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DRY BULK FREIGHT MARKET RESEARCH BASED ON CORRELATION AND REGRESSION ANALYSIS

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Abstract. *The correlation and regression analysis applied to the freight rates demonstrates a fairly good results which is confirmed by the relevant estimates of the models. However, the impact of each determinant on the freight rates is not the same in the different time period. Moreover, it is important to focus on the certain segment of dry bulk freight market more accurately to obtain the mathematical model reflecting segment specific.*

The study is aimed to develop the methodological basic for applying the correlation and regression analysis to the freight rates on the example of Baltic Panamax Index.

Various linear regression model structures for freight rates have been proposed, with appropriate detailing of the underlying market determinants. It has been determined that each freight market segment is characterized a certain specificity of demand, as well as competition with other segments, these should be taken into account when building regression models. The ideas suggested have been applied to Panamax segment. The Panamax bulk carriers serve mostly the grain, coal and ore; thus, these three types of goods are included in the model as demand determinants. The correlation and regression analysis were used to establish and mathematically draw the dependence of freight indexes on the set of the major freight market determinants on the example of the Baltic Panamax Index.

The output shows the obtained regression model can be used to predict the Baltic Panamax Index. Based on the forecasting of considered factors - seaborn grain trade, seaborn ore trade, seaborn coal trade, Panamax bulk carriers' sector of merchant fleet, Panamax bulk carriers shipbuilding, Panamax bulk carriers scrapping, the values of the Baltic Panamax Index for following time points can be estimated.

Two approaches were considered – the regression analysis for original data and for logarithmically transformed data. Whether the first approach with the original data or the second one with the logarithmically transformed data is applied, the results approve the regression analysis use to establish the relationship between freight indexes (freight rates) and the set of the major freight market determinants.

Keywords: *freight rates, Panamax bulk carriers, model, market determinants, maritime transportation, forecast.*

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ДОСЛІДЖЕННЯ БАЛКЕРНОЇ СЕКЦІЇ ФРАХТОВОГО РИНКУ НА БАЗІ КОРРЕЛЯЦІЙНО-РЕГРЕСІЙНОГО АНАЛІЗУ

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Анотація. *Застосування кореляційно-регресійного аналізу для вивчення фрахтових ставок демонструє досить хороші результати, що підтверджується відповідними оцінками існуючих моделей. Однак вплив кожного фактора на фрахтові ставки по-різному в різні періоди часу. Крім того, у подібних дослідженнях важливо орієнтуватися на певний сегмент фрахтового ринку, щоб отримати математичну модель, що відображає специфіку цього сегмента. Метою дослідження є розробка методологічних засад застосування кореляційно-регресійного аналізу до фрахтових ставок на прикладі Baltic Panatax Index.*

Було запропоновано різні структури моделі лінійної регресії для фрахтових ставок з відповідною деталізацією ринкових детермінант, покладених у її основу. Визначено, що кожен сегмент фрахтового ринку має певну специфіку попиту, а також конкуренцію з іншими сегментами, що необхідно враховувати при побудові регресійних моделей. Запропоновані ідеї були використані до сегменту балкерів Panamax. Ця категорія суден обслуговує в основному зерно, вугілля та руду; таким чином, ці три типи вантажів включені у модель як детермінанти попиту. За допомогою кореляційно-регресійного аналізу встановлено та математично описано залежність фрахтових індексів від набору основних детермінант фрахтового ринку на прикладі Baltic Panatax Index.

Було розглянуто два підходи – регресійний аналіз вихідних даних та логарифмічно перетворених даних. Незалежно від того, застосовується перший підхід з вихідними даними або другий з логарифмічно перетвореними даними, результати підтверджують використання регресійного аналізу для встановлення взаємозв'язку між фрахтовими індексами (фрахтовими ставками) та набором основних детермінант фрахтового ринку.

Ключові слова: *фрахтові ставки, балкери Panamax, модель, ринкові детермінанти, морські перевезення, прогноз.*

Introduction. Maritime transportation is a basic for international trade and global economy. According to [1] «God must have been a shipowner. He placed the raw materials far from where they were needed and covered two thirds of the earth with water» (Erling Naess). Thus, the freight market changes should be taken into account while decision-making not only by shipping enterprises and carriers, but by exporters and importers as well. The freight rates tendency underlies the worldwide prices changes for almost all product and goods. Thus, it can be stated that freight market changes affect entire global economy whereas the global economy transformations and changes determine the corresponding changes in freight market. The relevant research concerns the shipping industry and traders around the world.

The dry bulk freight market concerns the transportation of dry bulk, the major bulks are iron ore, coal, grain, bauxite, alumina, phosphorite. As noted in [2], these commodities are vital to various industries and human life. Since the dry bulk freight market has a certain specificity, the corresponding study should take it into account. Thus, this paper is focus on dry bulk freight as an important segment of global freight market what is responsible for the great part of maritime transportation.

In order to forecast the freight rates tendency, it is important to understand what and how impact on freight market, and in what mathematics form it can be represented. Therefore, the study of methods that can help solve this problem, is an important and relevant for modern economic science as it was important fifty years ago.

Literature review. It should be noted, that the freight market research was conducted and presented in many studies. Nowadays, the main determinants of freight market are defined and described. M. Stopford [1] as the great and famous economist dealing with freight market set the fundamentals of maritime economics, including the understanding the nature of shipping circles. Many studies (for example, [2-6]) have used the principles defined by Stopford for more accurate consideration the certain aspects of freight market.

There two major mathematical techniques are used for understanding and exploring the freight rates changes: the correlation and regression analysis [7-11], the time-series analysis [12-16]. The first one relies on relationships between the freight rates and the determinants of supply and demand. The second one concerns the technical analysis and does not take into account the causes leading to freight rates changes. Its main result is the pattern of freight rates behavior. But it should be noted that they complement each other and together provide more opportunities for understanding and forecasting freight market, than individually.

Three freight market determinants – seaborn trade, fleet and bunker price – were included in the regression model in [7] to forecast the Baltic Dry Index as the key indicator of the dry bulk freight market. This approach corresponds to the Stopford’s point of view [1].

Some of studies focus on specific factors affect the freight rates based on correlation and regression analysis. Thus, in [17] the China Trade Volume was considered as the determinant of dry bulk freight market in regression equation. The proposed model in [18] incorporates the Chinese steel production, the dry bulk fleet development and a new composite indicator, the Dry Bulk Economic Climate Index (DBECI). Correlation analysis was applied for container shipping market regarding to freight rates in [19], the impact of China factor has been analyzed. The regression model reflecting relationships between freight rates and shipbuilding was provided in [20].

As a conclusion to the literature review, the correlation and regression analysis applied to the freight rates demonstrates a fairly good results which is confirmed by the relevant estimates of the models. However, the impact of each determinant on the freight rates is not the same in the different time period. Thus, the analogous studies should be carried out constantly in order to revise whether each determinant impact as it was or not.

Moreover, it is important to focus on the certain segment of dry bulk freight market more accurately to obtain the mathematical model reflecting segment specific, what was noted in [16; 21].

According with the foregoing **the study is aimed** to develop the methodological basic for applying the correlation and regression analysis to the freight rates on the example of Baltic Panamax Index.

Theoretical basic for model. To obtain the model that can help in understanding of how the changes in the main freight market determinants affect freight rates and predict their behavior based on the forecasts of these changes, the correlation and regression analysis should be applied.

The first stage of any research is to find an equation that reflects the relationship between one dependent variable and one or more independent variables. To achieve this, the relationship must be established logically and then mathematically based on correlation analysis.

The main factors that affect the dependent variable should be set and evaluated numerically. Evidently, there are special statistical methods that operate on the non-numeric variables and are used for the same objective. However, this topic focuses on the correlation and regression analysis due to the nature of the main factors affecting the freight rates.

As it was mentioned and characterized above, the following factors can be defined as a key freight market determinant (Fig.1). They can be combined in different ways and with different degrees of detailing according to the research methodology. However, the greater the degree of aggregation of information, the more general the results. What does it mean?

The main general indicator of freight market (dry section) is Baltic Dry Index that reflects the market situation in general based on the freight rates of key freight market segments related to the main categories of bulk carriers. Thus, the Baltic Dry Index level and direction of its change helps to understand what the demand and supply ratio is. Following this way, to obtain the regression model it should be considered:

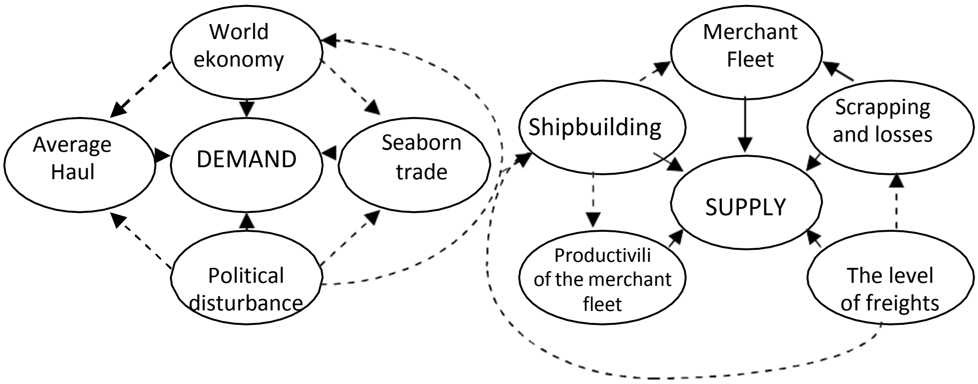

Fig.1. The main factors affecting supply and demand in the freight market

Source: Designed by authors based on [1-4]

The dependent variable Y − Baltic Dry Index;

The independent variables

X_1 – demand (seaborn dry cargo trade);

X_2 – supply (bulk carriers).

The linear regression model in this case is

$$Y = b_1 \cdot X_1 + b_2 \cdot X_2 + a. \quad (1)$$

Another approach to this problem is to use non-integrated information related to demand and/or supply. For example, the demand for each main dry cargo, such as coal, grain, and ore can be considered separately. In this case:

The dependent variable Y − Baltic Dry Index;

The independent variables

X_1 – seaborn grain trade;

X_2 – seaborn ore trade;

X_3 – seaborn coal trade;

X_4 – supply (bulk carriers).

The linear regression model is

$$Y = b_1 \cdot X_1 + b_2 \cdot X_2 + b_3 \cdot X_3 + b_4 \cdot X_4 + a. \quad (2)$$

The next step to build the model is to use more detailed information about supply. Thus, it can be considered that the main determinants of supply are merchant fleet, scrapping, and shipbuilding. According to this approach:

The dependent variable Y − Baltic Dry Index;

The independent variables

X_1 – seaborn grain trade;

X_2 – seaborn ore trade;

X_3 – seaborn coal trade;

X_4 – bulk carriers' sector of merchant fleet;

X_5 – bulk carriers scrapping;

X_6 – bulk carriers shipbuilding.

The linear regression model in this case is

$$Y = b_1 \cdot X_1 + b_2 \cdot X_2 + b_3 \cdot X_3 + b_4 \cdot X_4 + b_5 \cdot X_5 + b_6 \cdot X_6 + a \quad (3)$$

It should be noted that the above is associated with the general indicator of the freight market (dry section). Thus, the proposed theoretical models focus on the behavior of freight market (dry cargo section) as a whole. But, as it is known, the freight market includes the sum of «local markets» in accordance with relevant segmentation (see above). Thus, the research interest is to obtain the models mathematically describing the dependence of freight rates on the main determinants associated with a particular local market (market segment).

At first sight it seems obvious what to consider, as the detailed supply in this case – merchant fleet, scrapping, shipbuilding related to each segment. But it is only at the first sight. In fact, some of the segments are connected, among other things, by the influence of each other's determinants. For example, the Panamax bulk carriers and Handymax bulk carriers compete in some situation due to the possibility to serve the same cargo flow. Evidently, each category of bulk carriers is associated with relevant distances of transportation and cargo party volumes. Nevertheless, the mentioned vessels may be considered as a substitute by the shippers, especially in the «low market», when carriers are ready for any offers and any terms, not even a full load. In this case, it is necessary to establish the freight market segments that are similar in the mentioned context. It has to be considered in more detail to explain the pattern of relevant study. The diagrams below (Fig. 2) represent the shares of categories of vessels by the main seaborn goods transportation.

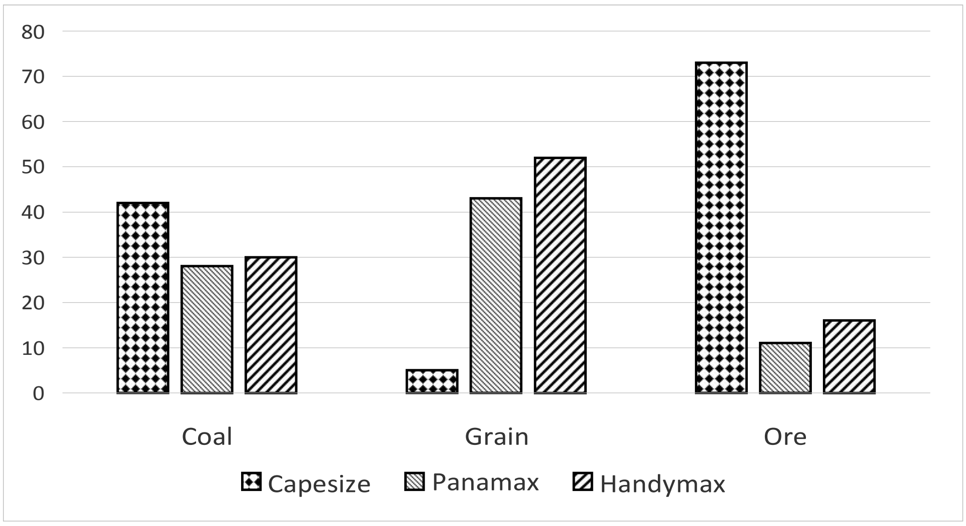

Fig. 2. Shares of categories of vessels by the main bulk goods transportation

Source: Designed by authors based on data [23]

These charts, for example, show that the greatest shares in grain transportation belong to Panamax and Handymax. In turn, Capsize accounts for an insignificant volume of grain. It can be explained by the specific requirement for grain transportation and these categories of vessels can be defined as «close» in the considered context. Thus, to build the model for Handymax freight rates the main determinants of Panamax segment should be taken into account.

The same reasoning should be applied to all segments. In this way, the basic for regression model's structures should be formed.

Below we present the obtained regression model on the example of the Panamax segment.

Panamax segment case study

The ideas suggested above have been applied to Panamax segment. According to [7] the Panamax bulk carriers serve mostly the grain, coal and ore (Fig. 3), thus these three types of goods should be included in the model as demand determinants.

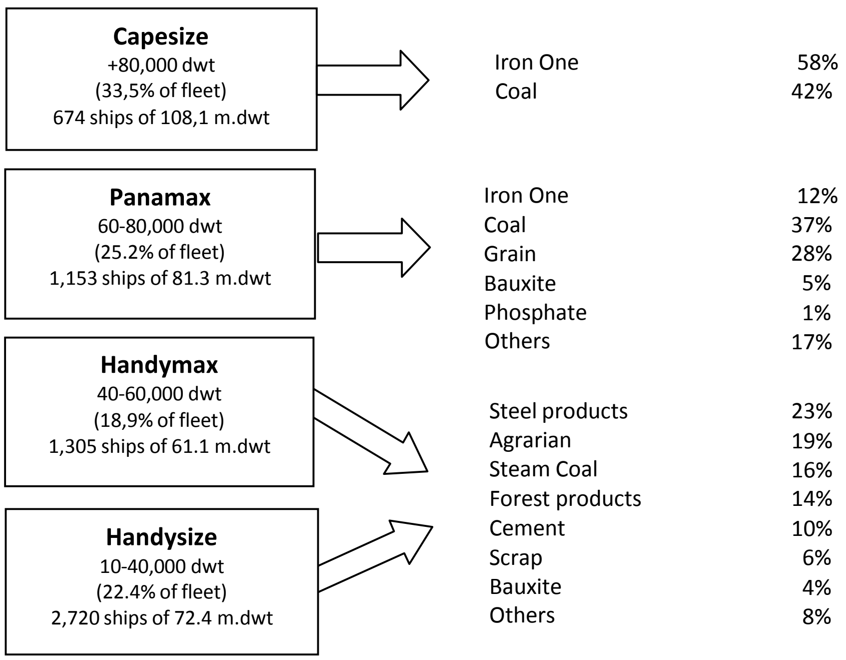

Fig.3. Dry bulk fleet overview

Source [7]

As a variant of model in theoretical terms the following is proposed:
The dependent variable Y –Baltic Panamax Index;
The independent variables X_1 – seaborn grain trade,

X_2 – seaborn ore trade;

X_3 – seaborn coal trade;

X_4 – Panamax bulk carriers' sector of merchant fleet,

X_5 – Panamax bulk carriers shipbuilding,

X_6 – Panamax bulk carriers scrapping.

The linear regression model is

$$Y = b_1 \cdot X_1 + b_2 \cdot X_2 + b_3 \cdot X_3 + b_4 \cdot X_4 + b_5 \cdot X_5 + b_6 \cdot X_6 + a. \quad (4)$$

Fig. 4 demonstrate the results of regression analysis carried out in Statistica.

Statistic	Summary Statistics; DV: Panamax Baltic Index Value
Multiple R	0,884926801
Multiple R?	0,783095443
Adjusted R?	0,674643164
F(6,12)	7,22064537
p	0,00193454046
Std.Err. of Estimate	1005,93135

Regression Summary for Dependent Variable: Panamax Baltic Index
R= ,88492680 R2= ,78309544 Adjusted R2= ,67464316
F(6,12)=7,2206 p<,00193 Std.Error of estimate: 1005,9

N=19	b*	Std.Err. of b*	b	Std.Err. of b	t(12)	p-value
Intercept			-4689,85	4847,277	-0,96752	0,352379
Grain	1,59637	1,559318	31,27	30,541	1,02376	0,326144
Ore	0,39395	2,306304	1,91	11,168	0,17081	0,867217
Coal	2,92065	1,200905	20,39	8,385	2,43204	0,031614
Fleet	-5,23194	1,237933	-45,15	10,683	-4,22635	0,001176
New ships	-0,39234	0,331427	-25,92	21,898	-1,18380	0,259414
Scrapping	0,16403	0,345354	25,40	53,477	0,47496	0,643344

Effect	Analysis of Variance; DV: Panamax Baltic Index Sums of Squares	df	Mean Squares	F	p-value
Regress.	43839334	6	7306556	7,220645	0,001935
Residual	12142774	12	1011898		
Total	55982109				

Fig. 4. Results of regression analysis for Baltic Panamax Index

Source: Designed by authors

The obtained model

$$Y = 31,3 \cdot X_1 + 1,9 \cdot X_2 + 20,4 \cdot X_3 - 45,1 \cdot X_4 - 25,9 \cdot X_5 + 25,4 \cdot X_6 - 4689,8 \quad (5)$$

The results in the context of quality and reliability of the gained model have to be evaluated. The p-value in the analysis of variance (ANOVA) table is less than 0,05 (p = 0,001935).

The signs of coefficients $b_1, b_2, b_3, b_4, b_5, b_6$ are as expected. This can be further explained. It is clear that the more ships enter the market, the greater supply. As a consequence, the freight rates are declining. Thus, the sign of relevant coefficient b_5 is «-». And vice versa, the more ships are scrapped, the less supply, and freight rates grow. This is reflected by the sign «+» of the corresponding coefficient b_6 . The same reasonings can be given for other coefficients of the model.

The R^2 = 0,78 indicates that the obtained model explains 78 % of the variability in Panamax Baltic Index. The correlation coefficient R = 0,88 indicates a fairly strong relationship between Panamax Baltic Index and the set of considered determinants.

Although P-value for some coefficients is greater than 0,05, the above gives grounds to state that there is a statistically significant relationship between the Panamax Baltic Index and the set of considered determinants at the 95 % confidence level.

According to the gained regression model the theoretical Panamax Baltic Indexes have been calculated and are presented on the graphic (Fig. 5) in comparison with the actual indexes. As it can be seen, the model-based indexes may be interpreted as similar to actual ones.

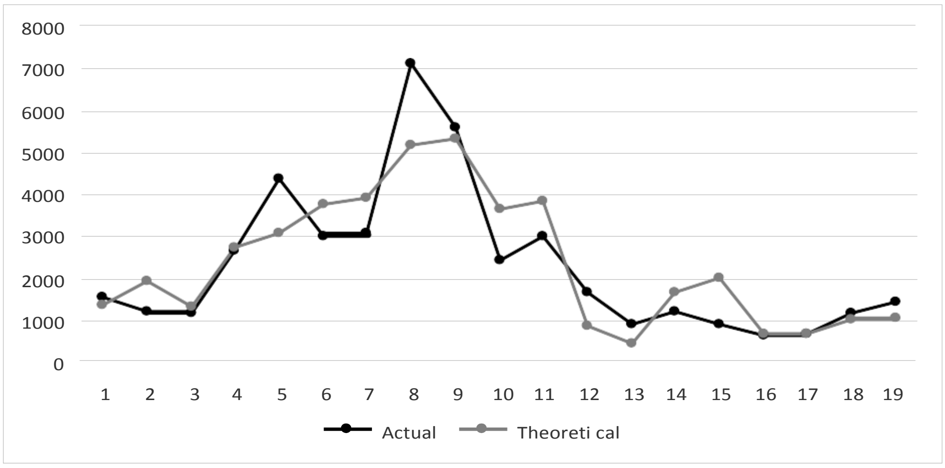

Fig. 5. Comparison the actual Baltic Panamax Indexes and model-based ones

Source: Designed by authors

It should be noted, for some reasons time series data related to econometric studies (including regression analysis) are transformed into logarithms. The main reason is that logarithms stabilize a non-stationary variable. Moreover, this approach helps to reduce the impact of atypical cases in data (anomalous points) on the regression model and increase its reliability. The reverse transformation is carried out by the exponential transformation Exp(Y).

The results of the same regressi-on analysis based on the logarithmic transformation are presented below (Fig. 6).

The fitted model is:

$$Ln(Y) = -0{,}35 \cdot \ln(X_1)+3{,}017 \cdot \ln(X_2)+2{,}9 \cdot (X_3)-5{,}35 \cdot \ln(X_4)- -0{,}108 \cdot \ln(X_5)-0{,}143 \cdot \ln(X_6)+3{,}05. \quad (6)$$

	Regression Summary for Dependent Variable: Panamax Baltic Index R= ,96644563 R2= ,93401715 Adjusted R2= ,90102573 F(6,12)=28,311 p<,00000 Std.Error of estimate: ,21721					
N=19	b*	Std.Err. of b*	b	Std.Err. of b	t(12)	**p-value**
Intercept			3,05822	5,644301	0,54182	0,597857
Grain	-0,13804	0,644090	-0,35813	1,671051	-0,21431	0,833902
Ore	1,82018	0,886728	3,01739	1,469965	2,05269	0,062573
Coal	1,24316	0,828369	2,90220	1,933846	1,50074	0,159269
Fleet	-3,16716	0,778446	-5,35097	1,315197	-4,06857	0,001558
New ship	-0,10129	0,162941	-0,10802	0,173768	-0,62165	0,545799
Scrapping	-0,32420	0,161570	-0,14381	0,071667	-2,00658	0,067866

Statistic	Summary Statistics; DV: Panamax Baltic Index **Value**
Multiple R	0,966445628
Multiple R2	0,934017152
Adjusted R2	0,901025728
F(6,12)	28,3109075
p	0,00000205687775
Std.Err. of Estimate	0,217205245

	Analysis of Variance; DV: Panamax Baltic Index				
Effect	Sums of Squares	df	Mean Squares	F	**p-value**
Regress.	8,013932	6	1,335655	28,31091	0,000002
Residual	0,566137	12	0,047178		
Total	8,580069				

Fig. 6. Results of regression analysis (log-log) for Baltic Panamax Index

Source: Designed by authors

The p-value in the analysis of variance (ANOVA) table is less than 0,05 (p = 0,000002) and less than in previous case (p = 0,001935), thus, the confidence level of the model has become higher.

The R^2 = 0,93 indicates that the obtained model explains 93 % of the variability in Baltic Panamax Index. The correlation coefficient R = 0,96 indicates a strong relationship between Baltic Panamax Index and the set of considered determinants.

In this way it can be stated that the quality and reliability of the gained model is indeed higher than the logarithmically transformed data. The corresponding graphs clearly demonstrate and confirm this statement (Fig. 7).

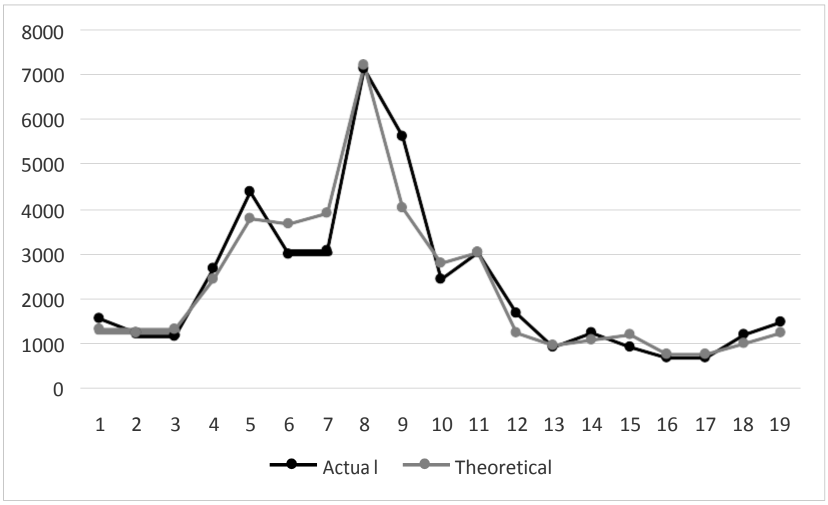

Fig.7. Comparison the actual Panamax Baltic Indexes and theoretical ones based on the logarithmically transformed data

Source: Designed by authors

In any case whether the first approach with the original data or the second one with the logarithmically transformed data is applied, the results approve the regression analysis use to establish the relationship between freight indexes (freight rates) and the set of the major freight market determinants.

Conclusion. In this study the correlation and regression analysis were used to establish and mathematically draw the dependence of freight indexes on the set of the major freight market determinants on the example of the Baltic Panamax Index.

The output shows the obtained regression model can be used to predict the Baltic Panamax Index. Based on the forecasting of considered factors − seaborn grain trade, seaborn ore trade, seaborn coal trade, Panamax bulk carriers' sector of merchant fleet, Panamax bulk carriers shipbuilding, Panamax bulk carriers scrapping, the values of the Baltic Panamax Index for following time points can be estimated.

It should be noted that the proposed model can be improved through extension. For example, the bunker price as the additional deter-minant can be included. The average haul may be one other determinant as well.

The more factors affecting the freight rates and relevant indexes are included in the regression model, the more precise model is.

At the same time each additional variable requires the additional retrospective data and the forecasting in order to use the model to predict freight rates behavior. Although no one will take responsibility for predict-ting the freight rates behavior, the different theoretical basics and methods should be applied to understand their possible direction of change.

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