant volumes of goods supplied to counterparties, it is advisable to constantly cooperate with a separate TFC on a bidding or contractual basis. Such an implementation will reduce the time for choosing and agreeing the terms of cooperation with various enterprises by 12 % and will provide an opportunity to reduce the share of applications that are served without downtime in the queue by 15 %.

4. A methodology for determining the optimal TFC has been devised, which will facilitate the customer's choice of a business entity that meets the needs for product delivery, taking into account qualitative and quantitative performance indicators. The implementation of the methodology involves the normalization of local indicators, the determination of generalized and optimal performance indicators of economic entities, taking into account weighting factors. On the basis of the introduced methodology, it is recommended to choose the optimal TFC taking into account the generalized integral efficiency indicator.

5. Determining the optimal TFC, taking into account the interests of the counterparties, is carried out by evaluating the quantitative and qualitative performance indicators. Based on the research results, it was established that the transportation route and the chosen commercial conditions of cooperation between TFC and the exporter have the main influence on efficiency indicators. The transition of subjects of international economic activity to cooperation on a bidding or contractual basis will ensure stable partnership relations between all stakeholders, which will affect the quality and reliability of service.

**Conflicts of interest**

The authors declare that they have no conflicts of interest in relation to the current study, including financial, personal, authorship, or any other, that could affect the study and the results reported in this paper.

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**Data availability**

All data are available in the main text of the manuscript.

**Use of artificial intelligence**

The authors confirm that they did not use artificial intelligence technologies when creating the current work.

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