Mechanisms to Enhance the Efficiency of Maritime Container Traffic Through "Odessa" and "Chernomorsk" Ports in the Balancing of Portfolios

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Abstract. Approaches to development classification mechanisms in condition of projects of marine container transportations by means of artificial neural networks are investigated. It is established that growth rates of transportation volumes not linearly depend on a ratio of volumes of import and export cargoes with obviously expressed maximum. Its offered mechanism of efficiency increase of the companies by a choice of a rational ratio volumes of import and export cargoes on the basis of a neural network assessment of the previous activity results of the company and its competitors which, unlike known mechanisms, provides possibility of an effective assessment of the situation which developed in the market of freight transportation.

Keywords: Management of projects · Sea transport · Classification
Neural network

1 Introduction

Maritime transport provides significant amounts of internal and external freight over long distances, it is an important component of the economy of coastal and maritime countries. In a competitive transport companies are faced with the problem of choosing an effective business acquisition strategy that provides adequate load vessels at admissible idle times.

The project management knows the position of the connection between resource efficiency and uniformity of loading. The high cost of ships and their operation generates interest maritime transport companies to the fullest use of available resources through the formation of portfolios of orders for shipping, which will provide a possible continuous and uniform loading of vessels [4, 5]. In addition in order to increase profits, such as loading of vessels can significantly reduce the additional costs associated with the peculiarities of navigation and safety of maritime transport, for example, caused by the need to idle, as the vessel is anchored or admission to under loading ship ballast water.

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1.1 Relation of Highlighted Issue to Scientific and Practical Tasks

In the simplest case, the condition of continuous and uniform loading of vessels is achieved in a situation where in each port of loading and unloading cargo discharged is replaced by an equivalent volume, weight and requirements for transporting cargo for delivery to the ports on the route of the vessel. Unfortunately, such a balancing circuit is often unachievable due to the impact of a number of factors, such as competition between carriers, seasonal traffic fluctuations in the imports and exports volume of the countries, the orientation of certain ports for certain types of goods, and etc. As a consequence, marine transport companies have to contend with incomplete congestion of vessels, lost profits and the risk of possible loss of the transport market [7, 9].

The aim of the article: research of load balancing indicators for resources transportation companies and the development of mechanisms to improve project management effectiveness of marine transport by improving the balance of the load on the resources in accordance with the state of each company and the transport market as a whole.

1.2 Analysis of Recent Researches and Publications

The methodology of the research. To achieve this goal will perform data collection based on the results of marine transport companies work in "Odessa" and "Chernomorsk" ports, to analyze the data to identify the relationships between levels of balanced portfolio of orders and the growth in maritime freight transport methods of comparative analysis, time series analysis, correlation and regression analysis, the method of neural models.

Statement of the main research material. Delivery of goods through "Odessa" and "Chernomorsk" ports provided by shipping lines: CMA, ACOL, ANL, APL, ARKAS, BUL, COSCO, CSCL, ECM, EMES, EVERGR, HJS, HLC, HMM, KLINE, MAE, MISC, MOL, MSC, NOR, NYK, OOCL, PIL, UASC, WHL, YMG, ZIM and others [8–12]. Due to the significant volume of initial data on volumes of freight traffic through "Odessa" and "Chernomorsk" ports on mentioned shipping lines such data are represented in graphs (Fig. 1 – cargo turnover data; Fig. 2 – data on the ratio of import and export cargo volume).

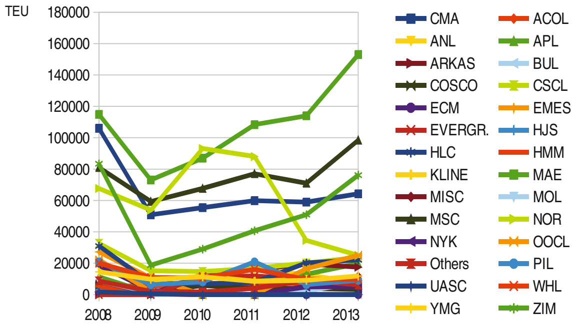

Fig. 1. The volume of freight traffic (in TEU) through "Odessa" and "Chernomorsk" ports along the lines of (2008–2013)

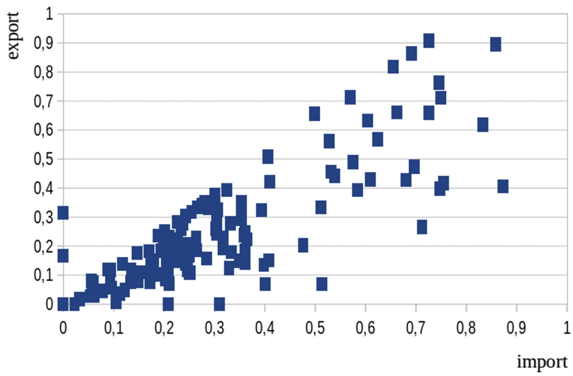

Fig. 2. Allocation of import and export cargoes (TEU) through "Odessa" and "Chernomorsk" ports (2008–2013)

As is evident from Fig. 1, the volume of container shipping for the past few years in general increased slightly – despite the considerable drop of transportation in 2009 caused by global crisis 2008–2009. After a recession in 2009 traffic volumes generally rose slightly, and according to the data for 2013 almost reached pre-crisis levels.

2 The Main Objectives of the Research and Their Meaning

Taking into account available data project management efficiency of each company can be assessed through growth indicator volume transportation. Total volume of traffic of each company is:

$$V_i = \sum_{j=s}^{f} v_{i,j}, \tag{1}$$

where: f, s – year end and beginning of the period, respectively; $v_{i,j}$ – the volume of traffic "i" company in the "j" year.

Then, the average annual traffic growth of each company for a certain period can be calculated as the ratio of in the relative increment in traffic volume during that period to a long period in years:

$$k_i = \frac{v_{\mathrm{i,f}} - v_{\mathrm{i,s}}}{(f - s)V_i}, \tag{2}$$

where: k_i – growth coefficient i company; $v_{i,f}$ – the volume of traffic at the end of the period; $v_{i,s}$ – the volume of traffic at the end of the period.

Under the impact on traffic volumes of random factors (as is the case here), the average annual traffic growth rate for each company for the analyzed period can be more accurately expressed by the coefficient a of the linear regression $y = ax + b$:

$$a_i = \frac{\sum_{j=1}^{m} v_{i,j} * \sum_{j=1}^{m} j - m * \sum_{j=1}^{m} j * v_{i,j}}{\left(\sum_{j=1}^{m} v_{i,j}\right)^2 - m * \sum_{j=1}^{m} v_{i,j}^2}, \quad (3)$$

where: a_i – the growth factor of traffic with linear regression, j – the position of the indicator of traffic volumes $v_{i,j}$ in the time series, m – the number of elements of the time series.

The calculated gain coefficients traffic volumes for expression (2) are shown in Table 1, for expression (3) – in Table 2. As can be seen from Fig. 1 and Tables 1, 2, despite the unfavorable conjuncture in 2009, some companies were able to significantly increase the volume of traffic. Among the leaders highlighted Maersk company (shipping line MAE), which is not only the largest carrier, but also has a high average annual growth of 8.8% (Table 2) and absolute growth of 33.2% (Fig. 1). Impressive results have also demonstrated the company Mediterranean Shipping Company (MSC line, respectively, 5.0% and 21.6%) and the company ZIM (eponymous line). The latter, although it showed a slight decline in general, showed the best among large companies after the collapse of the growth rate of 2009.

Table 1. The coefficients of the average annual traffic growth for expression (2)

№	Line	Grow rate	№	Line	Grow rate
1	ACOL	−0,106	15	KLINE	−0,129
2	ANL	0,089	16	MAE	0,059
3	APL	0,163	17	MISC	0,123
4	ARKAS	0,189	18	MOL	−0,046
5	BUL	0,265	19	MSC	0,039
6	CMA	−0,990	20	NOR	−0,118
7	COSCO	−0,103	21	NYK	−0,426
8	CSCL	−0,073	22	OOCL	0,042
9	ECM	−0,719	23	PIL	−0,164
10	EMES	−0,719	24	UASC	−0,751
11	EVERGR	0,224	25	WHL	−0,132
12	HJS	−0,842	26	YMG	−0,040
13	HLC	−0,092	27	ZIM	−0,024
14	HMM	0,149	28	Others	−0,081

In order to identify efficiency of resource management consider the connection between the import and export cargo volume (Fig. 2). In the most simple case, this link can be expressed in terms of linear correlation coefficient [1–3] calculated between the amount of import and export goods for every single company. Company's results of correlation calculations are shown in Table 2 (in the calculation of available authors full data have been used for months).

Table 2. The coefficients of the average annual traffic growth for expression (3)

№	Line	Grow rate	№	Line	Grow rate
1	ACOL	0,099	15	KLINE	−0,113
2	ANL	0,306	16	MAE	0,088
3	APL	0,300	17	MISC	0,191
4	ARKAS	0,386	18	MOL	−0,019
5	BUL	−0,854	19	MSC	0,050
6	CMA	−0,078	20	NOR	−0,131
7	COSCO	−0,055	21	NYK	−0,331
8	CSCL	−0,039	22	OOCL	0,150
9	ECM	−0,761	23	PIL	−0,109
10	EMES	−0,761	24	UASC	−0,772
11	EVERGR	0,312	25	WHL	−0,109
12	HJS	−0,803	26	YMG	−0,047
13	HLC	−0,008	27	ZIM	−0,024
14	HMM	0,217	28	Others	−0,041

As can be seen from Tables 1 and 2 growth data for individual companies have significant discrepancies. Further we will use the data from Table 2, which, unlike Table 1, take into account the traffic volumes for all the years of the period, and therefore more accurately reflect the growth trends in the volume of traffic companies.

As can be seen from Fig. 1 and Table 2, between the volume of import and export cargo takes place significant correlation due to aspiration provide company managers possible more complete and balanced load of vessels. Obviously, this regularity is achieved by the replacement of discharged goods at ports (most of which – import) taking on board cargo (export).

Nevertheless, individual companies, this correlation is far enough from 1.0. For example, for a large and rapidly increase volumes of traffic, Maersk correlation coefficient of 0.959, this corresponds to the level of the eighth balanced load on resources of the positions among more than 27 companies that provide transportation through "Odessa" and "Chernomorsk" ports. Similar deviations are reviewed on several other companies, which in this case indicates a mixed growth dependence on the level of traffic load balanced resource.

Table 2 shows that Maersk Company (MAE line) in terms of growth takes only eighth position, which indicates the existence of reserves for future growth. The position of Maersk becomes even more significant because companies with smaller volumes of freight traffic and, consequently, larger relative overhead costs, able to get ahead of Maersk in terms of growth.

In order to determine the relationship between the values of uniformity level of loading resources and value of the relative growth of the company's share in cargo transportation, consider the relationship between the growth in traffic volume and the companies defined above correlation coefficients reflecting the regularity loading of resources (Table 3, Fig. 3). Figure 3 also shows the linear regression (dashed line). As can be seen from the figure, "a" coefficient of linear regression equation $y = ax + b$ is

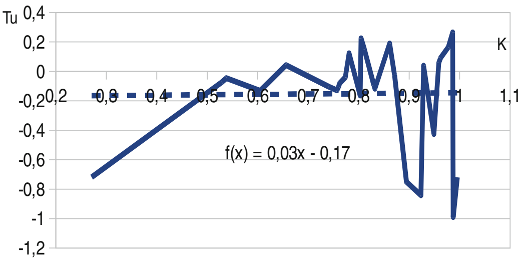

Fig. 3. Dependence of the rate of the relative growth companies *Tu* from the uniform level of loading resources *K* (dotted trend line set)

Table 3. The coefficients of the linear correlation between the volume of import and export cargo

№	Line	Correl.	№	Line	Correl.
1	ACOL	0,962	15	KLINE	0,757
2	ANL	0,977	16	MAE	0,959
3	APL	0,861	17	MISC	0,781
4	ARKAS	0,986	18	MOL	0,538
5	BUL	0,987	19	MSC	0,929
6	CMA	0,760	20	NOR	0,832
7	COSCO	0,740	21	NYK	0,949
8	CSCL	0,529	22	OOCL	0,656
9	ECM	0,271	23	PIL	0,803
10	EMES	0,995	24	UASC	0,895
11	EVERGR	0,805	25	WHL	0,605
12	HJS	0,923	26	YMG	0,773
13	HLC	0,830	27	ZIM	0,871
14	HMM	0,811	28	Others	0,762

0.03, which generally indicates a slight increase with the growth of freight traffic load balanced.

In order to detect changes in traffic volume trend performed polynomial smoothing of rates depending on the company's growth from a uniform level of resource utilization. Smoothing results are presented in Fig. 4. A polynomial curve flattening is designed for smoothing exponent 3. Here, the trend line indicates that increasing resource utilization level of uniformity results in a corresponding significant change in the rate of growth of the company's operations. In the low level of resources balanced load values (here – up to the value of the correlation coefficient of 0.7) achieved significant growth, and above – a significant drop of transportation volumes. Polynomial fourth-order gives close to the Fig. 4, curve smoothing, which confirms the convex nature of the trend distribution with one peak.

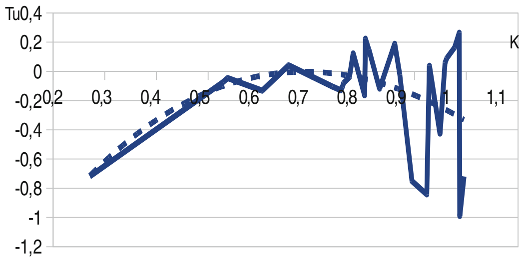

Fig. 4. The results of the smoothing depending on the relative rates of growth of the company *Tu* from the uniform level of loading resources *K* (third-degree polynomial trend line set a dotted line)

Considering the significant fluctuations in traffic volumes and, above all, their import component, in order to represent the company's previous history in the traffic market, it is important to clear the performance of companies from changes caused by fluctuations in total traffic volumes. This can be achieved most simply by calculating the correlation coefficient between the total volumes of traffic and the company's share (including import and export shipments). Such data are presented below: for import and export operations (Fig. 4), separately for import (Fig. 5) and separately for export (Fig. 6) operations.

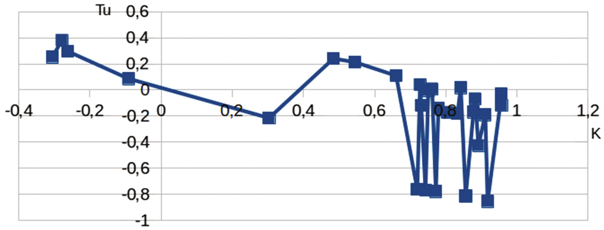

Fig. 5. Dependence of the rates of relative growth of companies on the consistency of the volumes of import traffic

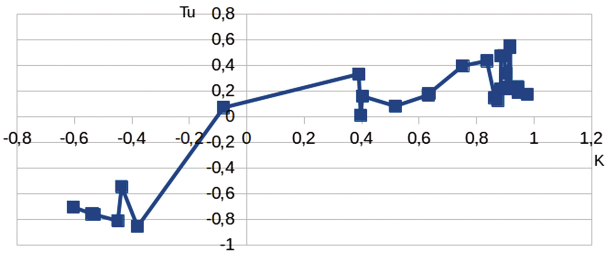

Fig. 6. Dependence of the rates of relative growth of companies on the consistency of the volumes of export traffic

As can be seen from Fig. 5, with a general drop in the volume of traffic by import, the growth rates of companies are also decreasing, thus the growth of companies is in a negative correlation with the company following the current market trends. Similarly, from Fig. 6, with the overall growth in the volume of traffic by export, the growth rates of companies also increase, so the growth of companies is in a positive correlation with the company following the current market trends. At the same time, the correlation between traffic volumes and growth rates is insignificant and is 0.24. Obviously, differently directed dependencies are a consequence of a significant excess of imports over exports to these ports.

The obtained results allow us to consider the problem of finding the optimum ratio of volumes received/discharged as the problem of maximizing on a convex curve, and the task of improve management efficiency – as the task of identifying dependencies, ensuring high growth rates in the most successful from this point of view of companies.

Mathematical formulation of this problem can be worded as follows: it is necessary to find a value for the level of load evenly on resources which in the current market position and market conditions will maximize the value of the index rate of growth of the company. This problem can be solved as a problem of clustering and classification [13, 14].

Based on the available data for each prediction cargo turnover in some of the following moment in time $n + 1$ can be performed. This forecast can be viewed as a function of the time series of indicators of its previous cargo turnover viewed through the ports, many companies state, working in these ports, and the ratio of values of import and export goods (see Fig. 4).

$$v_{i,n+1} = G\left(V_{i,n}, S_n, x_{n+1}\right), \tag{4}$$

where: x_{n+1} – expected ratios of values of import and export cargo at time $n + 1$.

Imagine the state of the "i" – company at the time "n" as a function of time series the values of achieved cargo turnover:

$$s_{i,n} = g\left(v_{i,s}, v_{i,s+1}, \ldots, v_{i,s+n}\right), \tag{5}$$

where: g – calculation function state – cargo turnover (see (1)).

The states of all companies can be represented as a matrix:

$$S_n = \left\{s_{1,n}, s_{2,n}, \ldots, s_{m,n}\right\}, \tag{6}$$

The time series of cargo turnover – as a matrix:

$$V_{i,n} = \left\{v_{i,s}, v_{i,s+1} \ldots, v_{i,s+n}\right\}, \tag{7}$$

To substitute (5) and (6) in (4), we find the expected cargo turnover of each company at some assignment of ratios of import and export cargo.

The problem of calculating the forecast values can be solved by means of an artificial neural network with back-propagation errors. The number of network inputs should be chosen according to the number of time series values of n ($n - 1$ value of a time series and one coefficient value of import and export cargo relations), the last value of the time series in the training must be seen as a prediction result. With a significant number of time-series elements can be introduced horizon cyclically shifted training the time series. Solution of the problem is a value ratio of received and discharged cargoes, which ceteris paribus will provide the greatest increase in cargo turnover.

Popular neural networks are networks with back-propagation errors. In the simplest case, a single-layer network its output "*s*" can be represented by a vector of input signals and "*x*" coefficient vector "*k*" as:

$$s_c = f\left(\sum_{i=0}^{n} x_i k_{i,c} + b_{i,c}\right), \tag{8}$$

where: s_c – the output status for the class "*c*"; x_i – *i* value of the parameter at the input; $k_{i,c}$ – transfer coefficient of "*i*" entry on "*c*"-output; "*f*" – the activation function; $b_{i,c}$ – displacement.

As can be seen from (4), a single-layer network is able to reproduce the linear dependence of the output values from the input and their subsequent transformation activation function. In the case of more complex dependencies apply multilayer network. For a two-layer network output value s:

$$s_c = f\left(\sum_{j=0}^{n}\left(k_{j,c} f\left(\sum_{i=0}^{m} x_i k_{\mathrm{j,i}} + b_{\mathrm{j,i}}\right)\right)\right), \tag{9}$$

where: $k_{\mathrm{j,c}}$ – transmission coefficient intermediate "*j*" element of the intermediate layer on "*c*" element output; x_i – "*i*" value of the parameter at the input; $k_{j,i}$ – transmission ratio "*i*" input of the input layer to the intermediate "*j*"-input.

Test ANNs trained on known data sets (Figs. 1 and 2, Table 2) has been implemented with the aim of testing the quality of cargo turnover of volumes forecasting growth.

Justification of results. The results predict cargo turnover of individual companies received for fixed values of the correlation of import and export of goods are shown in Fig. 7. In Fig. 6 shows the results of simulation of the relative of volumes cargo turnover in some companies in 2013 with different ratios of volumes import and export cargo.

From the modeling results can be seen that generally increase in the level of resources provides balanced load cargo handling increase growth (Fig. 7).

At the same time, for ACOL lines, MAE, MSC growth reserves are almost exhausted (Figs. 8 and 9), which clearly indicates the high quality of management in these companies. For other companies, the growth of reserves are significant.

The selection task factor of a parity of import and export goods, providing the greatest increase in competition between companies can be resolved by known methods of research.

In general, testing results have shown the ability to improve maritime transport companies' management.

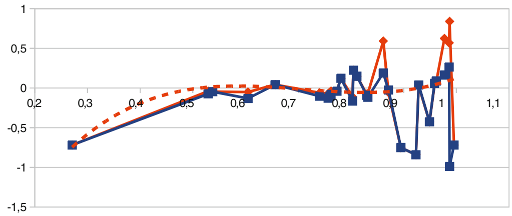

Fig. 7. The results of forecasting for companies that constantly were present on shipping market via the “Odessa” and “Chernomorsk” ports (trend line shown in phantom)

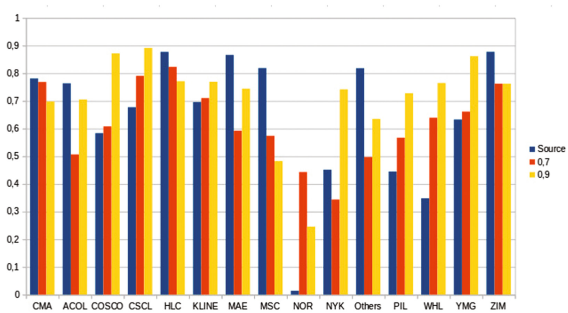

Fig. 8. Forecast of the relative traffic volumes for 2013 through the “Odessa” and “Chernomorsk” for some companies at different values of the correlation of “imports” and “exports” amounts (for testing)

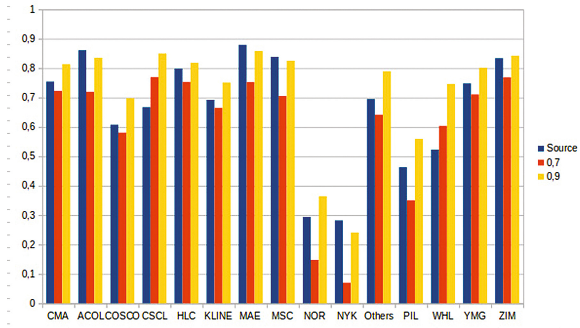

Fig. 9. Forecast of the relative traffic volumes for 2014 through the “Odessa” and “Chernomorsk” for some companies at different values of the correlation of “imports” and “exports” amounts

3 Conclusion

The obtained results show the possibility of increasing the effectiveness of management of marine transportation in the form of the portfolio orders to the best, in terms of growth in the volume of transported goods, by the relations “of import” and “export” of goods.

Obtained results may be used in the formation and transport companies balancing portfolios of projects, as well as in dealing with other project management tasks for which the available data on the levels of uniformity of loading of resources and associated performance of the company.

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