

*Розроблено логит-модель для оцінки успішності укладення угоди фрахтування на рейс. Експериментальним шляхом встановлено правило формування на базі логит-моделі висновків про наявність балансу інтересів сторін, відображених в умовах оферти. Охарактеризована область практичного використання логит-моделі в діяльності фрахтових брокерів для формування рекомендацій сторонам по досягненню балансу інтересів*

*Ключові слова: логит-модель, фрахтування, рейсовий чартер, успішність, оцінка, угода, фрахтова ставка*

*Разработана логит-модель для оценки успешности заключения сделки фрахтования на рейс. Экспериментальным путем установлено правило формирования на базе логит-модели выводов о наличии баланса интересов сторон, отраженных в условиях оферты. Охарактеризована область практического использования логит-модели в деятельности фрахтовых брокеров для формирования рекомендаций сторонам по достижению баланса интересов*

*Ключевые слова: логит-модель, фрахтование, рейсовый чартер, успешность, оценка, сделка, фрахтовая ставка*

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# DEVELOPING A LOGIT MODEL FOR THE PROVISION OF THE PROCESS OF MANAGING THE CONCLUSION OF VOYAGE CHARTERING TRANSACTIONS

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## 1. Introduction

The conclusion of agreement for chartering the voyage (voyage charter) is, as a rule, an iterative process of exchanging the information, in the course of which the parties – a charterer and a ship-owner, as well as a broker, who represents interests of one of the parties (brokers of the sides), – come to an agreement on all points of the agreement in question. It is natural that the freight rate is the most significant point of a voyage charter.

An analysis of practical experience of the freight broker activity makes it possible to formulate the following question: why, in certain cases, at the rate of voyage charter whose level is considerably lower than the market average, does a ship-owner agree to sign the deal while in some situations even fairly high level of rate is not acceptable for him? Similar question can be asked as well to a charterer (cargo owner). The reason for this phenomenon in particular deals are specific motives of each of the parties – for example, a lack of prospects for another order for the ship-owner, or the need for the urgent fulfillment of foreign trade contract by exporter-charterer. Nevertheless, the specified situation is characteristic only for the insignificant part of the freight deals.

As was noted in [1], conclusion of the deal for chartering the voyage is a certain compromise between the interests of a charterer and a ship-owner, at which the parties agree to certain concessions that lead to either additional expenditures

or decrease in income. Specifically, the balance of interests and possible risks, caused by many conditions of voyage charter, affects making a decision about conclusion of the deal for voyage charter.

A study of the indicated balance is relevant from the point of view of realization of the control process over the conclusion of deals in the marine business.

Let us note that in reality freight brokers, who are the connecting links in the freight deals, intuitively, to a larger degree, determine existence of the balance between interested parties and propose them their recommendations for reaching successful conclusion of the deal. Nevertheless, contemporary science possesses mathematical apparatus in the form of logit and probit models that make it possible to evaluate probabilities of binary choice for the assigned set of conditions. The given models may serve a theoretical base for a quantitative analysis of the conditions of offers and the substantiated formation of conclusions and recommendations in the process of freight activity.

## 2. Literature review and problem statement

A considerable number of publications, devoted to the marine business control processes (for example, [2–9]), are connected to the modeling and prediction of behavior of freight rates, which is achieved, as a rule, based on the correlative-regressive analysis and analysis of time series.

Paper [2] proposes an approach to the description of behavior of rates of the time charter contracts based on the theory of random processes.

Article [3] explores dynamics of rates of the time charter taking into account the risk premium in their structure. In this case, risk premium is predetermined by the specific character of the state of market performance. Papers [4, 5, 8] deal with a study of rates behavior in the dry cargo section of the freight market; [6] examines tanker section of the freight market and substantiates the nonlinear nature of dynamics of the freight rates.

Article [7] presented regression models for the rates of voyage charter when transporting grain, ore and coal, where the following independent variables were used: oversupply, level of demand, a set of a vessel's characteristics and the voyage distance. Similar problem is addressed in paper [8], which analyzed influence of the characteristics of vessel and voyage on the level of freight rates for the voyage chartering for the dry cargo section of the freight market, as well as proposed the regression models that describe dependence of the freight rates of voyage charter on the dead weight, duration of voyage, etc.

Article [9] presented results of correlation-regression analysis of the rates of time charter and basic characteristics of the vessel – its age and dead weight; the regression models of dependence of the rate of voyage charter on the transportation distance are built.

Thus, behavior of the freight rates depending on the market conditions or conditions of particular voyage is the object of considerable number of contemporary studies.

Let us note that the rates of voyage charter are characterized by significant dispersion [9], even when we mean particular direction of transportation and load. This is explained by existence of multitude of conditions in a voyage charter, which influence the costs and potential risks of ship-owners, and which they naturally attempt “to overlap” by a certain surcharge (in the terminology of ref. [3] – the risk premium).

The presence of balance between the interested parties in the contract of carriage and, as a result, the establishment of a certain correspondence between a freight rate and other conditions, is practically not examined by contemporary scientists.

Paper [1] presented results of the statistical analysis of offers, which made it possible to establish the force of influence of the basic conditions of voyage charter on the successful conclusion of a freight deal. The regression model is proposed, which reflects dependence of successful conclusion of the deal on the quantitative characteristics of voyage charter. The notion of “success”, proposed by the authors, is close in its essence to the probability, but, taking into account its possible values during modeling (less than 0 and larger than 1), they introduced the term “success”. Let us note that the represented results substantiated the possibility of quantitative assessment of the balance between interested parties in the contract of carriage. Nevertheless, we consider that in situations when the resulting variable from a practical point of view takes only two values (in this case, success of the conclusion of transaction – the deal is concluded or not concluded), it is more appropriate to use a special mathematical apparatus that allows us to describe binary choice.

In contemporary science, the modeling of “behavior” of different subjects under conditions of binary choice is achieved with the help of the logit and probit models. This approach to the formation of statistical-probabilistic models

is widely spread in different subject areas (marketing, investing, sociology, medicine, etc.).

In particular, the construction of such models is addressed in papers [10–15].

The marine business in the context of modeling the behavior of subjects is explored in articles [16–18]. In [16, 17] examine the problem of investing and reflect results of the empirical analysis that deals with the behavior of ship-owners when making investment decisions about acquisition of vessels, including those regarding the type of vessel. The authors formulated two logit models: the model of binary choice for making an investment decision and the nested logit model for decision making on the selection of vessel. The obtained results may to a considerable degree explain the behavior of ship-owner when making investment decisions.

Article [18], based on the logit model, substantiates the selection of port for the delivery of cargoes in containers (on the example of Spanish ports). The cost and temporal characteristics of delivery are proposed as the influencing parameters.

Thus, contemporary studies demonstrate the applicability of the models of binary choice for the substantiation of decisions in the marine business.

We consider that the success of conclusion a freight transaction may also be predicted with the help of the models of binary choice and present research is a logical continuation and development of results, presented in [1], and it is devoted to the problem of using the logit model for evaluating the success of concluding a voyage charter based on its conditions that are of quantitative nature.

This approach will make it possible to enlarge the scope of application of the binary choice models and to ensure at the theoretical level the solution of practical and scientific problem of evaluating the success of the conclusion of freight transaction based on the analysis of existence of balance between the interested parties under existing market conditions.

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### 3. The aim and tasks of the study

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The aim of this research is the development of a logit model for the provision of management processes over transactions for voyage chartering.

To achieve the set aim, the following tasks were to be solved:

- development and empirical verification of the logit model as the means of analysis of the balance of interests between the parties in offers and of the evaluation of success in concluding an agreement for voyage chartering;
- development of practical recommendations regarding the use of the logit model for analysis of the balance of interests between the parties in the offers by freight brokers.

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### 4. Methods, statistical base and the tools for examining information from offers

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As a mathematical tool for information analysis by the conditions of offers, we use the probabilistic-statistical logit model, which takes the form [19]:

$$Y = \frac{e^z}{1 + e^z}, \quad (1)$$

where  $Y \in [0;1]$  is the function of distribution of probabilities of binary choice, in this case, the conclusion of freight transaction;

$$Z = b_0 + \sum_{i=1}^m b_i X_i, \tag{2}$$

where  $b_i, i = \overline{0, m}$  are the numerical coefficients,  $X_i, i = \overline{1, m}$  are the “predicting” variable logit models,  $m$  is the quantity of predicting variables of logit model.

The information base of the research is the sample from 100 offers for the bulk carriers with load capacity about 25000 t; the area of operation is the Black Sea – the Mediterranean Sea, over the period 01.01.2015 – 01.01.2016. 42 offers were accepted for concluding the agreements for voyage charter. The given vessels are the most characteristic for the transportation provision of the Ukrainian export.

The built-in functions of the Statistica 10 software package were used for obtaining numerical coefficients of the logit model and analysis of its adequacy.

**5. Results of development and empirical verification of the logit model as the tool for evaluating the success of concluding a freight transaction**

**5. 1. Preparation of initial data for constructing the logit model**

Taking into account basic conditions of a voyage charter, which have quantitative nature [1], expression (2) in this case will take the following form:

$$Z = b_0 + \sum_{i=1}^6 b_i X_i, \tag{3}$$

where  $X_1$  are the norms of cargo handling at the loading port, t thousand;  $X_2$  are the norms of cargo handling at the discharging port, t thousand;  $X_3$  is the demurrage rate, USD thousand;  $X_4$  is the time interval, during which the vessel must arrive in the port for loading, days;  $X_5$  is the percentage

of the freight payment for three days, %;  $X_6$  is the relative level of freight rate.

It was noted above that the freight rate in the majority of cases is not only the price of transportation (formed with regard to market factors, specific character of voyage and load) but it also includes a compensation for possible risks, which are, in turn, linked to particular conditions of a voyage charter.

Therefore, for constructing the adequate logit model, one of the predicting variables used is the “relative level of freight rate”, which [1] proposed to calculate as follows:

$$I_f = \frac{f^{\max} - f}{f^{\max} - f^{\min}}, \tag{4}$$

where  $I_f$  is the relative level of freight rate, which characterizes the degree of its approximation to lower  $f^{\min}$  or upper  $f^{\max}$  in the examined direction of transportation. This approach toward the estimation of the level of freight rate is accepted in the present research.

For the examined offers, let us introduce parameter  $Y^{\text{actual}} = \{0; 1\}$ :

- $Y^{\text{actual}} = 1$ , if the transaction is concluded for the set conditions of charter in the offer;
- $Y^{\text{actual}} = 0$  – otherwise.

Initial data on the offers in question are compiled in the table whose fragment is represented in Fig. 1.

Further development of the logit model based on statistical information from the offers was conducted with the help of the Statistica 10 package.

**5. 2. Construction and empirical testing of the logit model**

Results of determining coefficients of the logit model based on available statistical data are represented in Fig. 2.

	1 success of Charter Party completion	2 loading	3 discharging	4 demurrage rate	5 laycan	6 freight percentage paid	7 relative freight rate level
1	1	5,5	5	14,5	5	1	0,2
2	1	7,8	7,4	15,5	3	0,95	0,5
3	0	8	6,8	12	10	1	0,5
4	1	7	5,6	14,5	10	0,95	0,3
5	0	5	5	10	14	1	0,9
6	0	7,5	6,6	11,5	5	0,8	0,7
7	1	4,5	4,1	12,2	7	0,95	0,2
8	1	6	3,9	12,5	7	1	0,2
9	1	5,5	4,8	16	3	0,9	0,5
10	0	6	5,2	9,9	3	0,95	0,8
11	1	12	10,6	17,5	14	0,85	0,5
12	0	7	7	12	7	0,9	0,9

Fig. 1. Fragment of initial data in the Statistica package

Model: Logistic regression (logit) N of 0's: 58 1's: 42 (logit_2016)							
Dep. var: success of Charter Party completion Loss: Max likelihood							
Final loss: 16,814761187 Chi?( 6)=102,43 p=0,0000							
N=100	Const.B0	loading	discharging	demurrage rate	laycan	freight percentage paid	relative freight rate level
Estimate	10,45	0,243406	-0,682816	-2,13815	-0,587281	19	9,145
Odds ratio (unit ch)	34612,26	1,275587	0,505193	0,11787	0,555837	244088400	9367,221
Odds ratio (range)		7,009393	0,010308	0,00000	0,001565	48	952,156

Fig. 2. Results of constructing the logit model in the Statistica package for evaluating the probability of charter party completion

Let us carry out interpretation of the obtained results. In the desired logit model (3)

$$Z = 10,45 + 0,24X_1 - 0,68X_2 - 2,13X_3 - 0,587X_4 + 19X_5 + 9,145X_6 \tag{4}$$

Thus, for the vessels of considered specialization and size in the assigned area of operation, a probability of voyage charter party completion may be evaluated with the help of the following logit model:

$$Y = \frac{e^{0,45+0,24X_1-0,68X_2-2,13X_3-0,587X_4+19X_5+9,145X_6}}{1+e^{0,45+0,24X_1-0,68X_2-2,13X_3-0,587X_4+19X_5+9,145X_6}} \tag{5}$$

The value of the Pearson criterion is  $\chi^2=102,43$  (degrees of freedom – 6), as well as  $p<0,05$  (Fig. 2), allow us to draw a conclusion about adequacy of the constructed logit model. Histogram of residuals distribution (Fig. 3) also confirms this conclusion.

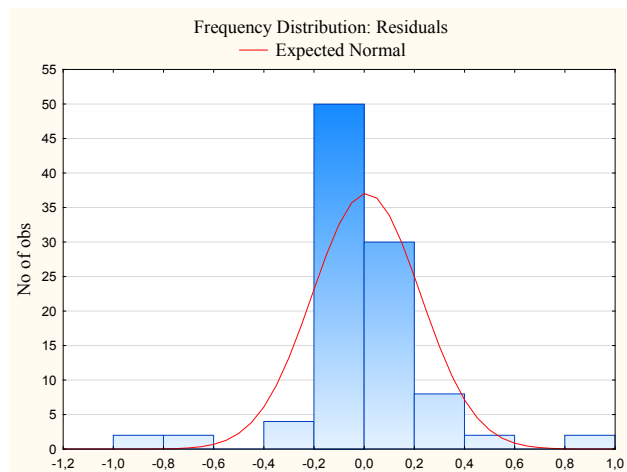


Fig. 3. Histogram of residuals distribution for the constructed logit model

An empirical verification of the model was performed by comparing values of the obtained probabilities of the conclusion of transaction for the assigned sets of conditions from the offers and corresponding actual values  $Y^{actual}$ , which is represented in Fig. 4. As can be seen (Fig. 4), the comparison of  $Y^{actual}$  and the probabilities, obtained based on the logit model, appears to be rather difficult.

According to existing approaches, for obtaining a binary variable based on the probabilities, calculated by the logit model, a specific rule should be established, which could, from the probability evaluated by the logit model, directly obtain the binary choice – “yes” or “no” – transaction is concluded or not concluded at the given set of conditions.

That is why we introduce  $Y^* \in \{0; 1\}$  into the consideration – success of concluding a transaction. In the process of experimental studies, we examined the following rule of determining  $Y^*$  based on the logit model:

- if  $Y \in [0; K]$ , then the probability of transaction completion is low and  $Y^*=0$ ;
- if  $Y \in (K; 1]$ , then the probability of transaction completion is high and  $Y^*=1$ ;

In this case, we performed variation by the level that determines  $Y^* - K = \{0,5; 0,6; 0,7\}$ .

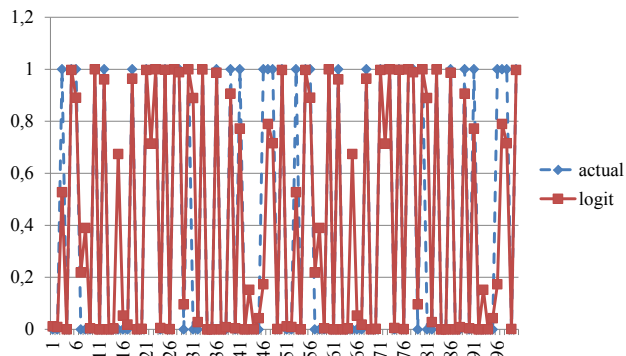


Fig. 4. Probabilities of concluding transaction Y, obtained on the basis of the logit model, and the actual values of success of the conclusion of transactions  $Y^{actual}$

In the process of analysis of empirical testing of the developed logit model for different values of K, the following conclusions were drawn:

- at  $K=0,5$ , the obtained evaluations of success of concluding transaction  $Y^*$  are not satisfactory, since the share of erroneous conclusions exceeds the permissible (higher than 0,1);
- at  $K=0,6$ , results of the comparison of actual and calculation data prove to be satisfactory (the share of erroneous conclusions is about 0,06);
- the best results correspond  $K=0,7$  (Fig. 5) the best results correspond to  $K=0,7$  (Fig. 5). Comparison of the actual and theoretical values of success of the transaction conclusion in Fig. 5 allows us to draw a conclusion that  $K=0,7$  provides for the share of erroneous conclusions, equal to 0,04, which is fairly acceptable from a practical point of view.

The larger values of K in the process of experimental studies led to an increase in the share of erroneous conclusions, yielding unsatisfactory results of evaluating the success of concluding a deal.

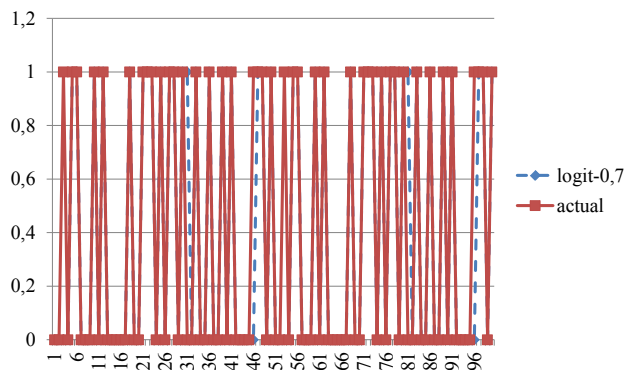


Fig. 5. Evaluation of success of concluding transaction  $Y^*$  based on the logit model at  $K=0,7$ , and the actual values of success of the conclusion of transactions  $Y^{actual}$

Thus, for solving the problem of evaluating the success of the conclusion of the transaction for voyage chartering according to the conditions of the offer, threshold value  $K=0,7$  should be accepted, which divides the models of probability obtained on the basis of the logit model into two subsets, for which the following is valid: if  $Y \in [0; 0,07]$ , then conditions of the offer does not make it possible to evaluate the transaction as successful; if  $Y \in (0,7; 1]$  – conditions of the offer make it possible to evaluate the transaction as successful.

**6. Discussion of results of development and empirical testing of the logit model for evaluating the success of the voyage chartering transaction**

Within the framework of present research, we developed a logit model and substantiated the expediency of its application for information analysis by offers for the purpose of evaluating the success of concluding a freight transaction (voyage chartering).

The area of practical use of the proposed approach is the process of making recommendations to the parties – to a charterer and to a ship-owner – by the freight broker.

Thus, freight brokers with the aid of the proposed approach may run preliminary analysis on the success of concluding a transaction based on information analysis by an offer and prepare recommendations regarding its correction.

Fig. 6 illustrates the process of reaching compromise conditions for the freight transaction (based on the example of one of the procedures applied in the practice of chartering): 1 – charterer submits a request for the sea transportation to freight broker, 2 – freight broker submits a request for the sea transportation to shipowner, 3 – ship-owner compiles an offer, 4 – freight broker evaluates the success of transaction completion based on the logit model, 5 – in the case of high probability of concluding the transaction under given conditions, freight broker submits proposals on the offer to charterer, 6 – in the case of low probability of the transaction conclusion, freight broker prepares recommendations to correct particular conditions of charter, 7 – shipowner submits corrected conditions of the offer (or does not correct and rejects the transaction in principle).

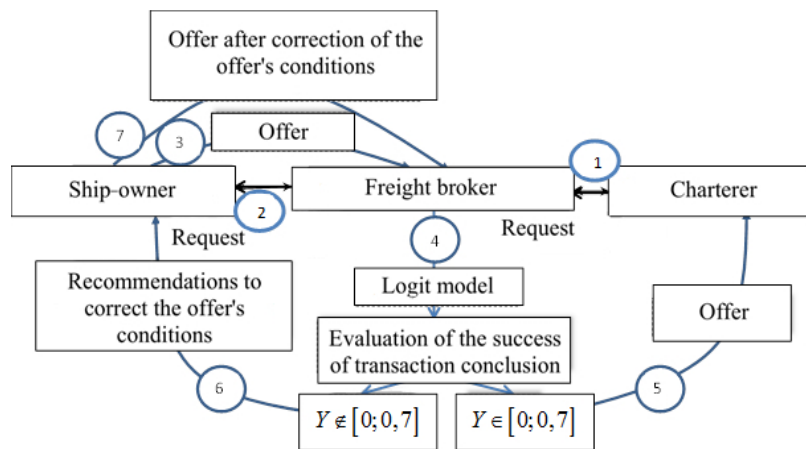


Fig. 6. Application of the logit model for information analysis in the practical activity of freight brokers

Let us note that the described process can be conducted iteratively until the parties reach an agreement or turn down the transaction.

Analogous procedures might be formed for other variants of interrelations between participants in the process of chartering.

Attention should be paid to the fact that in different market situations the role of particular conditions of the

charter increases. Nevertheless, the proposed approach to deal with information analysis and evaluation of the success of the conclusion of a freight transaction could be used in any market situations after correcting the logit model taking the changed market behavior into account.

An advantage of presented research is the formalization of the decision making processes regarding freight transactions, which makes it possible to substantiate by means of calculation the existence of balance of interests between the parties in offers and to prepare proposals regarding the correction of offers in the case of its absence.

The given results make a contribution to the theoretical base of marine business, enriching it with new tools of analysis in the processes of decision making. The activity of freight brokers when concluding voyage chartering transactions is the area of practical application of the obtained results.

We should note as a shortcoming in this research the limitation of statistical base with only one segment of the freight market considered, which does not allow us to extend automatically the obtained results to other segments of the market. That is why, the examination of transactions for vessels of different specializations and size in operation in different geographical segments should form a logical continuation of the given research.

**8. Conclusions**

1. Based on statistical information from the offers, for which the information is available about conclusion or non-conclusion of transactions, we obtained the probabilistic-statistical logit model, which, according to the values of statistical criteria, is adequate. This model evaluates probability of the conclusion of the voyage chartering transaction based on the set of values, which correspond to quantitative conditions of the offer (for example, demurrage, level of the freight rate, intensity of cargo operations, interval of time for vessel delivery).

Using empirical methods, we established boundary value of the probability, obtained by the logit model, which predetermines the existence of balance of interests between the parties and the possibility of concluding the transaction under the given conditions. An empirical verification of the obtained logit model demonstrated the share of erroneous conclusions that can be considered acceptable (less than 5%).

2. We developed a procedure for the application of the logit model in the activity of freight brokers for information analysis of the offers on the example of one variant of interrelation between the participants in the chartering process. The use of the logit model may enable brokers to work out substantiated recommendations to the parties regarding the attainment of balance of interests under existing market conditions.

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