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Development of Logistics Routes of Intermodal Transport in the Eastern Adriatic

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ABSTRACT

The subject of this paper is the assessment of the development of logistics routes in intermodal transport in the Eastern Adriatic, measured through container throughput in the seaports of Koper, Rijeka and Bar (as dependents variables in our hypothetical model). The aim of this paper is to show how certain significant economic and logistical factors (marked as independent variables) affect the stated dependent variable. The paper investigates the impact assessment of three independent variables: a) seaport connectivity measured by the LSCI (Liner Shipping Connectivity Index), b) seaport development and c) seaport connectivity with dry ports (intermodal terminals, i.e. economic centers) in the hinterland. The starting point is the hypothesis that the development of logistics routes of intermodal transport is proportionally influenced by all three mentioned factors (independent variables). The paper uses data collected on the basis of assessments of 180 surveyed experts from the subject area from Southeast Europe, which are given on the basis of official statistics on container traffic throughput the observed seaports and the Liner Shipping Connectivity Index in the period 2006-2020, as well as the second and third independent variables. All data were processed by the method of multiple linear regression analysis, which showed predictions of the movement of the dependent variable depending on the projected values of the independent variables. The results have confirmed the validity of the hypothesis and, consequently, the selected factors have the high influence to the development of logistics routes of intermodal transport in the analyzed ports.

INTRODUCTION

Maritime transport experienced a revolution in the mid-1960s with the invention of the container unit for the transport of goods. Since then, intermodal transport of all types of cargo has been continuously growing, namely, container transport of goods by land and sea has risen exponentially (De Langen and Sharypova, 2013). Modern logistics systems in seaports integrate the organizational functions of marketing and management, through which the process of cargo handling in primary and accompanying logistics flows is carried out (Bichou and Gray, 2004; Draskovic, 2019). In the situation when there is a heavy international competition, quality performance and low costs of all logistics activities are essential for the business success of seaports (González and Trujillo, 2009). B. Beskovnik (2010) points out to the need for cooperation of all entities and factors of within the intermodal chain, which refers to the ports of the Eastern Adriatic. Underdeveloped intermodal infrastructure (Baran and Górecka, 2019) and lack of investment are the main limiting factors for the development of the considered seaports. The former relates primarily to railway and road infrastructure (Vlahinic-Lenz et al., 2018), which connects intermodal hubs, as well as the deficit of intermodal terminals, which operate using limited equipment and space. Also, specialized staff and management skills are in short supply.

One of the basic conditions for the development of a logistics route in intermodal transport is the existence of dry ports in the hinterland of seaports (Roso, 2013). The increase in freight transport by sea generates an almost proportional increase in the land flow of goods. It has to be accompanied by the development of dry ports (Bask et al., 2014). The concept of a dry port (which can be more or less remote) is based on the fact that it is connected to the seaport by rail.

In this paper, the economic modeling was applied to the three selected the Eastern Adriatic seaports (Koper, Rijeka and Bar), in which we conducted a field survey (the samples of 50 respondents in each of these seaports). The aim of the survey was to obtain valid responses, based on the perception of 180 respondents about the level of development of logistical routes of intermodal transport in the three mentioned seaports, as well as about the possible positive impacts of the selected factors. In this sense, we have obtained the responses to the following research questions:

- What is the level of development of logistical routes of intermodal transport in the three mentioned seaports? (the dependent variable in the model);
- What is the positive impact of LSCI on the development of logistical routes of intermodal transport in the three mentioned seaports? (the first independent variable in the model);
- What is the positive impact of the development of the seaport on the development of logistical routes of intermodal transport in the three mentioned seaport? (the second independent variable in the model), and
- What is the positive impact of connection of the seaport with the network of intermodal terminals in the hinterland (the third independent variable in the model).

In addition to theoretical considerations, and in order to verify the initial and auxiliary hypotheses, we have used numerical tables, graphical and statistical analysis and regression multiple linear analyses applied to the data obtained in the course of surveying 180 respondents.

1. THEORETICAL APPROACH

Before explaining our hypothetical model, we will point out an interesting theoretical idea (Draskovic, 2019), which with a good political will, economic logic and institutional elaboration (harmonization) could be applied in the future to increase the level of development of intermodal transport logistics routes in selected seaports of Eastern Adriatic (Bar, Rijeka and Koper). It is about the implementation of the partial business integration, with a certain redistribution of transport, port and logistics services in the region, which would strengthen the key competencies of the considered sea-ports. The implementation of this idea also considers a significant degree of partnership and the associated long-term forms of partial business integration between these ports (Ibid.). It should enable a synergistic strengthening of the competitiveness and key competencies the ports of Koper, Bar and Rijeka by increasing cargo throughput and their participation in the global flows of integrated marketing logistics keeping in mind their geographical position for the cargo from/to Asia compared to the Western European ports. Development and implementation of discussed ideas has to be seen at the practical regional level (political, economic, and institutional), with the wider participation and cooperation of all /regional stakeholders (govenrmental entities, mentioned Adriatic ports, and the selected global logistics provider). It is also necessary to bear in mind the theoretical model (Figure 1), proposed by A. Montwiłł (2014, p. 260) in accordance with

UNCTAD recommendations (2004). Our adaptation refers to the inclusion of independent variables from the hypothetical model in the stated theoretical model, which unequivocally indicates a certain degree of their complimentarily.

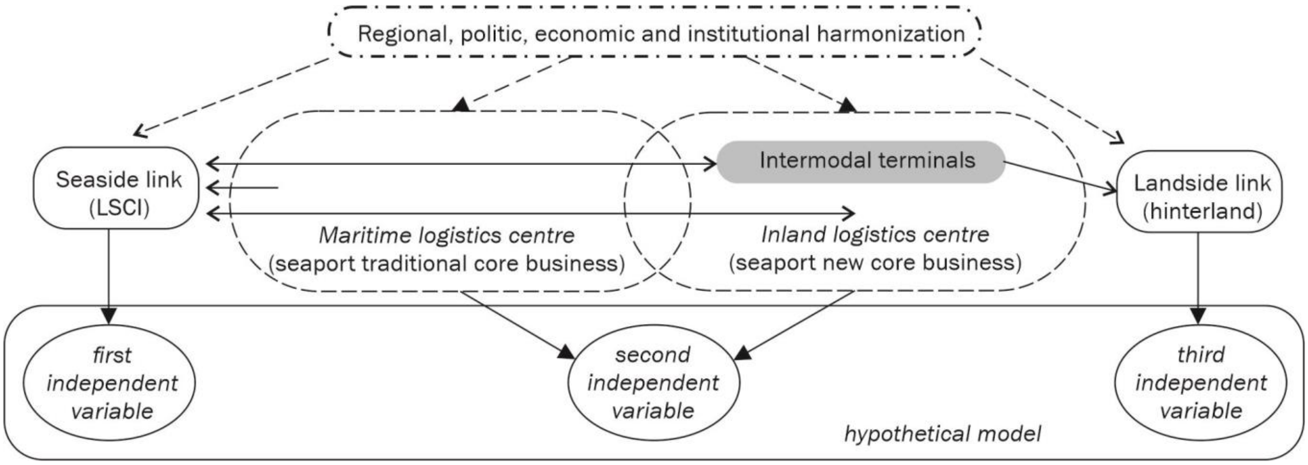


Figure 1. Possibilities of developing logistics routes

Source: adapted from UNCTAD, 2004; Montwiłł, 2014.

In accordance with the subject and goal of the research, in defining a hypothetical economic model, the following variables were selected for evaluation by the surveyed experts: The level of development of intermodal transport logistics routes in the Eastern Adriatic in the period 2006-2020. in the seaports of Koper, Rijeka and Bar (Figure 2).

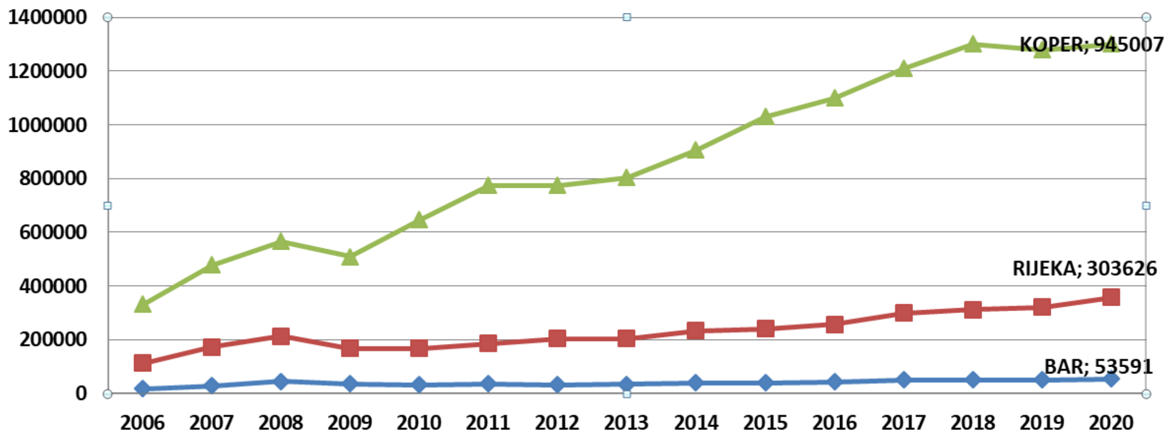


Figure 2. Container throughput 2006-2020 / TEU.

Sources: Container statistics by lines, Port of Bar and Port of Adria Bar, 2021; Container statistics by lines, Port of Rijeka and Adriatic Gate Container Terminal, 2021; Port of Koper, 2021,

The influence of the real data for *Liner Shipping Connectivity Index* (LSCI)[1] on the specified dependent variable (Table 1) was chosen as the first independent variable.

[1] LSCI aims at capturing the level of integration into the existing liner shipping network by measuring liner shipping connectivity. It can be calculated at the country and the port level. LSCI can be considered a proxy of the accessibility to global trade through to proxy of its shipping network. The higher the index, the easier it is to access a high capacity and frequency global maritime

Table 1. Liner Shipping Connectivity Index 2006-2020

Port	2006	2007	2008	2009	2010	2011	2012	2013	1014	2015	2016	2017	2018	2019	2020
Bar	1,51	1,51	2,51	3,82	3,50	3,37	4,40	3,65	3,88	3,65	4,55	3,92	3,11	4,27	5,25
Rijeka	10,36	11,43	13,80	10,82	16,89	17,35	17,87	18,72	19,97	23,17	26,99	29,80	29,32	32,34	33,35
Koper	13,23	13,85	16,67	17,83	19,28	19,91	20,12	21,05	22,61	26,78	29,96	32,44	31,37	34,26	35,32

Source: *Country and Port Level Liner Shipping Connectivity Index*, 2020

The second independent variable in the model is the development of the seaport, measured through the development of port infrastructure, superstructure and logistics, as well as the amount of total costs in the observed ports.

The third independent variable is the connection of the seaport with the network of intermodal terminals in the hinterland.

The initial research model connects three independent variables with one dependent variable. For the realization of multiple linear regression analysis, we used Modules Solver and SPSS (Coakes, 2013; Pallant, 2011; Teles and Schachtebeck, 2019, Bayraktar, 2019). In addition, for simple mathematical statistical modeling, we used the works of N. Balakrishnan et al. (2007); D. Bertskas and J. Tsitsiklis (2008). The constructs used in this study were measured on a Likert scale from 1 to 5, where 1 means the least impact and 5 the greatest impact. Multiple regression analysis was applied to the results of the respondents & # 39; perceptions obtained through the survey, for cases of specified ports.

2. DATE AND RESEARCH METHODOLOGY

2.1 Model

For this research, we have conceived questionnaires in accordance to the previously presented theoretical framework. In total 180 surveyed experts from the subject area from Southeast Europe have been interviewed. They were asked to evaluate, based on their best knowledge, experience and(or) intuition, the dependent variable in the model, defined as the *levels of development of logistics routes of intermodal transport in the Eastern Adriatic (Zp)* (each respondent for the corresponding in his/her own country). Also, they were asked to evaluate the values of the positive influence of the three independent variables in the model (listed above) on the dependent variable.

The constructs from the research framework were measured with point 1; 1,5; 2; 2,5; 3; 3,5; 4; 4,5; 5 Likert-type multi-item scale. In fact, the respondents used linguistic qualifications: very strong (5), strong (4), medium (3), weak (2) and very weak (1) to answer the questions. These qualifications were later coded into Likert's scale as it is noted in the brackets next to each of the linguistics qualification. In the next section is described shortly multiple linear regression model which we used for the responds quantitative analysis.

2.2 Linear multiple regression model

The idea is to determine functional relationship between the dependent variable: *levels of development of logistics routes of intermodal transport in the Eastern Adriatic (Zp);* and independent ones: a) seaport connectivity measured by the LSCI (Liner Shipping Connectivity Index) *(Np_1)*, b) seaport develop-

freight transport system and effectively participate in international trade. Therefore, LSCI can be jointly considered as a measure of connectivity to maritime shipping and as a measure of trade facilitation. It reflects the strategies of container shipping lines seeking to maximize revenue through market coverage (https://porteconomicsmanagement.org/pemp/contents/part1/ports-and-container-shipping/country-port-level-liner-shipping-connectivity-index). The LSCI is calculated based on six major components (Ibid.): a) *Scheduled ship calls*; b) *Deployed capacity*; c) *Number of shipping companies and liner services;* d) *Average and vessel size*; e) *Directly connected ports; and* f) A number of destination ports that can be reached without the need for transshipment.

ment *(Np_2)* and c) seaport connectivity with dry ports (intermodal terminals, i.e. economic centers) in the hinterland *(Np_3)*. Our goal was to estimate the realistically expected mean value of the dependent variable ($\overline{Zp}$), based on individual estimation of the respondents. Since the respondents have estimated the dependent variable *Zp* and independent variables (NP_1, Np_2 and Np_3) on their own discretion, our task was, in line with the requirements of multiple linear regression, to determine the coefficients: B_0, B_1, and B_3, and to calculate $\overline{Zv}$, using Eg. (1):

$$\overline{Zp} = B_0 + B_1 Np_1 + B_2 Np_2 + B_3 Np_3 \qquad (1)$$

Where,

$\overline{Zp}$ - is the mean expected value of the dependent variable;

B_0 - is the intercept, determined on the basis of an appropriate sample;

B_1, B_2, and B_3 – are coefficients of independent variables Np_1, Np_2, and Np_3, or slopes of the correspondent lines. This practically means that for any new value of each independent variable from a predefined interval, we can estimate the value of the dependent variable. It should be said that $\overline{Zp}$ is an average estimated value, since it is a mean value of Np_1, Np_2, and Np_3. To determine $\overline{Zp}$ it is used the last square method (Bertskas et al., 2008). In fact, our goal was to determine the coefficients: B_0, B_1, B_2, and B_3, so as to minimize the sum of squared errors (SSE), which is represented by Eq. (2):

$$SSE = \sum_{k=1}^{n} \left(Zp_k - \overline{Zp}_k\right)^2 = \qquad (2)$$

$$= \sum_{k=1}^{n} \left(Zp_k - \left(B_0 + B_1 Np1 + B_2 Np_2 + B_3 Np_3\right)\right)^2$$

Where,

Zpk - is actual value of the dependent variable, given by the k respondents ($k = \overline{1,n}$);

$\overline{Zpk}$ - is the estimated value of the dependent variable on the basis of the model, in the case of k respondents ($k = \overline{1,n}$);

n – is the total number of respondents (180), $k = \overline{1,n}$.

Using the least-squares method, here is actually determined a straight line, which minimizes the sum of vertical differences for each pair of points (Balakrishnan et al., 2007). In other words, identified is a straight line that best fits the given set of points, by determining the optimal value of intercept (B0), as well as coefficients (B_1, B_2, and B_3), in order to obtain a more accurate value of $\overline{Zp}$ for the given (estimated) values of Np_1, Np_2, and Np_3, and *Zp* (for $\forall k$, $k = \overline{1,n}$).

2.3 Results and discussion

The obtained results are shown in Table 1. In addition to the coefficients: B_0, B_1, *and* B_3, the following statistical indicators were also determined: mean absolute deviation (MAD), correlation coefficient r, coefficient of determination (r^2), mean square error (MSE), mean absolute percent error (MAPE), and standard error of regression estimate (SE). These indicators show high model correspondence and respondents' estimates.

In accordance with the data shown in Table 1, the lines representing the functional dependency between the dependent *(Zp)* and the independent variables ($Np_{1\text{-}3}$) are below.

- ***Port Bar:***

$$\overline{Zp} = B_0 + B_1Np_1 + B_2Np_2 + B_3Np_3$$

$$\overline{Zp}_1 = 1{,}178+0{,}740 \ x \ Np_1+0{,}284 \ x \ Np_2 + 0{,}007x \ Np_3 \tag{3}$$

- ***Port Rijeka:***

$$\overline{Zp} = B_0 + B_1Np_1 + B_2Np_2 + B_3Np_3$$

$$\overline{Zp_2} = 0{,} \ 914+0{,}238 \ x \ Np_1+0{,}038 \ x \ Np_2+0{,}395 \ x \ Np_3 \tag{4}$$

- ***Port Koper.***

$$\overline{Zp} = B_0 + B_1Np_1 + B_2Np_2 + B_3Np_3$$

$$\overline{Zp_3} = -0{,}336+0{,}615 \ x \ Np1_1+0{,}342 \ x \ Np_2+0{,}173 \ x \ Np_3 \tag{5}$$

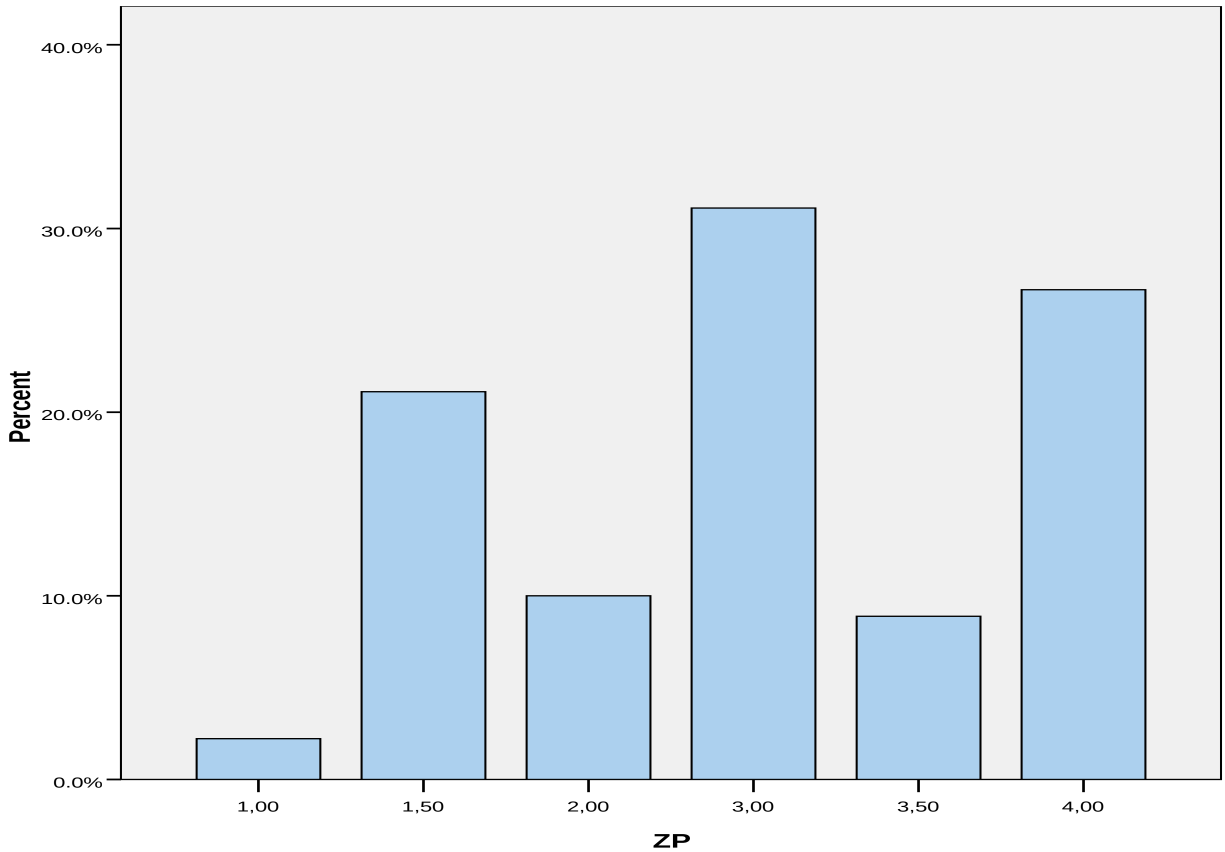
Table 1. Key parameters and statistics in a multiple linear regression model (Source: own)

Param.	*Port Bar:*	*Port Rijeka:*	*Port Kopar:*
B_0	1,178	0,9143	-0,336
B_1	0,74	0,238	0,615
B_2	0,284	0,0383	0,342
B_3	0,007	0,395	0,173
R	9,761	0,725	0,953
r^2	0,579	0,526	0,909
MAD	0,109	0,133	0,084
MSE	0,033	0,038	0,015
MAPE	7,37%	0,041%	2,22%
SE	0,18	0,20	0,12

The mean value of the dependent variable was calculated and the following results were obtained:

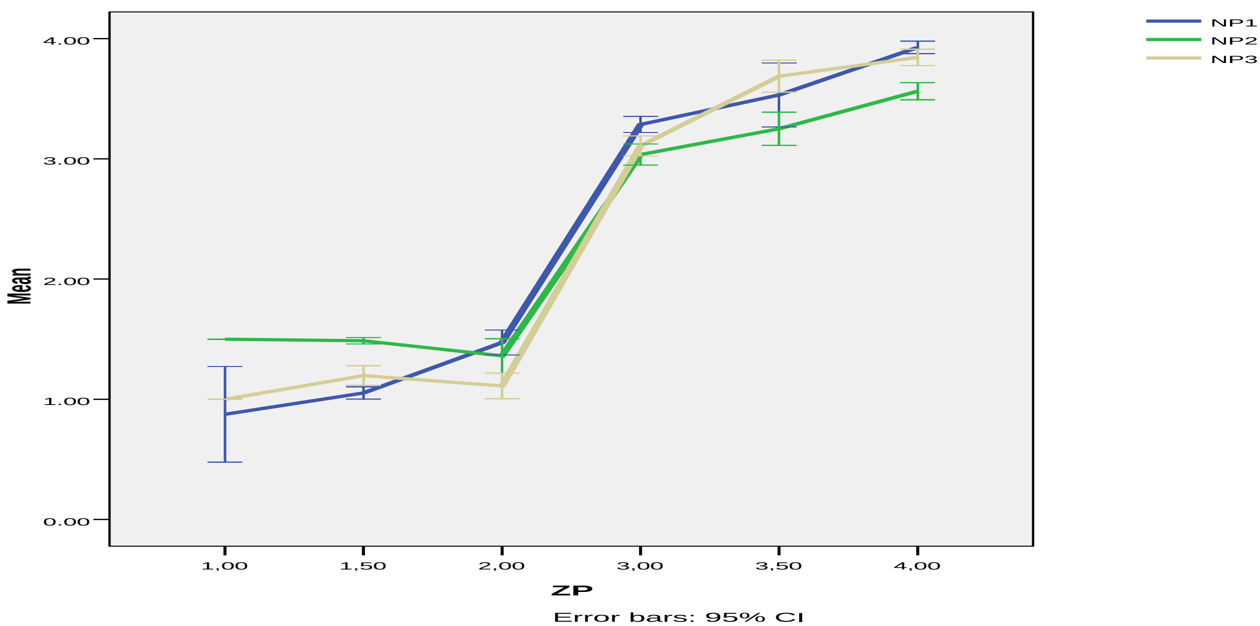
Port Bar	*Port Rijeka*	*Port Koper*
1,51	3,15	3,76

According to the analysis of the linear dependence between the dependent variable and the mean values of the independent variables at the level of all respondents (Graph 2), it is clear that variable Np_1 has the most pronounced influence on the dependent variable. These analyses (Gaph (2) were done over the entire sample. Based on the analysis of the individual sample, the rank of the influence of the independent on the dependent variable given in Table 2 was obtained.



Graph 1. Percentage of estimates 1 to 5 in the set of dependent variable (Zp)

Source: own



Graph 2. The dependent variable (Zp) vs independent variables ($Np_{1\text{-}4}$) in the model

Source: own

In accordance with the mean values of the independent variables (Table 5), the largest impact of the independent variable is the Liner Shipping Connectivity Index LSCI (*Np_1*), in all Ports. The impacts of this variable is low at the Port of Bar, and significant at the Port of Rijeka and Koper. Also, the dependent variable (*Zp_1*) is proportionally influenced by all three independent variables (*Np_1, Np_2,* and *Np_3*).

Table 2. Mean values of independent variables (*Np_{1-3}*) and rank of their influence on the dependent variable (Zp)

Rang	*Port Bar:*	*Port Rijeka:*	*Port Kopar:*
1	Np_1 [1,616]	Np_1 [3,433]	Np_1 [3,716]
2	Np_2 [1,450]	Np_3 [3,308]	Np_3 [3,650]
3	Np_3[1,158]	Np_2 [3,075]	Np_2 [3,475]

Source: own

CONCLUSION

The research showed that the seaport of Bar is noticeably behind the seaports of Rijeka and Koper in terms of the development of logistics routes for intermodal transport. This was ascertained and corroborated by through real data and hypothetical assessments of 180 respondents. The reasons are numerous, and they are dominated by the low level of infrastructural, superstructural and logistical development of the Port of Bar, high costs of its port and logistics services, deteriorating political relations between Montenegro and Serbia, the poor infrastructural transport connections of the Port of Bar with Serbia, development investment deficit, orientation of Serbia to other seaports, a percentage of idling of engaged containers in the return direction, etc.

The functional dependencies between the dependent variable the levels of development of logistics routes of intermodal transport, and the above mentioned the independent variables, were established. Based on the conducted analysis, it was found that the prevailing influence on achieved levels of development of logistics routes of intermodal transport are factors: Liner Shipping Connectivity Index LSCI, seaport development, and seaport connectivity. On the basis of statistical modelling it has been shown that mean values of the dependent variable are: Port Bar is 1.51, in Port Rijeka is 3.15, and Port Koper is 3.76. Also, the rank of independent variables influence to the dependent variable has been established. Testing impact of independent factors shows that ports with the higher level of these factors, have achieved the greater levels of development of logistics routes of intermodal transport. According to the above stated, the starting hypothesis in the paper has been fully verified.

From the perspective of enhancing the levels of development of logistics routes of intermodal transport, the findings of this research give support for deciding on the directions, that when setting up a good strategy of the development, the given factors and their influence should be considered as the most important. These factors are, on the basis of regression analysis, significant elements in the influence the level of the levels of development of logistics routes of inter-modal transport. The selected independent variables in the model explains over 65% of the variation of the level of the levels of development of logistics routes of intermodal transport. If the observed countries strive to develop the levels of development of logistics routes of intermodal transport and create a competitive the levels of development of logistics routes of intermodal transport, understanding the selected factors in this model is invaluable.

Despite some limitations, this research provides the notable contributions. First, it fills up deficit of research in this field. Second, the analysis of the impact factors is given, with certain extensions compared to the previous studies. Thirdly, the theoretical framework for the research of the achieved level of the levels of development of logistics routes of intermodal transport, can be generalized.

Further research should be carried out in the direction of the possible inclusion of additional independent variables, or the establishment of different, more complex aspects of functional dependence among the variables. There are significant internal reserves for the improvement of all independent factors in order to achieve the highest level of the levels of development of logistics routes of intermodal transport in observed ports.

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