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OPTIMAL ANALYTICAL INSTRUMENTS IN THE FUNCTION OF ESTIMATION OF TOTAL TRAFFIC IN THE PORT OF RIJEKA[1]

SUMMARY

The subject of the analysis in this paper is traffic in the Port of Rijeka, the largest and the most significant Croatian port for domestic and international public, predominantly cargo traffic, whose role, considering numerous plans for comprehensive modernisation and revitalisation of the Rijeka traffic route and hypercomplex traffic system, gains additional significance in terms of its impact on the general prosperity of the Rijeka area and the entire Croatia.

The research in this paper is oriented on the analysis of the total realised traffic movement in the Port of Rijeka, according to all cargo structures in the period between 2000 and 2009, with special reference to the analysis of the container traffic trend until 2011, which has shown the highest growth potential in the North Adriatic area. Therefore, based on the analysis of the total traffic movement in the Port of Rijeka, and selected by mathematical and statistical smoothing time series models, scientifically based conclusions have been derived in the segment of selecting the optimal forecasting model of future traffic trend in the Port of Rijeka. This selection is considered relevant for making quality business decisions in the future.

Key words: Port of Rijeka, smoothing time series models, analysis, estimation and forecasting of total traffic trend

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1 INTRODUCTION

The development of port activities, in the function of cargo trans-shipment and providing services to passengers, is the generator of the development of the total economy of Rijeka and the County, as well as of the Croatian economy in general. Therefore, this economic segment justifiably deserves full attention.

Taking into consideration the role and significance of the Port of Rijeka in the economic system of the Republic of Croatia, it is necessary to analyse and predict its growth and development scientifically, by means of selected mathematical and statistical methods, which also determine the *purpose and objectives of the research* in this paper.

The subject of research in the paper is, therefore, oriented on the analysis of the total realised traffic trend in the Port of Rijeka, according to all cargo structures, in the period between 2000 and 2009. Taking into consideration the obtained results, a model is selected which best describes the analysed trend, which will consequently serve as a forecasting model for future trends.

The basic hypothesis of the paper is: the selection of an optimal mathematical-statistical method for explaining the trend of the total realised traffic in the Port of Rijeka in the period between 2000 and 2009 has a direct impact on the quality of the forecasting growth and development of traffic in the Port of Rijeka.

The selected *scientific research methods* of analysis and forecasting traffic in the Port of Rijeka for the analysed period are the selected models of smoothing time series, such as the moving average model, the linear trend model, the simple exponential time series smoothing model, the Holt-Winters exponential time series smoothing model, and other.

2 SIGNIFICANCE OF THE PORT OF RIJEKA IN THE NATIONAL TRANSPORT AND ECONOMIC SYSTEM

According to its geographical position, the Port of Rijeka provides the most favourable and natural access to the Adriatic Sea for the entire area of the Pannonian plain and the wider European area. This position may be called ideal because of a well-protected 70-m-deep cove which, in comparison with the ports of the Baltic and the North Sea, offers a significantly shorter route (2000 Nm) to the countries of Near, Middle and Far East.

The Port of Rijeka groups into the North Adriatic ports which traditionally gravitate towards Central and East European countries (the area of about 700,000 km^2 of surface with about 80 million inhabitants), and, because of its location, the Port of Rijeka does not only provide the best access to the sea to Croatia, but also to Hungary, Austria, the Czech Republic, Slovakia, Serbia, Bosnia and Herzegovina, the western part of Ukraine, the southern part of Poland and the southern part of Germany [3, p. 97].

The Port of Rijeka is a universal port for all kinds of cargo. Dry bulk cargo, general cargo and timber are trans-shipped on eight terminals of the total surface of 1,176,043 m^2, while liquid cargo traffic is realised at the oil terminal in the Omišalj port area [9].

Rijeka has a long history of port traffic flow, which started at the beginning of the 18th century. Traffic in the Port of Rijeka had its good and bad periods. From 1999, trans-shipping over the Port of Rijeka gradually started increasing [6]. The Port of Rijeka reached its golden era in the container traffic from 2003 to 2008. The total traffic in 2011 amounted to 9,39 million tons, from which about 4,5 million tons referred to general and bulk cargo traffic and timber traffic, while as much as 4,9 million tons referred to liquid cargo. The following table shows the Port of Rijeka's traffic according to the cargo structure from 2001 to 2011 (cf. Table 1).

In the period between 2001 and 2007, the Port of Rijeka realised a total increase of 67 %, i.e. 5,3 million tons of cargo. In the same period, general cargo was increased by 160 %, bulk by about 67 %, i.e. 5,3 million tons of cargo, and timber traffic 120 %. In the dry cargo structure in 2007, the year when the Port of Rijeka realised the greatest traffic, bulk cargo participated with about 56 %, while general cargo participated with about 38 %, and timber with about 6 %. After the "golden years", further data on the traffic trends of the Port of Rijeka indicate a constant decline in the total traffic, which is primarily the result of the global recession and its influence on the traffic sector of the Rijeka traffic route, but also of the reduction of

Table 1 Traffic in the Port of Rijeka according to cargo structure from 2001 to 2011 (in mil. tons)

Cargo type	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
General	0,83	0,79	1,06	1,39	1,44	1,57	2,16	2,37	2,11	2,31	2,23
Bulk	1,93	1,73	2,33	3,08	3,19	3,20	3,14	3,38	2,87	2,00	2,02
Timber	0,15	0,20	0,17	0,18	0,22	0,24	0,33	0,28	0,22	0,25	0,25
Liquid	4,99	5,24	6,26	6,92	7,02	5,88	7,59	6,36	6,03	5,62	4,89
Total traffic	**7,90**	**7,96**	**9,82**	**11,57**	**11,87**	**10,89**	**13,22**	**12,39**	**11,23**	**10,18**	**9,39**

Source: Statistical Report of Luka Rijeka d.d., 2012

Note: General cargo: coffee, rice, paper, cotton, fruit, vegetables, timber, vehicles, etc.; Bulk cargo: cereals, coal, ores, coke, etc.; Liquid cargo: oil, petroleum products, various fluids and gases, etc.

work in the segment of oil supply over the Omišalj terminal (the Janaf route).

The total traffic in the Port of Rijeka in 2011 amounted to 9,39 million tons and is significantly lower than the traffic realised in 2007, yet higher than the one in 2011. The dry cargo structure in 2011 is somewhat different from the one in 2007, with indications of a reduction of bulk cargo, which now makes about 50 % of dry cargo, and in favour of the general cargo, which participates with about 45 %, while the share of timber of about 5 % does not vary significantly in the dry cargo structure. Analyses of the traffic trends of liquid cargo in the Port of Rijeka indicate its reduction in the total cargo structure from 57 % in 2007 to 52 % in 2011.

The most significant contribution to the results presented in the above table, as well as the most significant business results in the Port of Rijeka in the period between 2001 and 2011, were achieved by the very container terminal on which traffic recorded a strong growth after its modernisation at the end of 2002, and it was increased for over ten times in the analysed period (cf. Table 2), and it made as much as 15 % of the total traffic in the Port of Rijeka in 2011 (cf. Table 1 and 2).

It is important to point out that the Port of Rijeka in 2004, compared to 2001, recorded an increase in the container traffic of about 400 %. In 2005, the traffic of 76,258 TEU units was achieved at the container terminal, which is an increase of 25 % in relation to the preceding 2004. The highest annual growth, of as much as 54 %, was recorded in 2007 in comparison with 2006, and the greatest number of 168,761 TEU units was recorded in 2008, after which a great decline in the container traffic in the Port of Rijeka followed, primarily under the influence of recession and negative global economic trends [1, p. 180]. In 2010, there was a mild increase in the container traffic, which amounted to as much as 150,677 TEU units in 2011, which is by 11 % more than in the preceding 2010. The increase in the number of TEU units also implies the development of the port front, so that ships of the capacity of as much as 7,000 TEU units might enter the Port of Rijeka, which would also reflect on regular lines of large ships.

The increasing growth of container traffic is a direct result of new trans-shipping capacities, optimal acceptance quality and regular feeder lines from the Port of Rijeka. The ship feeder service Rijeka–Ploče–Malta–Gioia Tauro is the basic reason for the increase in the container traffic in the Port of Rijeka. This service includes the collection of containers by feeder ships from smaller ports to main Mediterranean ports (Malta, Gioia Tauro and Taranto),

Table 2 Container traffic in the Port of Rijeka from 2001 to 2011

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
TEU	12,711	15,215	28,205	60,864	76,258	94,390	145,040	168,761	130,740	137,048	150,677
mil. tons	**0,107**	**0,130**	**0,247**	**0,500**	**0,582**	**0,720**	**1,197**	**1,423**	**1,169**	**1,349**	**1,425**

Source: Statistical Report of Luka Rijeka d.d., 2012

which are reached by container ships of a higher capacity (the so-called parent ships). The feeder service includes the largest world container operators, such as the Hapag Lloyd Triestina, the Maersk&Sealand Linea, the CMA-MMG, the Evergreena, etc. [4, p. 197].

When the Republic of Croatia joins the European Union, there will surely be a further increase in the container traffic in the Port of Rijeka. It is expected that the container traffic in the Port of Rijeka will grow in the following years because of quality relations with Bosnia and Herzegovina, Serbia, and Hungary [2, p. 139]. The reason for the expected further increase in the container traffic in the Port of Rijeka is also procurement of new trans-shipping capacities, high acceptance quality, and servicing and returning domestic cargo (containers) from the Port of Koper to the Port of Rijeka [8, p. 473].

In any case, positive trends in the container traffic segment also indicate possible positive trends on the level of the total traffic in the Port of Rijeka in the years to come.

3 ANALYSIS OF THE TRAFFIC IN THE PORT OF RIJEKA USING SMOOTHING TIME SERIES MODELS

The period from 2000 to 2009 has been selected for the further analysis of the traffic in the Port of Rijeka. The reason for selecting this time period is the reliability of results as a consequence of relatively stable economic trends in the same period, i.e. a significant reduction of economic activities in the following years, burdened by global economic crisis, disturbances on world markets, which implied a general reduction of maritime traffic, which reflected on all its participants (ports, ship operators, land carriers). Except for the above mentioned facts, the year 2010 was marked in the Port of Rijeka by numerous construction works, such as the building of the input-output point as a part of the second stage of the container terminal expansion at Brajdica and the introduction of a new foreign strategic partner, the ICTSI company, with the goal to raise business standards of the container terminal of the Port of Rijeka. For this reason, this year is unfavourable for the analysis.

Below is a detailed overview of the realised traffic in the Port of Rijeka for the period from 2000 to 2009 (cf. Table 3).

In order to analyse the traffic in the Port of Rijeka, the selected smoothing time series models are used, such as the moving average model, the linear trend model, the simple exponential time series smoothing model, the Holt-Winters exponential time series smoothing model, and other. They are a foundation for the selection of a quality traffic forecasting method of the Port of Rijeka in the future. All these models are based on the data contained in Table 3.

Table 3 An overview of the realised traffic in the Port of Rijeka from 2000 to 2009

Year	General cargo (1)	Bulk cargo (2)	Timber (3)	Dry cargo (4=1+2+3)	Liquid cargo (5)	Total cargo (6=4+5)
2000	795,399	1,603,483	165,251	2,564,133	4,285,360	**6,849,493**
2001	831,951	1,925,659	150,620	2,908,230	4,993,235	**7,901,465**
2002	791,239	1,733,067	201,706	2,726,012	5,244,180	**7,970,192**
2003	1,061,748	2,327,629	167,829	3,557,206	6,259,000	**9,816,206**
2004	1,392,089	3,080,723	181,886	4,654,698	6,916,963	**11,571,661**
2005	1,435,225	3,186,176	219,580	4,840,981	7,022,789	**11,863,770**
2006	1,572,997	3,199,707	236,438	5,009,142	5,877,906	**10,887,048**
2007	2,155,506	3,142,518	325,551	5,623,575	7,588,889	**13,212,464**
2008	2,373,810	3,377,560	276,057	6,027,427	6,364,164	**12,391,591**
2009	2,112,870	2,873,487	220,975	5,207,332	6,030,822	**11,238,154**

Source: Statistical Report of Luka Rijeka d.d., 2010

3.1 Smoothing time series using the moving average model

Because it is necessary to smooth the time series, i.e. to reduce the effect of fluctuations in the traffic trends in the Port of Rijeka, below is a calculation of the three-year moving averages for the realised total traffic in the Port of Rijeka in the period from 2000 to 2009 (cf. Table 4).

It is evident, through the comparison of original values and moving average values, that the line which connects the moving average points indicates the tendency of the analysed trends better than the diagram of original values (cf. Chart 1).

This method has neutralised the extremes caused by random influences, which is, in fact, the basic task of moving averages. The line of moving averages deviates less, it is more standardised, and shows the tendency of the analysed occurrence better. These extremes are especially notable at the turn of 2006 and 2007, which is characterised by a maximum realisation of the traffic in the Port of Rijeka, in comparison with the preceding 2006, which recorded a great decline because of the reduction in the liquid cargo traffic.

Since the moving average method does not provide data for the first and last period of the series, these values are often estimated by the

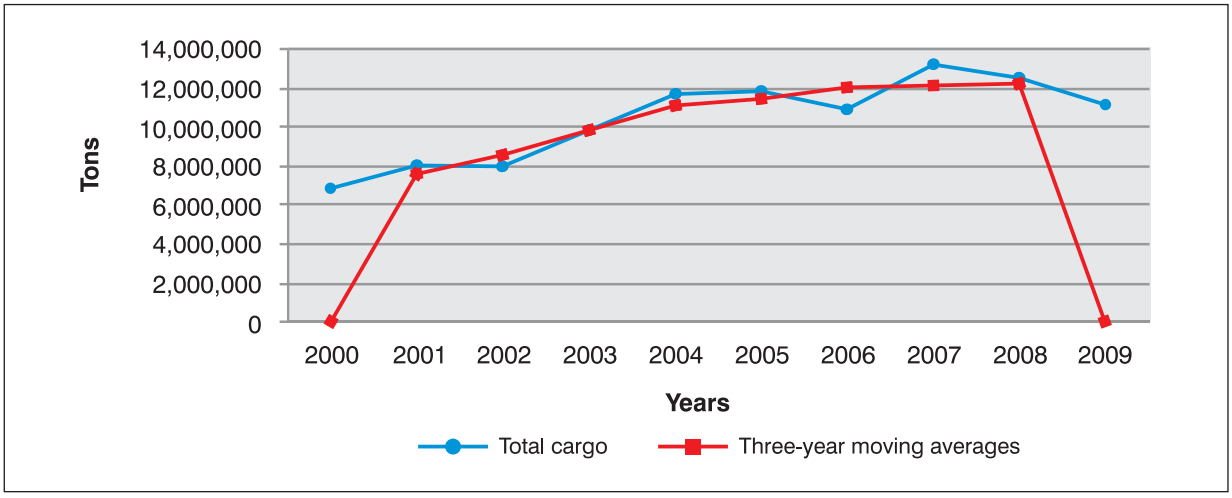
Table 4 Three-year moving averages of the traffic in the Port of Rijeka from 2000 to 2009

Year	Total cargo (y)	Three-year moving averages
2000	6,849,493	-
2001	7,901,465	7,573,716.67
2002	7,970,192	8,562,621.00
2003	9,816,206	9,786,019.67
2004	11,571,661	11,083,879.00
2005	11,863,770	11,440,826.33
2006	10,887,048	11,987,760.67
2007	13,212,464	12,163,701.00
2008	12,391,591	12,280,736.33
2009	11,238,154	-

Source: Authors' calculation

Note: Three-year moving average for the year "n" = $(y_{n-1} + y_n + y_{n+1}) / 3$

Chart 1 Traffic in the Port of Rijeka from 2000 to 2009 with smoothed values using the method of three-year moving averages



Source: Authors' calculation based on the data provided in Table 4.

method of *trend*, as a dynamic mean which indicates the basic tendency of an occurrence and best adjusts to the original time series data.

3.2 Smoothing the time series using the linear trend model

Taking into consideration that each economic occurrence is a result of numerous influences, from which some have features of random variations, the statistical time series model contains the function of time and the variable which represents random influences. According to the form of the line which follows the flow of such an occurrence, there is a difference between the linear trend, exponential trend, i.e. hyperbole, asymptotic function, etc. The selection of the type, i.e. model of the trend depends on the nature of the analysed occurrence. A simple linear trend model is used in the further analysis.

In the linear trend equation: $\hat{Y} = a + bX$, wherein:

$$a = \overline{Y} - b\overline{X}$$

$$b = \frac{\sum_{t=1}^{N} X_t Y_t - n\overline{XY}}{\sum_{t=1}^{N} X_t^{\,2} - n\overline{X}^2}$$

the following values of parameters are obtained: $a = 7{,}625{,}312$; $b = 609{,}976$.

Finally, the linear trend model with parameters estimated by the least-squares method, where the total cargo (Y) depends on time (t), and reads:

$$\hat{Y} = 7{,}625{,}312 + 609{,}976 \times X$$

Table 5 contains the values of line $\hat{Y}$ based on the traffic in the Port of Rijeka from 2000 to 2009.

Table 5 indicates that the sum of the expected values of the variable $\hat{Y}$ equals the sum of original values of the variable *Y*, which equals 103,702,044 of the total cargo.

Based on the obtained values from Table 5, the traffic in the Port of Rijeka for the period between 2000 and 2009 is presented below with the estimated linear trend.

Chart 2 shows that the Port of Rijeka basically records a growth of the total cargo in the analysed period. Between the points of the scatter diagram, the line of the estimated trend model is drawn, which also has a positive slope, i.e. shows an upward trend of the analysed time series.

After the estimation of the trend model parameters, there are questions of representativeness of the model, why certain absolute and relative indicators are used, which are, as is the case in the regression analysis, based on the distribution of variance values of the dependent variable *Y* in the trend model from its arithmetic mean $\overline{Y}$ and expected value $\hat{Y}$.

The calculation of the standard error of the trend model as an absolute indicator of the trend model of representativeness is:

$$S\hat{Y} = \sqrt{\frac{\sum d^2}{n}} = \sqrt{\frac{5.815 \times 10^{12}}{10}} = 762.561{,}47$$

Since this indicator is expressed in the original units of measure of the time series variable Y, it is difficult to compare representativeness of the model with various measurement units on the basis of the standard trend model error, so this problem is eliminated through the relative indicator, i.e. the coefficient of the trend model variation, the calculation of which follows below:

$$\%S\hat{Y} = \frac{S\hat{Y}}{a}100 = \frac{762.561{,}47}{7.625.312} \times 100 = 10\%$$

The smaller the values of standard deviation and variation coefficient are, the more representative the trend is. The relative value of 10 % is often taken as the agreed representativeness limit, which means that the presented model is at the representativeness limit. For this reason, the third indicator, the coefficient of determination, is set to determine representativeness of the model, the calculation of which follows below:

$$r^2 = \frac{SP}{ST} \quad \text{i} \quad 0 \le r^2 \le 1$$

wherein

$$SP = a \cdot \Sigma Yt \div b \cdot \Sigma Xt \cdot Yt - n \cdot \overline{Y}^2 =$$
$$= 7.625.312 \times 103.702.044 \div 609.976 \times$$
$$\times 516.982.157 - 10 \times 1.07 \times 10^{14} = 3.61 \times 10^{13}$$

$$ST = \Sigma Yt^2 - n \cdot \overline{Y}^2 =$$
$$= 103.702.044^2 - 10 \times 1.07^{14} = 9{,}68 \times 10^{15}$$

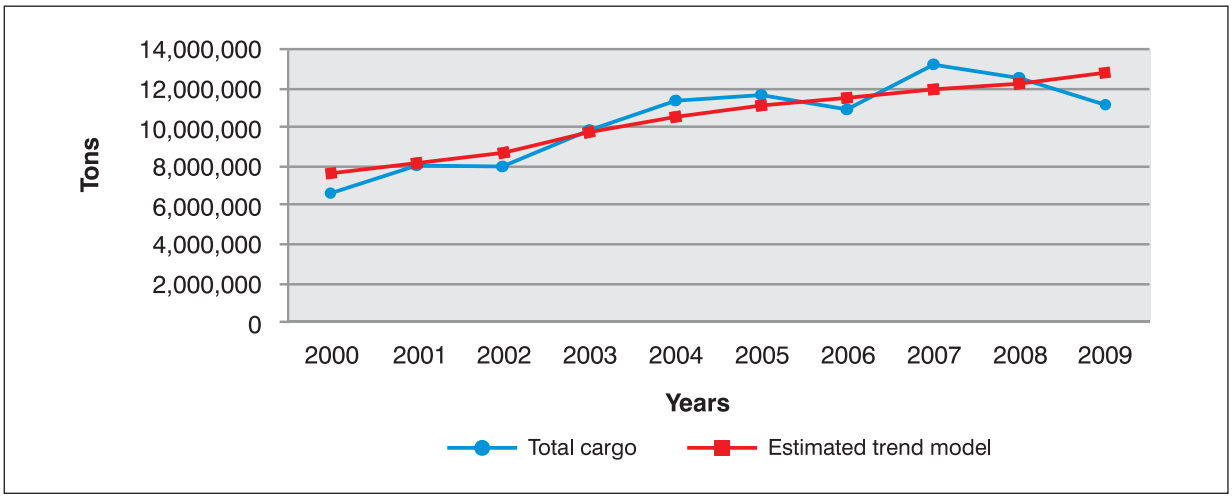
$$r^2 = \frac{3.61 \times 10^{13}}{9.68 \times 10^{15}} = 3.72 \times 10^{-3}$$

Table 5 Determination of the line $\hat{Y}$ based on the traffic in the Port of Rijeka from 2000 to 2009

Year	Total cargo (Y_t)	X_t	$X_t \times Y_t$	X_t^2	$\hat{Y}$	$d = (Y - \hat{Y})$	d^2
2000	6,849,493	0	0	0	7,625,312	-775,819	$6{,}02\times10^{11}$
2001	7,901,465	1	7,901,465	1	8,235,288	-333,823	$1{,}1\times10^{11}$
2002	7,970,192	2	15,940,930	4	8,845,264	-875,072	$7{,}6\times10^{11}$
2003	9,816,206	3	29,448,618	9	9,455,240	360,966	$1{,}3\times10^{11}$
2004	11,571,661	4	46,286,644	16	10,065,216	1,506,445	$2{,}3\times10^{11}$
2005	11,863,770	5	59,318,850	25	10,675,192	1,188,578	$1{,}4\times10^{11}$
2006	10,887,048	6	65,322,288	36	11,285,168	-398,120	$1{,}6\times10^{11}$
2007	13,212,464	7	92,487,248	49	11,895,144	1,317,320	$1{,}7\times10^{11}$
2008	12,391,591	8	99,132,728	64	12,505,120	-113,529	$1{,}3\times10^{10}$
2009	11,238,154	9	101,143,386	81	13,115,096	-1,876,942	$3{,}5\times10^{12}$
Total	**103,702,044**	**45**	**516,982,157**	**285**	**103,702,044**		**$5{,}815\times10^{12}$**

Source: Authors' calculation

Chart 2 Traffic in the Port of Rijeka from 2000 to 2009 with the estimated linear trend model



Source: Authors' calculation based on the data contained in Table 5.

The coefficient of determination equals 3.72×10^{-3}, which means that this trend model has explained only 0.372 % of the total deviations of the dependent variable of the time series from the arithmetic mean, which is far less than the theoretical limit of representativeness of the model (> 0.9). This model is, therefore, not a representative one.

Finally, in the time series, the stochastic factor may also have an influence on the value of the total realised traffic in the Port of Rijeka, which implies a mutual influence of all the remaining unobservable variables, which are a significant source of errors for the future forecasted value. For this reason and for the purpose of a further analysis, the model of simple exponential time series smoothing is used on the example of the total realised traffic in the Port of Rijeka in the period between 2000 and 2009, and the Holt-Winters model of exponential time series smoothing, which also take into account the above-mentioned stochastic factor.

3.3 The simple exponential time series smoothing model

The simple exponential time series smoothing model originates from the general expression for the calculation of smoothed values, which reads:

$$y_t^* = \alpha y_t + (1 - \alpha) \times y_{t-1}^*$$

whereby $0 < \alpha < 1$

wherein

y_t = value of the series in the period t

y_t^* = exponentially smoothed value of the period t

α = smoothing constant, which equals between zero and one.

In order to ensure the stability of the process, which is conditioned by the size of the standard error, for smoothing the time series, the value of the smoothing constant, $\alpha = 0.3$ is used (arbitrary value chosen in accordance with the assumptions of the model), and for the smoothed value of period zero, the value of the first member in the series is used ($y_0^* = y_1$), thus:

$y_1^* = 0.3 \times y_1 + 0.7 \times y_0^* = 0.3 \times 6{,}849{,}493.00 + 0.7 \times 6{,}849{,}493.00 = 6{,}849{,}493.00$

$y_2^* = 0.3 \times y_2 + 0.7 \times y_1^* = 0.3 \times 7{,}901{,}465.00 + 0.7 \times 6{,}849{,}493.00 = 7{,}165{,}084.60$

$y_3^* = 0.3 \times y_3 + 0.7 \times y_2^* = 0.3 \times 7{,}970{,}192.00 + 0.7 \times 7{,}165{,}084.60 = 7{,}406{,}616.82$

$y_4^* = 0.3 \times y_4 + 0.7 \times y_3^* = 0.3 \times 9{,}816{,}206.00 + 0.\ 7 \times 7{,}406{,}616.82 = 8{,}129{,}493.\ 57$

$y_5^* = 0.3 \times y_5 + 0.7 \times y_4^* = 0.3 \times 11{,}571{,}661.00 + 0.\ 7 \times 8{,}129{,}493.57 = 9{,}162{,}143.80$

$y_6^* = 0.3 \times y_6 + 0.7 \times y_5^* = 0.3 \times 11{,}863{,}770.00 + 0.\ 7 \times 9{,}162{,}143.80 = 9{,}972{,}631.66$

$y_7^* = 0.3 \times y_7 + 0.7 \times y_6^* = 0.3 \times 10{,}887{,}048.00 + 0.\ 7 \times 9{,}972{,}631.\ 66 = 10{,}246{,}956.56$

$y_8^* = 0.3 \times y_8 + 0.7 \times y_7^* = 0.3 \times 13{,}212{,}464.00 + 0.7 \times 10{,}246{,}956.56 = 11{,}136{,}608.79$

$y_9^* = 0.3 \times y_9 + 0.7 \times y_8^* = 0.3 \times 12{,}391{,}591.00 + 0.7 \times 11{,}136{,}608.79 = 11{,}513{,}103.46$

$y_{10}^* = 0.3 \times y_{10} + 0.7 \times y_9^* = 0.3 \times 11{,}238{,}154.00 + 0.7 \times 11{,}513{,}103.46 = 11{,}430{,}618.62$

Since the smoothing constant is a relatively a small value (0.3), the true statement is that a series of past periods will also have a significant impact on the forecasts of the future trends of this occurrence, in addition to the present period. This is why the preceding periods have been also included in the analysis. In contrast, if the smoothing constant were large value, the key impact for the prediction of the future trend of the occurrence would primarily be that of the present period, without the past periods.

The simple exponential smoothing procedure has been used to calculate the smoothed values of the traffic in the Port of Rijeka from 2000 to 2009, which is presented in Table 6.

Below is a presentation of the realised traffic in the Port of Rijeka with the smoothed values contained in the Table 6.

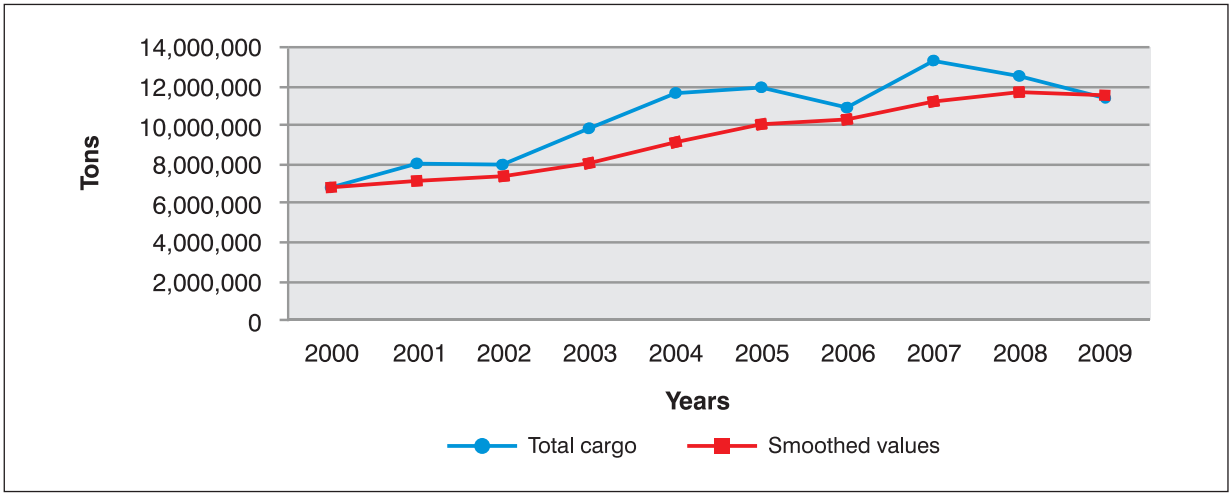
Chart 3 clearly shows the total traffic line and the smoothed values line obtained on the basis of the total traffic in the Port of Rijeka from 2000 to 2009 and the selected exponential smoothing coefficient, the value of which is 0.3. The lines match in 2001, 2002, and 2006, while other years are systematically overestimated for the analysed occurrence level.

Table 6 Simple exponential smoothing of the traffic in the Port of Rijeka from 2000 to 2009

Year	Total cargo (y_t)	X_t	Smoothed value (y_t^*)
2000	6,849,493.00	1	6,849,493.00
2001	7,901,465.00	2	7,165,084.60
2002	7,970,192.00	3	7,406,616.82
2003	9,816,206.00	4	8,129,493.57
2004	11,571,661.00	5	9,162,143.80
2005	11,863,770.00	6	9,972,631.66
2006	10,887,048.00	7	10,246,956.56
2007	13,212,464.00	8	11,136,608.79
2008	12,391,591.00	9	11,513,103.46
2009	11,238,154.00	10	11,430,618.62

Source: Authors' calculation

Chart 3 Traffic in the Port of Rijeka from 2000 to 2009 with smoothed values using the simple exponential smoothing method



Source: Authors' calculation based on the data contained in Table 6.

3.4 The Holt-Winters exponential time series smoothing model

For the application of the Holt-Winters exponential time series smoothing model in the first step, it is necessary to select the smoothing constants, i.e. their optimal combination, i.e. the one which ensures the lowest average sum of deviation squares [5, p. 261].

The Holt-Winters exponential time series smoothing model has the following form:

$$y_t^* = \alpha y_t + (1-\alpha)(y_{t-1}^* + T_{t-1})$$

$$T_t = \beta(y_t^* - y_{t-1}^*) + (1-\beta)\,T_{t-1}$$

$$0 < \alpha < 1;\ 0 < \beta < 1$$

wherein:

y_t = value of the series in the period t

y_t^* = exponentially smoothed value of the period t

T_t = estimation of trend influence

α and β = smoothing constants for the occurrence level and the trend effect.

The initial values for the application of the Holt-Winters model are determined by the linear trend equation: $\hat{Y} = a + bX$, wherein:

$$a = \bar{y} - b\bar{x}$$

$$b = \frac{\sum_{t=1}^{N} X_t Y_t - n\overline{XY}}{\sum_{t=1}^{N} X_t^{\,2} - n\bar{X}^2}$$

The following parameter values are obtained: $a = 7{,}015{,}376.87$; $b = 609{,}968.64$

The initial smoothed value (the smoothed value of period zero) equals the constant member in the linear trend equation:

$$y_0^* = 7{,}015{,}376.87$$

The estimation of the trend effect of the initial (zero) period equals the coefficient by the variable *time*:

$$T_0 = 609.968{,}64$$

The arbitrary smoothing constants equal: $\alpha = 0.2$; $\beta = 0.3$

The estimation of the model reads:

$$y_t^* = 0.2\,y_t + 0.8(y_{t-1}^* + T_{t-1})$$

$$T_t = 0.3\,(y_t^* - y_{t-1}^*) + 0.7\,T_{t-1}$$

The smoothed value for the first period ($t = 1$) equals:

$$y_1^* = 0.2\,y_1 + 0.8(y_0^* + T_0);\ y_1 = 6{,}849{,}493;$$
$$y_0^* = 7{,}015{,}376.87;\ T_0 = 609{,}968.64$$

The estimation of the trend effect for the first period ($t = 1$) equals:

$$T_1 = 0.3\,(y_t^* - y_0^*) + 0.7\,T_0$$

The smoothed values and estimations of the trend effect by the application of the Holt-Winters model are presented in Table 7.

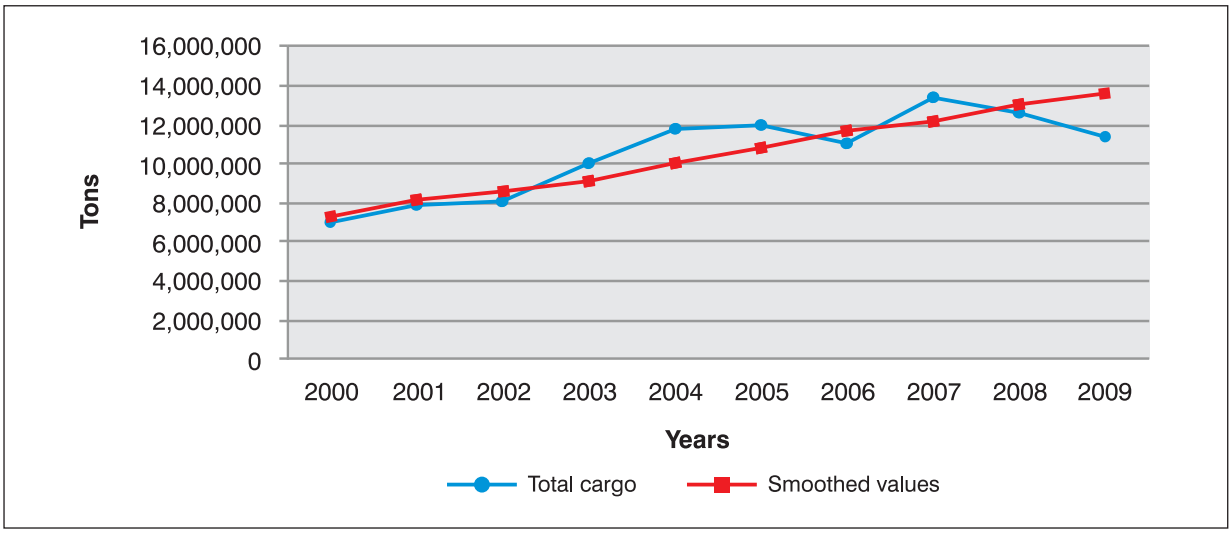
The results of the application of the Holt-Winters model from Table 7 are presented below in Chart 4.

Table 7 The Holt-Winters exponential smoothing model of the traffic in the Port of Rijeka from 2000 to 2009

Year	Total cargo (y_t)	X_t	Smoothed values (y_t^*)	Estimation of the trend effect (T_t)
2000	6,849,493.00	1	7,253,788.95	609,968.64
2001	7,901,465.00	2	7,783,303.85	585,832.52
2002	7,970,192.00	3	8,416,710.67	600,104.81
2003	9,816,206.00	4	8,937,827.77	576,408.50
2004	11,571,661.00	5	9,722,407.08	638,859.74
2005	11,863,770.00	6	10,700,056.17	740,496.55
2006	10,887,048.00	7	11,541,390.93	770,748.01
2007	13,212,464.00	8	12,021,199.19	683,466.08
2008	12,391,591.00	9	12,868,015.36	732,471.11
2009	11,238,154.00	10	13,383,206.78	667,287.20

Source: Authors' calculation

Chart 4 Traffic in the Port of Rijeka from 2000 to 2009 with the smoothed values by the application of the Holt-Winters exponential smoothing model



Source: Authors' calculation based on the data contained in the Table 7.

Comparing the obtained values based on the estimation of the trend effect with the realised values of the total cargo in the period between 2000 and 2009, it may be concluded that, for all the years except the last one, the trend estimation is smaller than the realised values. Likewise, by comparing the original and the smoothed values, it is noticeable that the line which connects the smoothed value points is very close to the original values and thus indicates the tendency of the analysed occurrence well.

4 ESTIMATION AND FORECAST OF THE TRAFFIC IN THE PORT OF RIJEKA

The time series smoothing techniques represent one of the most frequent forecasting techniques, and this is why, through the comparison of the results of the smoothed values obtained by the application of various methods, it is possible to select the one which provides the best results, which adapts best to the original data from the time series and thus best indicates the tendency of the observed occurrence. This is especially significant, since the selection of the method, i.e. model, has a direct impact on the

results of the forecast of a future trend of the analysed occurrence.

The selected time series smoothing models of the traffic in the Port of Rijeka for the period between 2000 and 2009 are presented below in Table 8.

The comparison of the presented time series smoothing models indicates that the Holt-Winters model has provided the best results according to all the assessment criteria. The smoothed values deviate the least from the original values and are thus closest to the forecasting ones; the model is representative and optimal considering all three indicators: MAD as the arithmetic mean indicator of the absolute deviations of the real from the predicted values, MAPE as the indicator of the arithmetic mean absolute percentage error, and RMSE as indicator of the root mean squared error.

It is thus verified that the optimal model for the explanation of the time series trend of the totally realised traffic in the Port of Rijeka in the analysed period, is the Holt-Winters model.

Unlike the Holt-Winters model, values smoothed by the simple exponential smoothing model, i.e. "forget the past" model, show significant deviations from the real values, and the values of all three indicators, MAD, MAPE, and RMSE are much higher, which points to a greater forecasting error of the model.

Although the linear trend model is very popular and simple to use, in addition to the fact that it shows higher values of all three indicators, MAD, MAPE, and RMSE in relation to the Holt-Winters model, it has proved non-representative in this analysis and has, therefore, been dismissed.

Ultimately, although the moving average model came close to the original values, its limitation is in the lack of the first and the last value of the series period. Therefore, this model has also been dismissed as an inferior one.

There is a series of other sophisticated models in the literature, available for the analysis and forecasting of the time series trends, such as the naive (status quo) models, linear regression (trend) model by number forecasting, in-

Table 8 Comparison of the selected time series smoothing models of the traffic in the Port of Rijeka from 2000 to 2009

Year	Total cargo (y_t)	Time (t)	Moving average model	Linear trend model	Simple exponent. smoothing	The Holt – Winters model
2000	6,849,493	1	-	7,625,312	6,849,493.00	7,253,788.95
2001	7,901,465	2	7,573,716.67	8,235,288	7,165,084.60	7,783,303.85
2002	7,970,192	3	8,562,621.00	8,845,264	7,406,616.82	8,416,710.67
2003	9,816,206	4	9,786,019.67	9,455,240	8,129,493.57	8,937,827.77
2004	11,571,661	5	11,083,879.00	10,065,216	9,162,143.80	9,722,407.08
2005	11,863,770	6	11,440,826.33	10,675,192	9,972,631.66	10,700,056.17
2006	10,887,048	7	11,987,760.67	11,285,168	10,246,956.56	11,541,390.93
2007	13,212,464	8	12,163,701.00	11,895,144	11,136,608.79	12,021,199.19
2008	12,391,591	9	12,280,736.33	12,505,120	11,513,103.46	12,868,015.36
2009	11,238,154	10	-	13,115,096	11,430,618.62	13,383,206.78
		MAD	**516,400.20**	**1,545,532.38**	**1,757,813.07**	**991,456.74**
		MAPE	**5.32**	**13.57**	**15.99**	**8.87**
		RMSE	**690,157.29**	**1,897,329.80**	**2,054,513.54**	**1,175,413.28**

Source: Authors' calculation

Note:

MAD – Mean Absolute Deviation

MAPE – Mean Absolute Percentage Error

RMSE – Root Mean Squared Error

ferential statistical forecasting (by interval), linear stochastic models (AP (p) and ARIMA) [2, p. 161], which may serve as a subject for a further research of the trend of this occurrence.

5 CONCLUSION

Sea ports are a key subsystem of the maritime and traffic system and an accelerator of development of numerous economic activities of any maritime country. This is primarily reflected through the trends of the basic economic indicators such as domestic product, employment, investments, or personal consumption on one hand, and the quantity of the transported goods and passengers, size of traffic demand, number and structure of transportation facilities on the other hand.

Considering the fact that almost 75 % of all goods are transported by sea, the importance of sea ports in the world commodity exchange is evident, as well as its role in the inclusion of the state in the global world logistics and transport system.

The traffic size of any port is the measure of its success, role and significance for the port, traffic and economic system, in the national framework and on the competitive traffic market alike. In this process, elements of the technical-technological and organisational-economic structure, development level, connectivity degree, and, ultimately, synchronisation of all these factors in the structure of the port and its surroundings, should not be ignored, taking into account that these particular factors represent a multiplicative factor and imply direct and indirect financial effects of individual ports on the national economy. Likewise, the estimation of the significance of a port for the economic system of a country should be the research result of all the above-mentioned factors.

The Port of Rijeka is in the focus of the analysis in this paper, as a nationally significant port, open to domestic and international public transport. It is predominantly intended for cargo traffic, in the structure of which container traffic has an important role. Consequently, the subject of a detailed analysis in this paper is the total traffic in the Port of Rijeka for the period between 2000 and 2009, according to all cargo structures, with special emphasis on container traffic, which represents the framework for maritime traffic.

In order to estimate the traffic in the Port of Rijeka, adequate mathematical-statistical instruments are used i.e. adequate models of time series smoothing such as the moving averages model, the linear trend model, the simple exponential time series smoothing model, and the Holt-Winters exponential smoothing model, although there are other forecasting estimation models in the literature.

The research results lead to the conclusion that there is no model which would be best in all circumstances and at any time. The same model may provide different results if applied in different circumstances. Forecasting quality is influenced by many other factors, such as the length of the analysed time series, stability of the process, and other, and the selection of the adequate forecasting method will depend on a series of factors.

From the theoretical elaboration and the conducted research, it may be concluded that the Holt-Winters exponential smoothing model has provided optimal estimation results, i.e. estimation within the allowed deviation limits, with minimum errors. This estimation is especially significant for forecasting purposes and, in this case, indicates a stable growth of the traffic in the Port of Rijeka in the future, which is also in accordance with the estimations obtained by the moving average model and the linear trend model, as well as an insight into the positive trends in the segment of the container traffic as a significant segment of the total traffic in the Port of Rijeka.

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