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COMPETITION BETWEEN CONTAINER PORTS IN THE NORTHERN ADRIATIC

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Abstract: World trade has changed in the last decade such that container traffic flows are oriented towards more parts of the European continent. The European container port system is not a homogeneous set of ports; instead it consists of several big ports (e.g., Rotterdam, Hamburg, Algeciras...) and a large number of medium and small ports. Northern Adriatic (NA) ports, namely Rijeka, Koper, Trieste, Venice and Ravenna, are small ports. Each of these ports have different development plans but in varying degrees common hinterlands and costumers. As these ports are located very close one to another, they have to cooperate, but at same time they are competing for their market share. Based on the literature related to port competition and port selection we have analysed the throughput in NA ports for the last twenty four years, and in accordance with this, we have prepared a model for expected growth of container throughput in this region. The resulting model of port dynamics includes three characteristics of container throughput: relative growth, market share and container shift. Furthermore, to obtain some insight into cooperation/competition between the NA ports we have set up a simple dynamic model in which we selected ports' market share fractions for each port as a dynamic variable.

Keywords: container throughput, dynamic model, competition.

1. Introduction

Port competition is very often analysed and the analyses depend on the criteria taken into consideration. In the publications of UNCTAD (1992), geographical location, hinterland networks, port tariffs, efficiency of land transport and port information systems have been selected as the most important criteria. Bichou and Gray (2005) concluded that port competition depends also on institutional and functional levels of management. Port competitiveness of East Asia was analysed by Yap et al. (2006); Notteboom (1997) analysed the European port system; Yeo et al. (2008) analysed ports in Korea and China. In addition, Ducruet and Notteboom (2012) presented the influence of the shipping network on the port system and port spatial development. All of the authors agree that the geographical location of the seaport is one of the most important elements and when we talk about containerized traffic this is even more important, because more than 90% of the trade of industrialized countries is transported by container.

In this paper we will analyse the northern Adriatic (NA) ports: Koper, Trieste/Triest, Venezia/Venice, Rijeka and Ravenna. These ports are located in the northern part of the Adriatic Sea, which penetrates deep into the middle of the European continent, providing the cheapest maritime route from the Far

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East, via Suez, to Europe. More than 100 million tons of water-borne cargo is handled by these NA seaports every year. Due to the tremendous variety of logistics services and the extensive traffic network, NA ports form a perfect multimodal gateway to the key European markets. The near-by fifth Pan-European transport corridor provides a quick link to 500 million European consumers. Large commercial and industrial hubs like Vienna, Munich and Milan are just few hours' drive away. The five entities combine their strengths in order to promote the northern Adriatic route and present themselves as an alternative to the northern European ports. In addition, the association anticipates cooperation in the development of maritime and hinterland connections, visits from cruise lines, environmental protection, safety and information technology (NAPA, 2011).

Because NA ports are located in close proximity to each other they hold a special position in the European ports system, operating in a relatively closed system in which the market and customers are limited and therefore the ports are forced to co-operate while they at the same time compete with each other. In addition they are located in three different countries, with different transport policies and plans of development. The purpose of this article is to examine some characteristics of container throughput in northern Adriatic ports in the period from 1990 to 2013 and also to identify competitive dynamics among them.

2. Some Characteristics of Container Throughput in the Northern Adriatic Ports

In this section we will analyse the throughput in NA ports – Koper, Trieste, Venice, Ravenna and Rijeka - from 1990-2013. During this period (Fig. 1) the total container traffic in these NA ports increased almost exponentially, on average 7% per year (however, this was lower than the average of all European ports); but the rate varied among ports. We can observe accelerated growth in the port of Koper, steady growth at the port of Venice, and stagnation at the Ravenna port. In the year 2013 the highest throughput was obtained in the port of Koper (600,441 TEU), a growth of 5.2% over that of the previous year. The highest growth was in the port of Venice (11.5%) and the lowest in the port of Rijeka (1.3%).

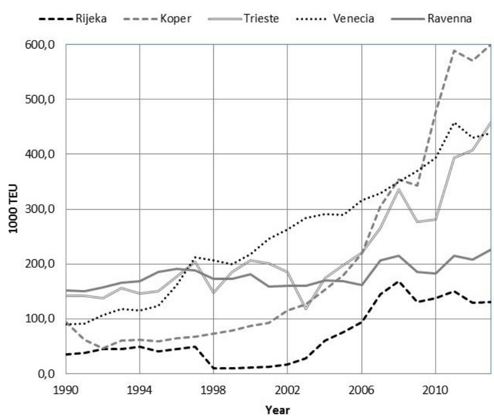

Fig. 1.
Containers Throughput in 1000 TEU from 1990-2013 at Northern Adriatic Ports

2008 and 2009 – the worst years of the global economic and financial crisis – offer some interesting results. During this period, Venice's throughput maintained a steady rate of increase at 5% per year, while the other four ports in experienced a decrease averaging 15%. The largest drop in traffic was recorded in Trieste, decreasing by more than 58,000 TEUs (17.5%). In terms of relative decrease, Rijeka performed the worst, registering a decline of 22.5% (38,000 TEUs less).

Next we performed a shift-share analysis similar to that proposed by Notteboom (1997). The result of calculating the absolute growth of container throughput and the total shift of containers among the NA ports are shown in the Table 1, from which we can see that absolute growth was at the beginning least in Koper (red colour) but at the end highest (green colour). The opposite case occurred in Ravenna, where the highest growth was recorded between 1991 and 1995, but at the end this port registered the smallest absolute growth of throughput expressed in TEU. In the second part of Table 1 the container shift between the ports is presented, and it can be seen that Ravenna has lost the biggest part of the market.

Table 1

Absolute Growth of Container Throughput and Total Shift of Containers for NA Ports

Period		Koper	Rijeka	Trieste	Venice	Ravenna
		Absolute growth TEU				
1991	1995	-3758	2000	8200	32300	34600
1995	1999	19821	-29866	35163	76703	-11595
1999	2003	48033	18164	-66765	83864	-13045
2003	2007	179411	116742	147465	45845	46220
2007	2011	283666	5637	127323	128851	8756
2011	**2013**	11127	-19367	65311	-19534	11424
1991	2013	538300	93310	316697	348029	76360
		Containers shift TEU				
1991	1995	-11851	-4065	-12307	16801	11422
1995	1999	10121	-34235	10592	51003	-37481
1999	2003	38067	16572	-84646	59706	-29698
2003	2007	68289	71020	37144	-124752	-51700
2007	2011	125743	-50263	8739	-16309	-67910
2011	2013	-4804	-23092	53883	-31527	5540
1991	2013	236230	-9248	-8873	-31385	-185777

The third characteristic of container throughput in NA that we will analyse is ports market share. By definition the market share s_i of market share of *i*-th port is (Eq. (1)):

$$s_i \equiv \frac{TEU_i}{\sum_{j=1}^{N} TEU_j} \qquad (i = 1,\dots,N) \tag{1}$$

where N is the number of ports and TEU_i is container throughput in TEU. Fig. 2 shows the dynamics of the market share for NA ports during the analysed period. We can see from that figure a very interesting situation among ports - that when one port lost a degree of container throughput another received it. Venice and Trieste have almost mirrored shares and the same may be observed between Koper and Ravenna. The shear of Koper almost constantly increases over the years while the share of Ravenna during the same period almost constantly decreases.

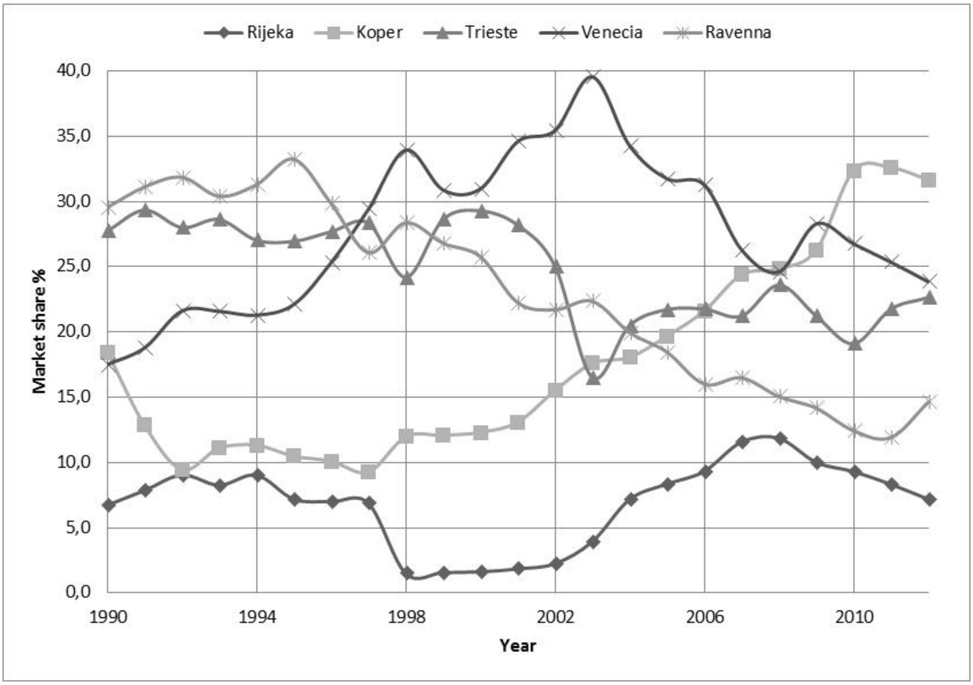

Fig. 2.
The Evaluation of the Market Share in Container Throughput for Northern Adriatic Ports (1990-2013)

3. A Markov Chain Model of Containers Throughput

How is it possible to predict the behaviour of container traffic in NA ports? We would like to know whether the market will grow or, say, fall, for example, in the next few years. The usual approach to answering such questions in terms of quantity is to analyse the data by sophisticated time series econometric methods. However in this paper we will use a Markov-chain like model by which we will estimate transition probabilities between two possible states: the state when the total throughput is growing and the state when the total throughput is falling (Twrdy and Batista, 2013). We define the container traffic growth rate index (CTR) as Eq. (2):

$$CTR_i = \frac{TEU_{TOTAL}(t_{i+1}) - TEU_{TOTAL}(t_i)}{TEU_{TOTAL}(t_i)} \quad (2)$$

where $TEU_{TOTAL}(t_i)$ stands for the total container throughput in a year t_i. The evaluation of the index over an observed period is shown in Fig. 3.

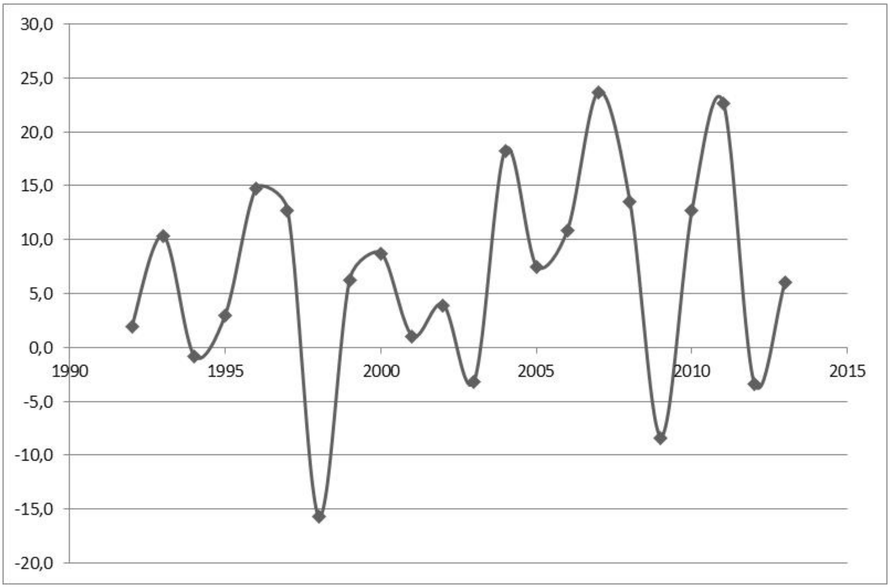

Fig. 3.
Container Traffic Growth Index for NA Ports in the Period 1991-2013

A particular state is detected simply by comparing two successive values of indices. If $CTR_{i-1} < CTR_i$ then the state at time *i* is the state of traffic growth and when $CTR_{i-1} > CTR_i$ the state at time *i* is the state of traffic decrease. From the graph we can now count the number of transitions between the states:

- we have 5 transitions from the state of traffic growth to the state of traffic growth;
- we have 7 transitions from the state of traffic growth to the state of traffic decrease;
- we have 7 transitions from the state of traffic decrease to the state of traffic growth;
- we have 2 transitions from the state of traffic decrease to the state of traffic decrease.

From this we can calculate that the probability that we remain in the state of market growth is 42% and enter a state of market decrease is 58%. If we are in the state of market decrease then there is a 25% chance of remaining in this state in the next year and a 75% chance of returning to a state of market growth. The Markov chain model with these transition probabilities and the Markov chain model with transition probabilities obtained from the period 1991-2002 are shown in Fig. 4. With this model we can make some future assessments. For example, the chance that the market will decrease in two successive years is about 6% and in three years about 2%. Also the chance that the market will increase in two successive years is about 18%, while for three successive years it is about 7%. All this shows that the system of NA ports will most probably annually oscillate between the two states.

Fig. 4.
Markov Chain Model for Growth or Decrease of Relative Rate of Total Container Throughput in NA Ports from 1991-2013

4. The Dynamic Model

To acquire some insight into cooperation/competition among the ports we have set up a simple dynamic model in which we chose ports' market share fraction for each port as a dynamic variable. We assumed a simple linear competition model of the form (Eq. (3)):

$$\frac{d\mathbf{x}}{dt} = \mathbf{A}'\mathbf{x} \qquad \mathbf{x}(0) = \mathbf{x}_0 \tag{3}$$

where t is time, $\mathbf{x}$ is vector of fractions, **A'** is system matrix we wanted to identify and $\mathbf{x}_0$ is the vector of initial values. In our case the dimension of all vectors is 5. We have identified the diagonal coefficient of this matrix as natural decline/growth rates. Also we regarded the ports connected by a positive matrix coefficient as cooperative, and by a negative coefficient as competitive.

Now this system of equation has an analytical solution; however, for future analysis we have replaced a continuous system with a discrete one. By using simple difference approximations of the derivatives we have, instead of Eq. (3), obtained for each time step Δt the following relations (Eq. (4)):

$$\mathbf{y}_n = \mathbf{A}\mathbf{x}_n \qquad \mathbf{y}_n \equiv \mathbf{x}_{n+1} - \mathbf{x}_n \qquad \mathbf{A} \equiv \Delta t\mathbf{A}' \tag{4}$$

This system can be rewritten as Eq. (5):

$$\mathbf{y}_n = \mathbf{X}_n\mathbf{a} \tag{5}$$

where $\mathbf{a} \equiv \left[\mathbf{a}_1, \mathbf{a}_2, \ldots, \mathbf{a}_N\right]^{\mathrm{T}}$ is now an unknown vector of dimension 25, consisting of $\mathbf{a}_k$ which are the columns of matrix **A**, and $\mathbf{X}_n$ is a 5 x 25 system matrix of the form (Eq. (6)):

$$\mathbf{X}_n \equiv \begin{bmatrix} x_{1,n} & & & & & & & & \\ & \ddots & & & & & & & \\ & & x_{1,n} & & & & & & \\ & & & \ddots & & & & & \\ & & & & \ddots & & & & \\ & & & & & \ddots & & & \\ & & & & & & x_{5,n} & & \\ & & & & & & & \ddots & \\ & & & & & & & & x_{5,n} \end{bmatrix} \qquad (6)$$

Now if the observed data is taken for the solution then we obtain an over-determinate system, which may be solved by the least-square method (Eq. (7)):

$$\left\| \tilde{\mathbf{X}}\mathbf{a} - \tilde{\mathbf{y}} \right\|^2 = \min \qquad (7)$$

Minimization yield system of equations (Eq. (8)):

$$\tilde{\mathbf{X}}^{\mathrm{T}}\tilde{\mathbf{X}}\mathbf{a} = \tilde{\mathbf{X}}^{\mathrm{T}}\tilde{\mathbf{y}} \qquad (8)$$

from which a can be calculated.

The matrix of the dynamic system shown in Table 2 can be used to determine the cooperation/competition relationships among ports in the NAP system in the observed period.

First we see from the diagonal values given in the table that only the port of Rijeka has natural tendency to grow, while all of the other ports have a natural tendency to decline.

Table 2

*Coefficient of Matrix **A** for Dynamic Model of Market Share during the Period 2001-2013*

	Koper	**Rijeka**	**Trieste**	**Venice**	**Ravenna**
Koper	-0.296	0.228	0.361	0.582	-1.094
Rijeka	-0.186	0.138	-0.129	0.339	-0.235
Trieste	0.224	0.350	-0.790	-0.124	0.733
Venice	0.289	-0.557	0.358	-0.891	0.959
Ravenna	-0.031	-0.158	0.200	0.095	-0.364

From Table 3, which is derived from Table 2, we can identify three possible relations between ports:

- Mutual cooperative relation: Koper-Trieste, Koper-Venice, Ravenna-Trieste, Ravenna-Venice;
- Mutual competitive relation: Koper-Ravenna, Rijeka-Ravenna;
- Asymmetric cooperative/competitive relation: Koper-Rijeka, Trieste-Rijeka, Venice-Trieste, Rijeka-Venice.

Table 3

Cooperative/Competitive Relations between NA Ports in the Period 2001-2013

	Koper	**Rijeka**	**Trieste**	**Venice**	**Ravenna**
Koper		cooperate	cooperate	cooperate	competitive
Rijeka	competitive		competitive	cooperate	competitive
Trieste	cooperate	cooperate		competitive	cooperate
Venice	cooperate	competitive	cooperate		cooperate
Ravenna	competitive	competitive	cooperate	cooperate	

From this we conclude that the ports of Koper and Ravenna are true competitors (red) but in mutually cooperative (blue) relationships with Trieste and Venice, which compete between themselves. Ravenna is also a competitor of Rijeka. Note also that Rijeka was not in a mutually cooperative relationship with any of the examined ports over the observed period.

5. Conclusion

The NA ports of the multi-port gateway region (Notteboom, 2010) of the northern Adriatic have a very good location especially for the containers arriving from the Far East intended for the markets of central and south-eastern Europe. Even if these ports have modern container terminals, they have lower rates of container throughput than the rest of the multi-port gateway regions in Europe.

Although the total container traffic in the northern Adriatic ports has increased in recent years it still represents a negligible proportion in total throughput of the European ports - the throughput of all NA ports is just 15.2% of the throughput of Europe's largest port – Rotterdam - in 2011, and 16% of its throughput in 2013.

New trends in maritime transport favour the use of bigger and bigger container ships (economy of scale) and the ports in the NA will have to join forces to attract shipping lines to this part of the Mediterranean. Consequently, collaboration and competition between NA ports will continue, and even more, it will probably be intensified in the future. Study and identification of relationships between the NA ports will thus continue to be an interesting field of research both from the theoretical as well as practical point of view.

Finally, the paper presents a simple model that can be of some help in forecasting the state of NA ports for the coming years. The model demonstrates that in most cases the container throughput rate will oscillate annually, with a relatively high probability that overall growth will prevail in all the NA ports.

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