MODELOWANIE ZAPOTRZEBOWANIA NA USŁUGI SPEDYCYJNE[1]

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Streszczenie. *W artykule zaproponowano podejście do oceny zapotrzebowania na usługi spedycji towarów. Zaproponowano model generowania popytu, który opisuje zapotrzebowanie na usługi spedycyjne jako połączone potoki nadawców. Przedstawiono regularność powstawania popytu zaobserwowaną jako wynik studiów eksperymentalnych.*

Słowa kluczowe: *spedycja towarów, zapotrzebowanie na usługi spedycyjne, symulacja*

1. Introduction

Development of information technologies over the past 15-20 years has provided a high level of informatization and virtualization of technological processes on contemporary transport markets. This led to the changes in role of freight forwarders as of companies providing intermediary services. Contemporary forwarders are the architects of supply chains that provide the most efficient way of interaction of the transport market subjects. Therefore, the efficiency of the forwarding companies nowadays is one of the key factors determining the efficiency of the transport systems [5].

Evaluation of demand on production of enterprises (or their services) is a necessary stage, which is usually implemented before the development of decisions aiming to improve the quality of production (or clients servicing), to increase the efficiency of technological processes, to improve the company's competitiveness, etc. Correctness of the demand parameters estimation determines the efficiency of the planning process.

For freight forwarders on road transport the stage of demand parameters estimation is particularly important. It could be defined as one of the most challenging activities in company's management process [2]. The complexity of evaluation of transportation services demand is caused by influence of numerous environmental factors on processes of formation of shippers' needs. The task of transport demand

1 Wkład autorów w publikację: NaumovV. 80%, NagornyiI. 20%

evaluation requires the development of complex models, which describe the stochastic nature of numerous parameters.

2. Literaturereview

The conducted literature review, based on [1,2,4-6,8,10,11], leads to the conclusion, that demand evaluation task is commonly considered as a task of numerical estimation of a single parameter, which is used for determination of demand. In most approaches the evaluation of a transport demand refers to the determination of its predictive value [1,2,4,8]. The need of preliminary studies of demand parameters, which are the stochastic values, as a rule, is not considered. Usually, the definition of predictive value is implemented on the basis of statistical data on the demand values for previous periods, which does not allow studying the process of demand formation. Such an approach causes incorrect results of evaluation process.

The task of demand parameters evaluation should not be defined as a task of forecasting. Evaluation of a demand on transport services is a preliminary stage for solving the problems in transportation processes management, including a forecasting problem.

It is common to estimate the demand on forwarders' services with the generalized quantitative indicators: the requests number or the cargo volume in tons and ton-kilometers (ton-miles) for a fixed period of time are the most commonly used ones [1,2,8]. However, these indicators do not give an opportunity to assess the demand character and its features. For example, the demand value in 100 tons per month does not allow estimation of the value of certain consignments (possibly, there are 20consignments of 5 tons each, or there are 2 consignments of 50 tons each), the delivery distances (100 tons could be carried on a distance of 1000 km, or – on a distance of 50 km), the frequency of requests on cargo delivery (requests for the delivery could appear once a week, or – once a day). The use of ton-kilometers as a measure for demand evaluation to some extent allows taking into account the delivery distance, but it does not provide an opportunity to characterize other parameters.

The evaluation of demand with a single indicator is not a valid approach for solving – most of the scientific and practical issues. In [11] for the first time it was proposed to implement an approach, which allows a comprehensive assessment of a demand on transport services. Four indexes were used for the demand evaluation: the volume of a shipment, the delivery distance, the dead mileage and an interval of incoming requests. It was proposed to solve the problem of freight forwarding companies' demand evaluation as a task of evaluation of parameters of requests flow.

The basic unit, which forms a demand, is a request on freight forwarding services – such a need of a client in transport services, which is supported by purchasing ability and is presented at the market in order to be satisfied. Presence of a request on transport servicing necessitates an interaction of transport market participants – freight forwarders, carriers, freight terminals and shippers. A set of potential and actual requests on company's services forms the demand on its services.

Any request could be evaluated numerically by a set of indicators. The most significant of them are the consignment volume, the delivery distance and the requests interval. Since a set of consecutive requests on forwarding services characterizes a demand, the problem of demand estimation could be transformed into a problem of flow parameters estimation [10].

3. An approach to measuring the demand on freight forwarding services

As it was noted, parameters of the requests flow on services of freight forwarders are the stochastic values. To estimate demand it is necessary to determine characteristics of each of the flow parameters as a stochastic value. It is known, that for the complete definition of a stochastic value its distribution function should be defined. But in practice usually it is enoughto determine the distribution law and its appropriate numerical characteristics.

Distribution laws of parameters and numerical characteristics of stochastic values are determined on the base of statistical information on the requests flow. Primary documents containing data on requests are the contracts on clients servicing. A standard contract contains the following attributes: names of the contract subjects, the object of the agreement, contact numbers of people in charge, bank requisites of the contract subjects, etc. The consignment characteristics (such as the delivery route, cargo type, batch size, the preferred loading and unloading methods, etc.) are the mandatory part of contracts; usually they are described in a special appendix. Information obtained as a result of contracts processing could be presented in a form of a table, like it isshown in Tab. 1.

If the delivery distance is not mentioned in a contract, it could be defined with the help of any ofthe known tools (MS AutoRoute, Google Maps and others) on the base of the delivery route.

Table 1. An example of a form for processing of information on the requests flow

Request number	*Date and time of the request submission*	*The deliveryroute*	*The consignment volume, tons*	*The requests interval, hrs.*	*The delivery distance, km*
1	25 Aug, 8^{40}	…	10	0,66	755
2	25 Aug, 16^{00}	…	20	7,33	605
3	26 Aug, 11^{00}	…	20	4,00	810
…	…	…	…	…	…

Source: own

The contemporary technology of freight forwarding provides a possibility of a remote servicing (such a form usually is the preferable one): a signed contract is sent by a client and is received by a forwarder by fax or e-mail. This allows toprecisely determine the time of a submission of a request. In the document, which was sent by fax, thetime and date of submission are noted in the right upper corner. The main requisites of thee-mail are theaddresses of the sender andthe recipient, and the date and the time of reception. Thus, for a contract received by e-mail, the time of request appearance is also determined uniquely.

For sequential requests, the interval I_i is defined as the difference between the submission time for the current and previous requests, excluding non-working time:

$$I_i = t_i - t_{i-1} - t_{nbi} \tag{1}$$

where:

t_i, t_{i-1} – submission time for the i-th and (i–1)-th requests respectively, hrs;

$t_{nb\,i}$ – non-business hours of a freight forwarding company, hrs.

The interval for the first request in a flow is defined as time, elapsed since the working day started (i.e. if working day starts at 800, then the interval value in 0,66 hrs means, that this request was submitted at 840). For the flow of requests submitted during several days, we propose to define the requests flow for such a time axis, which consists of segments of the company's working hours (Fig. 1). For such a type of a time axis the closing hour of a current working day (for example, 1700) coincides with the opening hour of the next working day (for example, 800), i.e. the hours from 1700 to 800 and holidays are „cut out". For example, the interval between the request submitted at 1600 August 25 and the request submitted at 1100 August 26 makes 4 hrs (1 hour before the closing of a working day at 1700 August 25 plus 3 hours after the openingof a working day at 800 August 26).

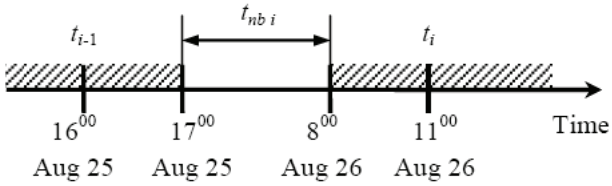

Fig. 1. Calculating the request interval: „cut out" of non-business hours
Source: own

If a value of the consignment volume is not defined in a contract clearly (in such cases the required vehicle is defined by its capacity, body type and other characteristics), then it is determined as a capacity of a vehicle, assuming that the vehicle will be loaded by a shipper entirely.

4. A model for generation of demand on freight forwarding services

In order to determine the patterns of formation of demand on freight forwarding services it was decided to develop a simulation model for generation of a flow of requests on freight forwarding services. The simulation model was implemented with the use of principles of object oriented paradigm in C# on the base of classes described in [10].

Demand on freight forwarding services is formally described as a set of consecutive requests – its flow. It is formed as a sum of requests flows of shippers, which are serviced by a forwarder. Schematically the process of formation of a demand on freight forwarding services for a single forwarder is shown at Fig. 2.

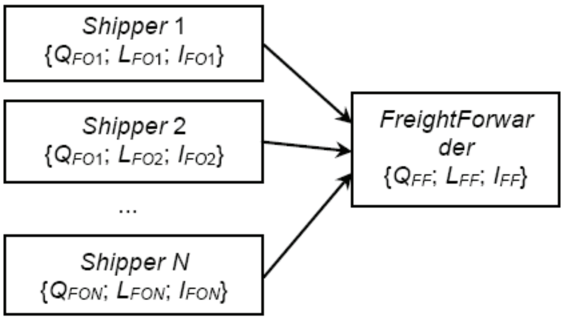

Fig. 2.Schematicdiagramofformationofdemandonforwarding services
Source: own

The shipper's demand could be formalized as a set of following parameters: a stochastic value of the consignment volume Q_{FO}, a stochastic value of the delivery distance L_{FO} and a stochastic value of the requests interval I_{FO}. A description of a shipper as a transportation market subject is proposed to implement as a class, which contains the *demand* field of a *RequestFlow* type (where *RequestFlow* is a class, which entity implements the requests flow). A set of flows of *N* shippers forms an incoming requests flow for the forwarding company, which services those shippers. A description of the freight forwarder we propose to implement as a class, which contains a field allowing the depiction of an incoming request flow as a set of appropriate stochastic values of the consignment volume Q_{FF}, the delivery distance L_{FF} and the requests interval I_{FF}.

The essential method of the model for formation of demand on forwarding company's services is such a method, which implements a summation of outbound flows of shippers' requests into an incoming requests flow of a forwarder. The method's algorithm is presented at Fig. 3.

A single argument of the summarizing method is a parameter *frwd* of the *FreightForwarder* type (an implementation of a *FreightForwarder*class – a class which allows depicting of a freight forwarder). This parameter is a pointer on a transportation market's subject entity, for which the demand simulation is implemented. The method uses internal counter variables *i* and *j*, as well as a variable *rf* of the

RequestFlow type. The variable *rf* is a totalizer, which contains sequentially recorded requests for each of serviced shippers.

The algorithm of the proposed method in a loop performs a procedure of summation of requests from *FOnumber* shippers. An index number of a shipper from the *fo* list is contained in the counter *i*. The first command in the loop, iterating through the shippers, resets the value of a *flowTime* field of the internal variable *rf* using the appropriate accessor*FT*. Next, the initial value of the counter *j*, which is used as a pointer on the request number for the *i*-th shipper, is set. In the nested loop --- adding of requests of *i*-th shipper to the *rf* flow is implemented. The access to the requests flow of a shipper *fo*[*i*] is implemented with the *GetRequestFlow*( ) method, the access to the *j*-th request in the flow is provided with the *GetRequest*(*j*) method. A number of requests in the requests flow of the *i*-th shipper is returned by the *GetRequestsNumber*( ) method of the *RequestFlow* class. The *AddRequest* method of the *RequestFlow* class allows adding of a new request to the end of the flow [10].

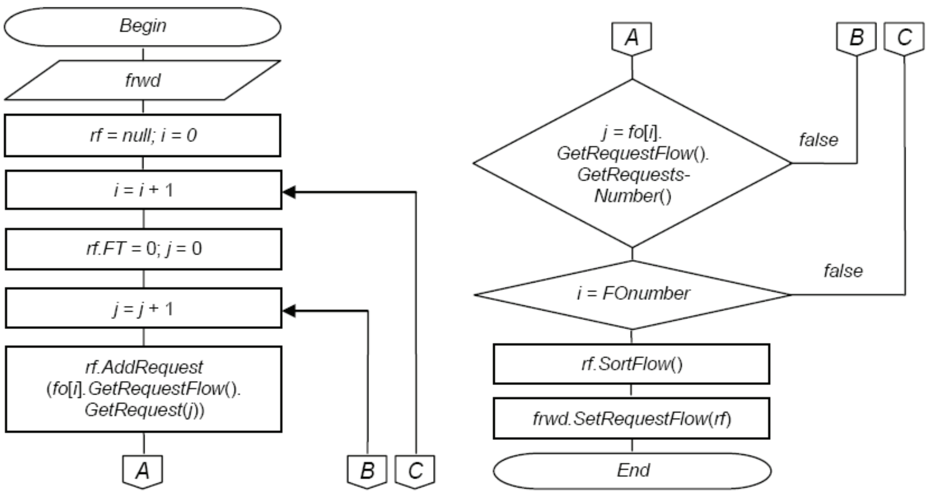

Fig. 3. Algorithm of SummarizeRequestsprocedure
Source: own

The methods of requests sorting *SortFlow*( ) and of intervals recalculation are used to summarize requests. Such procedures are needed to estimate parameters of demand on services of freight forwarders which are provided for several shippers, as well as demand on services of carriers and freight terminals which are provided for several freight forwarders. The flows summation process implies the sequential addition of requests into the totalizing flow which is followed by the sorting of requests by the time of receipt and with the recalculation of time intervals between requests. An algorithm of intervals recalculation is implemented in the private method of the *RequestFlow* class.

The algorithm of intervals' recalculation as an input parameter receives the requests list *r*[ ] sorted by the value of a model time (the procedure as a method of the *RequestFlow*class contains the *requests* field which is used as such a list). If the list-argument is not empty, then for the first list element, for its field *I*, containing the interval value, the value of the current model time *CT* of the request is assigned. If the number of list elements is greater than 1, in the cycle for each element the interval value is calculated as the difference between the model time for the current request and the previous one. Sorting of requests lists could be implemented with the use of anyknown sorting methods. The mentioned classes were implemented in C# 4.0, so to sort requests the internal method *Sort* of *List<T>* objects was used [7], wherein as the method's parameter it was specified an instance of the *RequestComparer* class, which implemented the comparison of requests by the value of its current model time *CT*.

Setting of the totalizing flow as an input requests flow of freight forwarder in the algorithm at Fig. 3 is carried out using the *SetRequestFlow* method of the *FreightForwarder* class.

5. Results of experimental studies

To identify patterns of formation of demand on forwarders services on the base of the proposed model a simulation experiment was conducted. In the plan of experiment the following situations were considered: a forwarder services 8 shippers, a forwarder services 64 shippers, a forwarder services 128 shippers, and a forwarder services 256 shippers.

For each ofthementioned groups the following variants of demand parameters distribution were verified:

- all the parameters are distributed uniformly;
- all the parameters are distributed normally;
- all the parameters are distributed exponentially;
- the distribution law of shippers demand parameters is random (unknown for a person conducted the research).

To justify a sufficient number of tests in the experiment series 10 tests for each situation (2, 8, 64, 128 and 256 shippers are serviced by a single forwarder) were conducted. Hypotheses about the distribution laws of parameters of the incoming flow were tested with the use of Pearson Chi-square criterion. Furthermore, from the set of distribution laws that were not rejected by Pearson criterion, as the distribution law of the flow parameter such a variant was accepted, for which the Kolmogorov criterion has the greatest value.

The results of experimental studies, conducted on the simulation model, allow the formulation of the following assertions:

1) if a freight forwarder services two shippers, the distribution law of incoming requests flow is normal regardless of the distribution of shipper's demand parameters, except the case, when the parameters of an outbound flow are the exponentially distributed stochastic values;

2) if parameters, characterizing outbound flows, are the stochastic values distributed exponentially, the distribution law of the input requests flow is exponential, regardless of a number of serviced shippers;
3) if a freight forwarder services a big number of shippers (guiding on numeric values, used in the experiment, – if the shippers numbers is more, than 8), the distribution law of the incoming requests' interval is exponential;
4) if a freight forwarder services a big number of shippers (guiding on numeric values, used in the experiment, – if the shippers numbers is more, than 64), the cargo volume and the delivery distance for the incoming requests' flow are the stochastic values with gamma-distribution.

The experimental studies were carried out on the base of Ukrainian freight forwarding companies – PE „Galagan" (Kherson, 2007), TOV „Kamaz-Transservis" (Rivne, 2007), TOV „Rimaks-Trans" (Kharkiv, 2008), PE „Fursenko" (Kharkiv, 2008), PE „Shemetov" (Kharkiv, 2009), PE „Rise-Rimbex" (Akhtyrka, 2010), TOV „TEK Avto-Transit" (Kharkiv, 2011). The number of observation was limited by the information available on enterprises (by available copies of documented requests), i.e. obtained sets of values were not general.

Verification of the significance of hypotheses about distributions of the stochastic values was carried out using the Statistica ver. 7 package. As the criteria of statistical significance of hypotheses the Pearson and Kolmogorov tests were used.

The results of conducted studies are presented in Tab. 2. The distribution variant, which is characterized by a higher value of Kolmogorov criterion, is presented as the first item in a pair of laws. As we can see, in most cases requests flow parameters have normal distribution or distributions, that are close to normal.

Theoretically, values of the requests interval are distributed exponentially in case, when requests are received independently from each other with a constant average intensity [3,9]. This statement is consistent with the results of the conducted simulation. Mentioned regularity is also confirmed experimentally for PE „Shemetov", PE „Fursenko", TOV „TEK Avto-Transit", PE „Rise-Rimbex" and VAT „Svetofor". For TOV „Kamaz-Transservis" and PE „Galagan": the hypothesis about exponential distribution is also not rejected by Chi-Square test, despite the significantly higher value of probability according to the Kolmogorov criterion. Normal distribution of the requests interval for TOV „Rimaks-Trans" could be explained by the small number of shippers, which are serviced by the enterprise and are its regular customers. This regularity is shown in the results of the conducted simulation experiment: if two shippers are serviced, then the requests interval is distributed normally.

Tab. 2. Distribution laws of the requests flow parameters

Company name	*The requests interval*	*The delivery distance*	*The consignment volume*
VAT „Svetofor"	exponential **	-*	gamma
TOV „Kamaz-Transservis"	chi-square / exponential	normal / gamma	chi-square / normal
PE„Galagan"	normal / exponential	normal	chi-sqaure / normal
TOV„Rimaks-Trans"	chi-square / normal	lognormal / gamma	normal

PE„Fursenko”	exponential	gamma	normal
PE„Shemetov”	exponential	normal / lognormal	chi-square
PE„Rise-Rimbex”	exponential	gamma	normal / chi-square
TOV„TEKAvto-Transit”	exponential	gamma	exponential / gamma

* *the parameter studies for this enterprise were not conducted*

** *the interval values were determined as the ratio of the working day duration to a number of requests per day*

Source: own

For the requests flows, which have been analyzed, the delivery distance has the distribution close to normal, lognormal or gamma-distribution. Lognormal distribution is defined on the basis of normal (in fact – it characterizes the normal distribution of a logarithm of stochastic value), so it could be assumed that the distributions of the delivery distance for TOV „Rimaks-Trans” and PE „Shemetov” also confirms the normality of this parameter in general. In accordance with the results of the conducted experiment, lognormal distribution of the delivery distance is typical for cases, when the delivery distance in request flows of shippers, which are serviced by the forwarder, has rectangular or normal distribution. Gamma-distribution of the delivery distance for PE „Fursenko”, PE „Rise-Rimbex” and TOV „TEK Avto-Transit” confirms the regularity, obtained as a result of the simulation for the case, when the distribution of the delivery distance in shippers' requests flows is not similar for the clients and, in fact, is random as well.

Stochastic value of the consignment volume in shippers' requests flows, according to the results of the experiment, presented in Tab. 2, generally has normal or close to normal (chi-square) distribution. Such regularity is typical for the cases, when a freight forwarder services a relatively small number of shippers (in accordance with the experiment results – if the number of clients is less than 64). The results, obtained while processing the incoming requests flow for VAT „Svetofor” and TOV „TEK Avto-Transit”, confirm the regularity, which is typical for the enterprises servicing clients with different characteristics of stochastic value of the consignment volume.

It was determined, that average values of the requests flow parameters for analyzed samples were in a quite a wide range (Tab. 3).

On the base of average values of the consignment volume and the delivery distance the specialization of a freight forwarder could be defined. For example, if a Ukrainian forwarder operates on the domestic market, its average delivery distance usually does not exceed 500 km (PE „Galagan”); if an enterprise provides delivery of small lots of cargos, an average consignment value does not exceed 10 t (VAT „Svetofor”), etc. On the base of average requests interval it is possible to make conclusions about the intensity of demand, and in a consequence – about competitive positions of a forwarder on the market of transport services. It is obvious, that the less mathematical expectation of the requests interval is , the greater number of clients is serviced by a freight forwarder, and therefore – the better position the forwarder has on the market relatively to its competitors.

Tab. 3. The mathematical expectation of the flow parameters

Company name	Year of studies	Sample size, units	The requests interval, hrs	The delivery distance, km	The consignment volume, tons
VAT „Svetofor”	2005	54	13,5	-	3,0
TOV „Kamaz-Transservis”	2006	176	1,22	2235	17,1
PE „Galagan”	2007	281	3,40	364	20,8
TOV „Rimaks-Trans”	2008	87	5,58	1726	20,5
PE „Fursenko”	2008	111	-	734	14,5
PE „Shemetov”	2009	187	8,19	1929	17,3
PE „Rise-Rimbex”	2010	51	12,78	1092	16,6
TOV „TEKAvto-Transit”	2011	219	9,04	799	13,95

Source: own

Obtained results allow the consideration of the following hypothesis as an accepted one: the specialization of an enterprise and its competitive position do not determine the distribution laws of the requests flow parameters. As we can see, the distribution of the consignment volume stochastic value is the same for VAT „Svetofor”, which ensures the delivery of shipments of 3 t in average, and for PE „Galagan”, which services requests with the consignment volume of about 20 t, as well. The hypothesis about an exponential distribution of the requests interval is not rejected for TOV „Kamaz-Transservis” servicing requests with the interval equaled to 1,22 hrs, as well as for PE „Rise-Rimbex”, for which the requests interval is more than 12 hrs in average. The delivery distance is distributed normally for PE „Galagan”, which services the clients in southern regions of Ukraine, as well as for TOV „Kamaz-Transservis”, which is specialized on cargo deliveries in the direction of Ukraine – Italy.

6. Summary

It is expediently to carry out the estimation of demand on services of freight forwarders on the base of the set of parameters – the stochastic values of the consignment volume, the delivery distance and the requests interval.

As the base for modeling of demand on freight forwarding services we propose to use the model of requests flow as a set of separate requests, which are ordered in time. The conducted simulation experiment has allowed the definition of a number of regularities for formation of demand on services of freight forwarders. The following regularities have the practical significance: an interval of requests on forwarding services is distributed exponentially, and the consignment volume and the delivery distance are gamma-distributed values in cases, when the freight forwarder services more than 8 clients and the distribution laws for their requests flow parameters are unknown.

The obtained regularities for formation of demand on freight forwarding services could be interpreted as a theoretical base for demand simulation while solving a number of problems of applied character: justification of forwarder's behavioral strategies on the market of transport services, choice of the optimal variant for the technology of client's servicing, justification of the necessary number of dispatchers for a freight forwarding company, etc.

The studies of demand on freight forwarding services, conducted on a number of enterprises of Ukraine, allow the consideration of the following statement as a correct one: a distribution of the requests flow parameters does not correlate with the forwarder's specialization and with the competitive position of the enterprise on the market. The empirical studies of demand on freight forwarding services confirm the regularities obtained as a result of the simulation experiment.

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