Dr. sc. Marko Tomašević / ***Ph. D.***
Sveučilište u Splitu / *University of Split*
Pomorski fakultet u Splitu /
Faculty of Maritime Studies Split
Zrinsko-frankopanska 38
21000 Split

Dipl. oec. Nela Jadrijević / ***B. Sc., Ph. D. studentica***
Croatia Yachting
Supilova 26 a
51000 Rijeka

Dr. sc. Čedomir Dundović / ***Ph. D.***
Sveučilište u Rijeci / *University of Rijeka*
Pomorski fakultet u Rijeci /
Faculty of Maritime Studies Rijeka
Studentska 2
51000 Rijeka
Hrvatska / *Croatia*

Pregledni članak
Review article

UDK / *UDC*:
56.615.073.235(497.5 Rijeka:497.4 Kopar)
519.2

Primljeno / *Received:*
26. siječnja 2011. / *26th January 2011*
Odobreno / *Accepted:*
9. prosinca 2011. / *9th December 2011*

ANALIZA KRETANJA KONTEJNERSKOG PROMETA LUKE RIJEKA U USPOREDBI S LUKOM KOPAR

THE ANALYSIS OF THE CONTAINER TRAFFIC MOVEMENT IN THE PORT OF RIJEKA COMPARED TO THE CONTAINER TRAFFIC IN THE PORT OF KOPER

SAŽETAK

Predmet istraživanja ovoga rada je kretanje kontejnerskog prometa u riječkoj luci te usporedba istoga s kontejnerskim prometom u luci Kopar. Analizom vremenskih nizova, kao jednom od kvantitativnih metoda prognoziranja, obrađeni su podaci kretanja kontejnerskog prometa uz pretpostavku da će se kontejnerski promet kretati kao u prijašnjem razdoblju. Kontejnerski promet u luci Rijeka direktno utječe na opći prosperitet riječkog područja i Hrvatske u cjelini. Zato je važno uočiti čimbenike koji utječu na kontejnerski promet u riječkoj luci i izračunati trend -polinom koji aproksimira kretanje kontejnerskog prometa. Iz predloženog modela gdje su obrađeni podaci zadnjih dvanaest godina preko trend-polinoma moguće je predvidjeti ponašanje kontejnerskog prometa u sljedećih osam godina.

Ključne riječi: *kontejnerski promet, luka Rijeka, luka Kopar, trend-polinom, koeficijent determinacije*

SUMMARY

The subject of this paper is the movement of the container traffic in the Port of Rijeka and consequently, the comparison has been made with the container traffic in the Port of Koper. The container traffic movement data have been analyzed by the analysis of time series, which is one of the quantitative methods of estimating the future container traffic movement, under the assumption that the container traffic will be moving in the same way as it did in the previous period. Container transport has a direct impact on the general prosperity of the Rijeka area and of Croatia as a whole. Therefore, it is important to identify the factors influencing the container traffic in the Port of Rijeka and to calculate the polynomial trend that approximates the movement of the container traffic in the Port of Rijeka. From the proposed model with the processed data over the past twelve years via polynomial trend, it is possible to predict the behaviour of the container traffic in the next eight years.

Keywords: **container** *traffic, Port of Rijeka, Port of Koper, polynomial trend, coefficient of determination*

1. UVOD

Svrha i cilj ovog istraživanja je prognozirati buduća kretanja kontejnerskog prometa luke Rijeka pomoću trend-polinoma *k*-tog stupnja. Od 1999. godine pa sve do recesijske 2008. godine kontejnerski terminal riječke luke ostvaruje stalan porast kontejnerskog prometa. Shodno tome, luka Rijeka postaje efikasnija luka koja će kvalitetnim uslugama privlačiti sve više poslovnih klijenata te biti luka ticanja mnogim kontejnerskim servisima u prekooceanskoj plovidbi. Uspješno poslovanje luke Rijeka pozitivno se odražava na ekonomski razvoj Republike Hrvatske te investicije u lučki kontejnerski terminal u vrlo kratkom roku daju pozitivne rezultate.

Iz svega navedenog utvrđuje se predmet istraživanja koji se očituje u ispitivanju i određivanju bitnih značajki koje utječu na povećanje kontejnerskog prometa u luci Rijeka. Pomoću prijašnje dinamike kretanja kontejnerskog prometa, trend-polinomom *k*-tog stupnja će se procijeniti kretanje kontejnerskog prometa u budućnosti. Dobiveni rezultati mogu poslužiti kao smjernica za daljnja kapitalna ulaganja u lučki kontejnerski terminal, s ciljem izbjegavanja prekapacitiranosti samog terminala. U radu su iznesene i bitne značajke koje utječu na privlačenje kontejnerskog prometa na riječki prometni pravac. Osim kapitalnih ulaganja, bitnu ulogu u privlačenju tereta igra i tarifna lučka politika. Jedna od konkurentnih prednosti riječke luke za pridobivanje tereta za srednjoeuropsko tržište mogu biti niže lučke tarife s obzirom na tarife susjedne luke Kopar.

Predmet istraživanja je:

- utvrditi relevantne značajke kontejnerskog prometa
- kvantificirati elemente zavisne varijable Y i nezavisne varijable X
- ispitati kretanje kontejnerskog prometa u luci Rijeci i usporediti ih s lukom Kopar
- procijeniti kretanje kontejnerskog prometa u lukama Rijeka i Kopar.

U ovome slučaju, zavisna varijabla Y je broj TEU jedinica u lukama Rijeka i Kopar, dok vrijednosti nezavisne varijable X predstavljaju vrijeme. U radu se pomoću trend-polinoma *k*-toga stupnja vrši analiza kontejnerskog prometa u luci Rijeka i luci Kopar. Koristio se parabolični

1. INTRODUCTION

The purpose and goal of this research is to predict the future container traffic movement by means of the k-degree polynomial trend in the Port of Rijeka. From 1999 to the recession year 2008, the container terminal of the Port of Rijeka achieved a continuous growth of the container traffic. Accordingly, the Port of Rijeka has become more successful and is expected to attract more business customers because of its quality services. It will also be the port of call to many container services in the transatlantic shipping. The successful business of the Port of Rijeka has a positive effect on the economic development of the Republic of Croatia, and the investments in the port container terminal have shown positive results in a very short period of time.

All these above-mentioned facts determine the subject of this research, which is presented in the examination and determination of the important features that affect the container traffic increase in the Port of Rijeka. By using the previous dynamics of the container traffic movement, the movement of the ontainer traffic will be estimated in the future via the k-degree polynomial trend. The results achieved may serve as guidelines for further capital investments into the port container terminal in order to avoid the terminal overcapacity. The paper presents the essential features influencing the attraction of the container traffic on the Rijeka traffic route. Besides the capital investments, an important role in the cargo attracting plays the tariff port policy. One of the competitive advantages of the Port of Rijeka, which should result in getting more cargo for the Central European markets, may be presented in lower port tariffs as compared to the neighbouring Koper port tariffs.

The subject of this research is:

- to determine the relevant features of the container traffic,
- to quantify the elements of the dependent variable Y and of the independent variable X,
- to examine the movement of the container traffic in the Port of Rijeka and its comparison to the Port of Koper,
- to estimate the movement of the container traffic in the ports of Rijeka and Koper.

trend, a regresijski parametri su ocijenjeni pomoću metode najmanjih kvadrata, koja se sastoji u određivanju onih procjena parametara za koje rezidualni zbroj kvadrata postiže minimum.

2. KRETANJE KONTEJNERSKOG PROMETA U LUKAMA RIJEKA I KOPAR

Veličina prometa u morskim lukama zavisi od:

- geoprometnog položaja
- veličine gravitacijskog područja
- veličine i suvremenosti lučkih kapaciteta
- infrastrukture i suprastrukture
- razvijenosti pročelja luke (broja linijskih servisa)
- organizacije rada u luci i
- stručnosti lučkog osoblja i menadžmenta [3].

Najveća koncentracija lučkog prometa na europskom kopnu jest u lukama Sjevernog mora. Na njih su usmjereni glavni tokovi europske pomorske trgovine. Visoka tehnička opremljenost, primjena najnovijih transportnih i informacijskih tehnologija, odlična organizacija i povezanost sa sustavom kopnenog transporta, njihova su nedostižna prednost. U odnosu na te luke po opsegu prometa dosta zaostaju luke sjevernog Jadrana. Priliku za sjevernojadranske

In this case, the dependent variable Y is the number of the TEU units in the ports of Rijeka and Koper, while X represents the time (the value of the independent variable). In this paper, the container traffic has been analysed in the ports of Rijeka and Koper by the polynomial trend of the k-degree. A parabolic trend has been used and, furthermore, regression parameters were evaluated using the least squares method, which consists in determining those estimates of parameters for which the residual sum of squares reaches a minimum.

2. THE CONTAINER TRAFFIC MOVEMENT IN THE PORTS OF RIJEKA AND KOPER

The volume of the sea port traffic depends on:

- its geotraffical position,
- the size of its gravitational area,
- the size of the port capacity,
- its infrastructure and supra-structure,
- the degree of development of the **port foreland** (the number of liner services),
- organization of the work in all port activities and
- the proficiency of the port personnel and management. [3]

The greatest concentration of the port traffic of the European inland is in its ports of the

Tablica 1. Kontejnerski promet luka Rijeka i Kopar (u TEU)
Table 1 *Container traffic in the ports of Rijeka and Koper (in TEU)*

Godina / ***Year***	Rijeka	Kopar	**Ukupno** / ***Total***
1999	6 866	78 204	85 070
2000	8 925	86 679	95 604
2001	12 711	100 000	112 711
2002	15 215	115 000	130 215
2003	28 205	120 000	148 205
2004	60 864	153 347	214 211
2005	76 258	179 745	256 003
2006	94 390	218 970	313 360
2007	145 040	305 648	450 688
2008	168 761	353 880	522 641
2009	130 740	343 165	473 905
2010	137 048	476 731	607 471
Ukupno / ***Total***	885 023	2 531 369	3 410 084

Izvor: Lučka uprava Rijeka i Lučka uprava Kopar
Source: *The Port of Rijeka authority and the Port of Koper authority*

luke predstavlja feeder servis od glavnih mediteranskih hub luka koje bilježe oko 13 puta veći kontejnerski promet od sjevernojadranskih luka [3].

Rijeku prati duga povijest protoka prometa kroz luku koja započinje već početkom 18. stoljeća. Promet u riječkoj luci imao je svoje dobre i loše faze. Od 1999. godine postupno se počeo povećavati prekrcaj preko riječke luke. Svoje najbolje doba, kada je u pitanju kontejnerski promet, luka Rijeka proživljava od 2003. do 2008., sličan, ali puno manji rast ima luka Kopar.

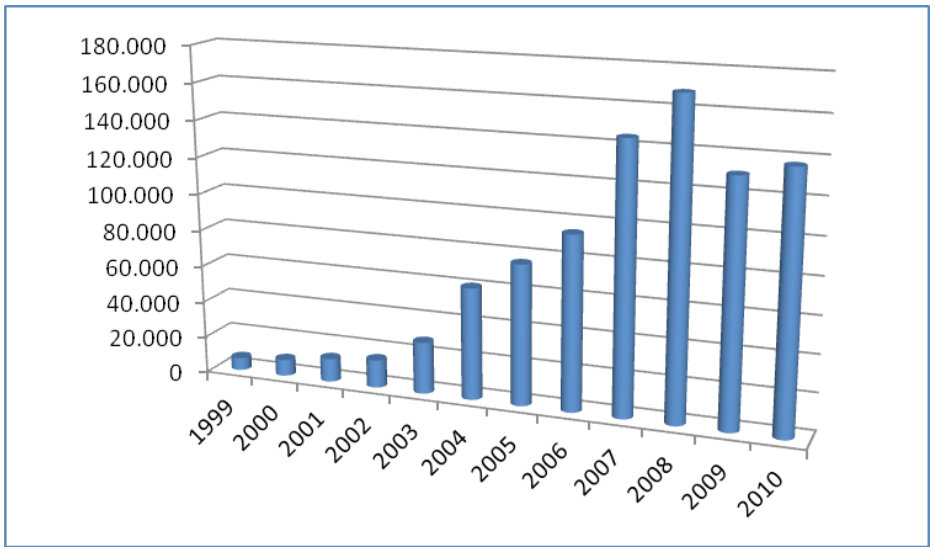
Visoka stopa rasta naročito je prisutna u kontejnerskom prometu što je prikazano na grafikonu 1. Porast prometa u 2004. godini s obzirom na 2003. se povećao 216%, 2005. s obzirom na 2004. se povećao 25%, 2006. s obzirom na 2005. se povećao 24%, 2007. s obzirom na 2006. se povećao još 54%, 2008. s obzirom na 2007. se povećao za 16%. 1999. godina je interesantna po najmanjem udjelu kontejnerskog prometa u luci Rijeka 8% u odnosu na ukupan promet obje luke, dok je u isto vrijeme Kopar imao 92%. Ako se to usporedi s 2008. onda je kontejnerski promet u riječkoj luci 32%, u koparskoj 68% udjela u ukupnom prometu obje luke. Može se vidjeti da je luka Rijeka s 8% od ukupnog prometa 1999. godine došla na 32% u 2008. godini, Kopar s 92% na 68%. Recesija je znatno utjecala na pad kontejnerskog prometa u luci Rijeka u 2009. godini. Dok je istovremeno u luci Kopar ukupni promet porastao sa 68% na 72%, a u luci Rijeka se smanjio s 32% na 28%. Situacija u 2010. je slična, te je u luci Rijeka kontejnerski promet dosegao udio od 22%, u Kopru 78%. Ulaskom Republike Hrvatske u Europsku uniju, doći će zasigurno do povećanja kontejnerskog prometa u luci Rijeka, što je očito kod luke Kopar koja svake godine ima sve veći porast prometa, a pogotovo ulaskom Slovenije u Europsku uniju. Očekuje se da će u narednim godinama kontejnerski promet u riječkoj luci porasti zbog dobrih odnosa s Bosnom i Hercegovinom, Srbijom i Mađarskom. Razlog porasta kontejnerskog prometa u riječkoj luci je i nabavka novih prekrcajnih kapaciteta, dobra kvaliteta prihvata i servisiranja te vraćanje domaćeg tereta (kontejnera) iz koparske u riječku luku [3].

U razdoblju od 1999. do 2010. godine kontejnerski promet riječke luke je porastao sa 6.866 TEU-a na 137.048 TEU-a, što je povećanje od

Northern Sea. The most important currents of the European maritime trade are directed towards those areas. What makes those areas the invincible competitors is their technological equipment, the appliance of the latest transport and informational technologies, great organization and connection to the inland traffic. The North Adriatic ports fall behind those ports on the criterion of the amount of traffic. The only opportunity for the North Adriatic ports lies in the feeder service of the main Mediterranean hub ports, which are characterized by 13 times better container traffic than the North Adriatic ports [3].

Rijeka has a long history of the traffic flow through the port, which began in the early 18th century. The traffic at the port of Rijeka had its good and bad phases. Since 1999 the transshipment through the port of Rijeka has begun to increase gradually. As far as the container traffic is concerned, the port of Rijeka experienced its best period from 2003 to 2008 and the port of Koper experienced a similar but lower increase as well.

The high rate of growth is particularly present in the container traffic, which is shown in Graph 1. The container traffic growth in 2004 as compared to the year 2003 increased by 216%, in 2005 by 25% as compared to the year 2004, in 2006 by 24% as compared to the year 2005, in 2007 by even 54% as compared to the year 2006 and, finally, in 2008 it increased by 16% as compared to the year 2007. The year 1999 was an interesting year, because it was the year of the lowest share of the container traffic at the port of Rijeka. The port of Rijeka had only 8% as compared to the total turnover of both the ports, while at the same time the port of Koper had 92%. The container traffic ratios in 2008 showed that the port of Rijeka had 32% and the port of Koper 68% of the total share in the total turnover of both the ports. It is evident that the port of Rijeka increased from 8% of the total turnover in 1999 to 32% in 2008, while the port of Koper decreased its share from 92% to 68%. In 2009, the recession period significantly affected the decline of the container traffic in the port of Rijeka. While at the same time the total turnover increased from 68% to 72% in the port of Koper, the container traffic decreased from 32% to 28% in the port of Rijeka. The situation in 2010 was similar and the container traffic reached a share of 22% in the port of Rijeka,

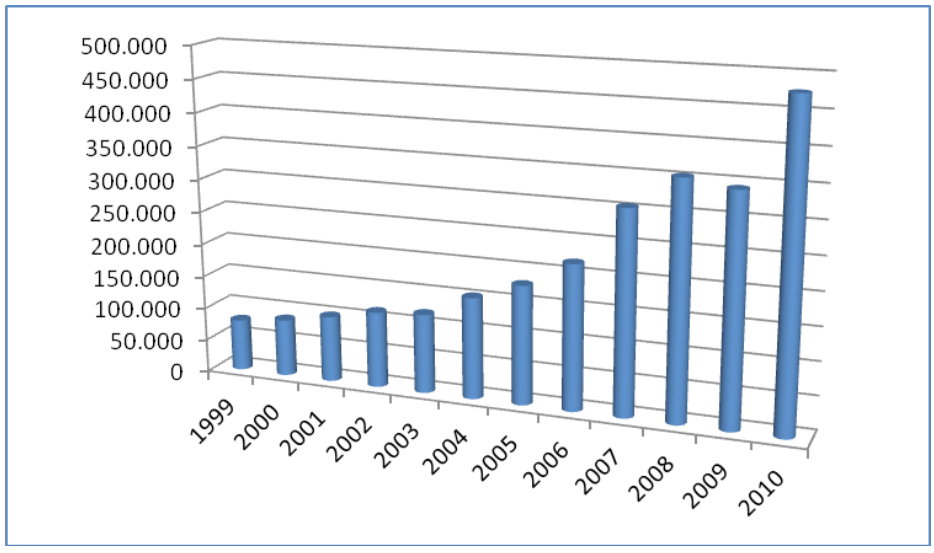


Grafikon 1. Kontejnerski promet luke Rijeka u razdoblju 1999. – 2010. (u TEU jedinicama)
Figure 1 Container traffic in the port of Rijeka in the period from 1999 to 2010 (in TEU units)

Izvor: izradili autori prema statističkim podacima Lučke uprave Rijeka
Source: *made by authors as per statistical data of the Rijeka Port Authority*

20 puta. Povećanjem broja redovitih linija iz luke Rijeka prema vodećim lukama na Sredozemlju, kontejnerski promet luke Rijeka je u 2008. godini iznosio 168.761 TEU-a, a plan za 2009. godinu bio je oko 188.000 TEU-a što se nije ostvarilo zbog recesije koja se dogodila u cijelom svijetu. Poradi smanjenih gospodarskih aktivnosti uzrokovanih ekonomskom krizom globalnih razmjera, poremećaji na svjetskim tržištima izazvali su

while in the port of Koper the share was 78%. The entry of Croatia into the European Union will certainly result in the container traffic increase in the port of Rijeka, which is evident in the container traffic increase in the port of Koper, since it has been increasing each year, especially after the entry of Slovenia into the European Union. In the upcoming years, it is expected that the container traffic will grow at the port of



Grafikon 2. Kontejnerski promet luke Kopar u razdoblju 1999. – 2010. (u TEU jedinicama)
Figure 2 *Container traffic in the port of Koper in the period from 1999 to 2010 (in TEU units)*

Izvor: izradili autori prema statističkim podacima Lučke uprave Kopar
Source: *made by authors as per statistical data of the Koper Port Authority*

pad pomorskog prometa i raširili se kao lančana reakcija na sve njegove sudionike (luke, brodare, kopnene prijevoznike). U 2009. godini ostvaren je ukupni kontejnerski promet u luci Rijeka od 130.740 TEU-a, u luci Kopar 343.165 TEU-a te je u odnosu na rekordnu 2008. godinu, ostvareni promet kontejnera u luci Rijeka manji za 23%, a u luci Kopar za 3%.

Kontinuirano visoki rast kontejnerskog prometa u luci Rijeka neposredno je rezultat novih prekrcajnih kapaciteta, optimalne kvalitete prihvata i servisiranja te redovnih feeder linija iz riječke luke. Naime, brodski feeder servisi i uvođenje direktnih servisa, osnovni je razlog povećanja kontejnerskog prometa riječke luke. Da kontejnerski promet luke Rijeka bilježi nove rekorde, potvrđuje i podatak prema kojemu je u 2007. godine zabilježen promet od 145.040 TEU-a što je porast od čak 54% u odnosu na 2006 godinu, a u luci Kopar za isto razdoblje, promet je porastao za 40%. Povećanje broja TEU jedinica podrazumijeva i prilagođavanje prihvata brodova kapaciteta većeg od 4.000 TEU jedinica [7]. Znakovita je prisutnost vodećih kontejnerskih brodara u riječkoj luci koji su prepoznavši kvalitetu usluge, riječku luku uvrstili kao stalno mjesto ticanja u kontejnerskom prometu ove regije. To je sigurno obećavajući čimbenik za daljnji rast prometa i uspješno uključivanje Rijeke u konkurentno nadmetanje s Koprom [7].

S obzirom na činjenicu da se porast kontejnerskog prometa ostvaruje mnogo brže nego što ga prati rast prateće infrastrukture, luke su primorane širiti i prilagođavati svoje kapacitete u novonastalim uvjetima. Izgradnjom novih terminala znatno bi se povećao kontejnerski promet u luci Rijeka. Da bi luka Rijeka ostvarila svoje poslovne ciljeve, potrebna joj je odgovarajuća lučka mehanizacija i dovoljno veliki smještajni kapaciteti s kojima će biti spremna riješiti sve izazove modernog i brzog poslovanja [2].

3. BITNA ULOGA RAZVOJNIH PLANOVA U LUCI RIJEKA S CILJEM POVEĆANJA KONTEJNERSKOG PROMETA

Od velikog je značaja za razvitak kontejnerskog prometa projekt Rijeka Gateway II započet krajem 2008. godine potpisivanjem ugovora između Vlade RH i Svjetske banke kojim se

Rijeka due to its friendly relations to Bosnia and Herzegovina, Serbia and Hungary. The container traffic was increased in the port of Rijeka due to the purchase of new transshipment capacity, good quality of servicing and comeback ofthe domestic container cargo from the port of Koper to the port of Rijeka. [3].

In the 1999 – 2010 period, the container traffic increased from 6,866 TEUs to 137,048 TEUs in the port of Rijeka, which means that it increased 20 times. Due to the increased number of regular feeder lines form the port of Rijeka towards the leading Mediterranean ports, the container traffic of the Rijeka port was 168,761 TEUs in 2008 and was predicted to reach around 188,000 TEUs in 2009. This had never happened because of the recession that occurred in the whole world. The dysfunction of the world market caused the reduction of the maritime traffic, because of the diminution of the economic activities caused by the economic crisis of global proportions, and spread to all its components (ports, railway, and truck). In 2009, the container traffic in the port of Rijeka reached the value of 130,740 TEUs and in the port of Koper the reached value was 343,165 TEUs. In comparison to the peak year 2008, the overall container traffic in the port of Rijeka was reduced by 23%, and when taking into consideration the port of Koper container traffic it was reduced by 3%.

At the port of Rijeka, a continuous high growth of the container traffic is a direct result of the new transshipment capacity, quality service and regular feeder lines from the port of Rijeka. Namely, at the port of Rijeka, the increase in the container traffic is the result of the feeder services and the introduction of direct services. The 2007 data confirmed that the container traffic had reached new records at the port of Rijeka because, in that year, the total turnover of the container traffic was 145,040 TEUs, which indicated the increase by 54% as compared to the year 2006, while, in the port of Koper, the turnover increased by 40% during the same period. The enlargement of the TEU units number should be followed by the adjusted acceptance of ships with a capacity exceeding 4,000 TEUs [7]. There is a significant presence of the leading container shipping companies in the port of Rijeka, which have introduced the port of Rijeka as the pemanent port of call in the container traffic of this region after recognizing the excellent quality of its services. This is

odobrava zajam u iznosu od 84 milijuna USD čime se omogućava nastavak projekta Rijeka Gateway. Cilj je toga projekta prvenstveno proširiti lučke kapacitete, pogotovo kontejnerski terminal kao odgovor na sve veći porast kontejnerskog prometa koji određuje izgradnju velikih kontejnerskih brodova u svijetu i potreba luka za širim i dubljim pristanima te većim terminalima. Programom će se modernizirati strateški lučki objekti, povećati sudjelovanje privatnog sektora u luci, poboljšati poslovanje Lučke uprave Rijeka, te Rijeku bolje integrirati u međunarodne prometne koridore, a posebice poboljšati promet Paneuropskim koridorom Vb na čijem se početku nalazi luka Rijeka. Kao što je već navedeno, Rijeka Gateway – Projekt II. nastavak je Gateway projekta i oni čine integralnu cjelinu koja uključuje niz urbanih, infrastrukturnih i ekonomskih radnji čiji je cilj i svrha modernizacija, privatizacija i rekonstrukcija te obnova riječkog prometnog pravca [1].

U riječkoj luci, u narednih deset godina, u planu je povećanje prometa na više od pola milijuna TEU-a godišnje. Preduvjet za to je izgradnja Zagrebačke obale (680 metara) uz koju će moći pristajati najveći kontejnerski brodovi na svijetu, zatim u svibnju 2011., stavljanje u funkciju prometnice D404 (kontejnerski terminal – riječka obilaznica), te uvođenje nove tehnologije za prekrcaj kontejnera, jer postojeća ima ograničene kapacitete. Naravno, glavni preduvjet je izgradnja ravničarske pruge Rijeka – Zagreb – Botovo [5]. Ulaganje u željezničku mrežu RH bilo je zanemareno tijekom više desetljeća. Danas je prisutan trend prebacivanja težišta investiranja s cestogradnje na željeznicu [3]. U šestom mjesecu 2011. Luka Rijeka d.d. kupila je tri nove mobilne autodizalice za kontejnere, čime su povećani operativni učinci u prekrcaju kontejnera, osobito kvaliteta usluge na skladištenju, punjenju i pražnjenju kontejnera te je time dodatno povećan ukupni kapacitet kontejnerskog terminala [16].

U trećem mjesecu 2011. novi strateški partner International Container Terminal Services Inc., jedan od najuspješnijih operatora međunarodnih terminala, obvezao se investirati oko 70 milijuna eura u terminal Brajdica s ciljem modernizacije kontejnerskog terminala. U sklopu projekta i planiranim ulaganjima tijekom tridesetogodišnje koncesije, razvit će se novih 330 metara obale, što će povećati i godišnji kapacitet kontejnerskog prometa na 600.000

certainly a promising factor for both the further traffic growth and the making of the port of Rijeka a dangerous rival in this business competition with the port of Koper [7].

Because of the fact that the container traffic growth is recognized much faster than its simultaneous infrastructure growth, the ports are forced to expand and adapt their capacities to the new context and conditions. The container traffic in the port of Rijeka would be significantly increased by the construction of new terminals. In order to achieve its business objectives, the port of Rijeka needs an adequate port suprastructure and sufficient area capacity by means of which it will be prepared for facing all of the challenges of the modern and rapid business ventures [2].

3. THE IMPORTANT ROLE OF THE DEVELOPMENT PLANS IN THE PORT OF RIJEKA, AIMED AT INCREASING THE CONTAINER TRAFFIC

The project called Rijeka Gateway, which began at the end of 2008, is of great importance for the development of thecontainer traffic. The signing of the contract between the Croatian Government and the World Bank approves a loan to the amount of 84 million USD and enables a continuous realization of the Rijeka Gateway project. The main aim of this project is to expand the port capacity, especially the container terminal, which is a response to the increasing growth of the container traffic. That growth determines the construction of large container ships in the world and the port`s need for wider and deeper quays and larger terminals. The strategic port facilities will be modernized by this program, the private sector participation in the port operations will be improved, the port of Rijeka will be better integrated into the international transport corridors in order to improve the pan-European transport corridor Vb because the port of Rijeka is situated at the beginnig of that corridor. As it was already mentioned, the Rijeka Gateway II Project is a sequel of the Gateway Project and they form an integral unit that includes numerous urban, infrastructural and economic activities. The main goal and purpose of these activities is modernization, privatization and reconstruction of the Rijeka traffic route [1].

TEU-a do 2016. godine. Najveća ulaganja te tvrtke, specijalizirane za poslovanje kontejnerskih terminala, usmjerit će se u implementaciju modernih tehnologija koje će omogućiti automatizaciju praćenja iskrcaja, skladištenja i otpreme kontejnera, podizanje standarda poslovanja Brajdice te dogradnju željezničke infrastrukture u okolici terminala. ICTSI, kao novi strateški partner luke Rijeka, radit će na povećanju efikasnosti terminala te proširenju njegovog dosega, odnosno proširenju tržišta na Mađarsku, Češku, Slovačku, Poljsku, Srbiju i BiH. Na kontejnerskom terminalu luke Rijeka očekuje se povećanje prometa, otvaranje novih tržišta centralne i jugoistočne Europe te snažan logistički iskorak. Cilj je postati vodeći terminal u jugoistočnoj Europi.

4. ANALIZA VREMENSKIH NIZOVA – TREND

Vremenski niz složen je od više različitih komponenti koje se mogu analizirati statističkim metodama. Te komponente su ponekad vidljive na prvi pogled (često iz grafičkog prikaza), ali je ponekad potrebna složenija statistička analiza da bi se navedene komponente otkrile i analizirale. Klasična dekompozicija vremenskog niza obuhvaća sljedeće komponente:

- trend komponentu
- kalendarsku komponentu
- sezonsku komponentu
- iregularnu (slučajnu) komponentu.

Vremenski niz može biti stacionaran ili može imati trend. Ako niz ima trend, to znači da ima dugoročnu tendenciju rasta ili pada.

S metodološkog aspekta gledano, trend-model može se definirati kao specifičan oblik regresijskog modela kod kojeg se kao nezavisna varijabla "uvijek i samo" pojavljuje varijabla "vrijeme". Stoga je i metodološki pristup ocjeni parametara različitih vrsta trend-modela gotovo isti kao i kod ocjene parametara regresijskog modela [4].

Cilj regresijskih modela je izabrati i ocijeniti parametre funkcije $f(X)$, odnosno $\hat{Y}$ koja će na najbolji mogući način opisati vezu između varijabli X i Y.

Ako se pretpostavi postojanje zavisne (regresand) varijable Y i samo jedne nezavisne (re-

In the next ten years, it is planned to increase the turnover at the port of Rijeka, so that it exceeds half a million TEUs a year. The prerequisite for this is the construction of the Zagrebačka obala (680 meters), at which the world largest container ships should be able to berth. Furthermore, the road D-404 (container terminal -Rijeka beltway) was released in May 2011, and the introduction of a new technology for the transshipment of containers must also take place because the current one has a limited capacity. Of course, the main prerequisite is the construction of the plain railway Rijeka - Zagreb - Botovo [5]. There is a trend of shifting the focus of investment from the road construction to the railways these days [3]. In June 2011, the Port of Rijeka purchased three new mobile cranes for containers, which increased the operational impacts on the container transshipment, especially on the quality of the storage services and on the loading and unloading of containers. Because of this, the total capacity of the container terminals was even more increased [16].

In March 2011, a new strategic partner of the International Container Terminal Services Inc., who is considered to be one of the most successful international terminal operators, committed to invest about 70 million Euros in the terminal Brajdica in order to modernize the container terminal. As a part of the project and investments that were planned during the 30 years of concession, additional 330 meters of the coast will be constructed. This will increase the annual container traffic capacity to 600,000 TEUs by the year 2016.. The largest investment of this company specialized in container terminal operations will be used for implementing modern technologies, which will enable the automated monitoring of the container unloading, storage and transportation. It will also raise the operating standards of Brajdica and upgrade the railway infrastructure in the area surrounding the terminal. ICTSI, as a new strategic partner of the Port Rijeka, will aim at increasing the efficiency of the terminal and expand its reach, that is, it will aim at expanding the markets to Hungary, the Czech Republic, Slovakia, Poland, Serbia and Bosnia and Herzegovina.. At the container terminal of the Port of Rijeka, what is expected is an increase of the traffic, establisment of new markets in Central and Southeastern Europe and a strong logistics progress. The goal is to become the leading terminal in Southeastern Europe.

gresorske) varijable X, riječ je o jednostavnom regresijskom modelu čiji je opći oblik[1]:

$$Y = f(X) + e \quad \text{ili} \quad Y = \hat{Y} + e. \tag{1}$$

Budući da varijabla e izražava rezidualne ili funkcijom *f(X)* neobjašnjene utjecaje koji proizlaze iz statističke povezanosti varijabli X i Y, najbolji model bit će onaj koji minimizira vrijednost varijable *e*.

Trend-polinom k-tog stupnja spada u aditivne modele, a izgleda ovako:

$$\mathrm{Y}_i = \beta_0 + \beta_1 x_i + \beta_2 x_i^2 + \cdots + \beta_k x_i^k + e_i \qquad i = 1, 2, ..., n \tag{2}$$

gdje su:

Y_i – *i*-ta zavisna (regresand, objašnjena) varijabla

x_i – *i*-te nezavisne (regresijske, eksplanatorne) varijable

β_0, β_1, ..., β_k – regresijski parametri (koeficijenti regresije)

e_i – stohastička varijabla koja predočuje nesistematske utjecaje na zavisnu varijablu

n – veličina uzorka.

Sustav jednadžbi u matričnoj notaciji glasi:

$$\mathrm{Y} = \mathrm{X}\beta + e, \tag{3}$$

gdje je:

$$\mathrm{Y} = \begin{bmatrix} y_1 \\ y_2 \\ \vdots \\ y_n \end{bmatrix}, \quad \mathrm{X} = \begin{bmatrix} 1 & \mathrm{x}_1 & \mathrm{x}_1^2 & \ldots & \mathrm{x}_1^k \\ 1 & \mathrm{x}_2 & \mathrm{x}_2^2 & \ldots & \mathrm{x}_2^k \\ \vdots & \vdots & \vdots & & \vdots \\ 1 & \mathrm{x}_n & \mathrm{x}_n^2 & \ldots & \mathrm{x}_n^k \end{bmatrix},$$
$$\beta = \begin{bmatrix} \beta_0 \\ \beta_1 \\ \vdots \\ \beta_k \end{bmatrix}, \quad e = \begin{bmatrix} e_1 \\ e_2 \\ \vdots \\ e_n \end{bmatrix} \tag{4}$$

Ovdje je Y vektor empirijskih vrijednosti zavisne varijable, X je matrica vrijednosti regresijske varijable, β+ je vektor nepoznatih vrijednosti parametara, *e* je vektor nepoznatih vrijednosti slučajnih varijabli e_i, pri čemu je $E[e_i] = 0$ za svako *i*.

[1] Tomašević, M., Statističke metode u istraživanju, Split, Sveučilište u Splitu, Pomorski fakultet 2007., str. 375.

4. ANALYSIS OF TIME SERIES: TREND

The time series consist of several different components that can be analyzed by statistical methods. These components are sometimes visible at first glance (often in graphic). In order to disclose and analyse them, sometimes a more complex statistical analysis is required. The classical decomposition of the time series includes the following components:

- the trend component,
- the calendar compnent,
- the seasonal component,
- the irregular (random) component.

Time series can be stationary or can have a trend if the time series has a trend, there is then a long-term trend of growth or decline. From a methodological point of view, the trend model can be defined as a specific form of the regression model which is always and only characterized by the independent variable ”time”. Therefore, the methodological approach for the assessment of the parameters relating to different trend-model types is almost the same as it is for the evaluation parameters of the regression model [4].

The aim of the regression models is to choose and evaluate the parameters of functions *f*(X), i.e. $\hat{Y}$ which will be the best way to describe the relationship between the variables X and Y.

Assuming the existence of dependent (regressand) variable Y and only one independent (regressor) variable X, it is a linear regression model whose general form is[1]:

$$Y = f(X) + e \quad \text{or} \quad Y = \hat{Y} + e. \tag{1}$$

Since the variable e expresses the residual or by the function *f*(X) unexplained effects arising from the statistical relation between variables X and Y, the best model will be the one that minimizes the value of the variable *e*.

4.1 Polynomial Trend of Degree k

Polynomial trend of degree k belongs to the additive models, and it is as follows:

[1] Tomašević, M., **Statistical methods in research, Split, University of Split, Maritime Faculty 2007,str. 375**

Na osnovi uzorka treba naći najbolje moguće ocjene $\hat{\beta}_0, \hat{\beta}_1, ..., \hat{\beta}_k$, odgovarajućih koeficijenata $\beta_0, \beta_1, ..., \beta_k$ trend-polinoma k-tog stupnja i time odrediti trend-polinom na uzorku:

$$Y_i = \hat{\beta}_0 + \hat{\beta}_1 x_i + \hat{\beta}_2 x_i^2 + ... + \hat{\beta}_k x_i^k, \ i=1,2,...,n \quad (5)$$

gdje je s $\hat{Y}_i$ označena ona vrijednost Y koja se nalazi na najbolje prilagođenoj regresijskoj krivulji, pa se naziva prilagođena vrijednost od Y.

Trend-polinom osnovnog skupa i uzorka se po pravilu razlikuju, jer se ocijenjene vrijednosti $\hat{\beta}_0, \hat{\beta}_1, ..., \hat{\beta}_k$, razlikuju od stvarnih vrijednosti parametara $\beta_0, \beta_1, ..., \beta_k$. Vertikalno odstupanje (razliku) između stvarne vrijednosti Y_i i prilagođene vrijednosti $\hat{Y}_i$ nazivamo rezidualom i označavamo s e_i:

$$e_i = Y_i - \hat{Y}_i = Y_i - \left(\hat{\beta}_0 + \hat{\beta}_1 x_i + \hat{\beta}_2 x_i^2 + ... + \hat{\beta}_k x_i^k\right), \quad (6)$$

Ocjene parametara $\hat{\beta}_0, \hat{\beta}_1, ..., \hat{\beta}_k$, traženog polinoma dobit ćemo metodom najmanjih kvadrata, tako da se od svih mogućih regresijskih krivulja odabere ona koja ima najmanju sumu kvadrata reziduala, tj. da se nađe minimum izraza[2]:

$$SQ = \sum_{i=1}^{n} e_i^2 = \sum_{i=1}^{n} \left(Y_i - \hat{Y}_i\right)^2 = \\ = \sum_{i=1}^{n} \left[Y_i - \left(\hat{\beta}_0 + \hat{\beta}_1 x_i + \hat{\beta}_2 x_i^2 + \cdots + \hat{\beta}_k x_i^k\right)\right]^2 \quad (7)$$

Do minimuma izraza (7) dolazi se tako da se (k+1) parcijalna derivacija $\frac{\partial SQ}{\partial \hat{\beta}_0}, \frac{\partial SQ}{\partial \hat{\beta}_1}, \ldots, \frac{\partial SQ}{\partial \hat{\beta}_k}$ izjednači s nulom, čime se dolazi do sustava $(k+1)$-nelinearne jednadžbe, tj. do sustava[3]:

$$\begin{aligned} & n\hat{\beta}_0 + \hat{\beta}_1 \sum_{i=1}^{n} x_i + \cdots + \hat{\beta}_k \sum_{i=1}^{n} x_i^k = \sum_{i=1}^{n} y_i \\ & \hat{\beta}_0 \sum_{i=1}^{n} x_i + \hat{\beta}_1 \sum_{i=1}^{n} x_i^2 + \cdots + \hat{\beta}_k \sum_{i=1}^{n} x_i^{k+1} = \sum_{i=1}^{n} x_i y_i \\ & \quad \cdot \qquad\qquad \cdot \qquad\qquad \cdot \\ & \quad \cdot \qquad\qquad \cdot \qquad\qquad \cdot \\ & \quad \cdot \qquad\qquad \cdot \qquad\qquad \cdot \\ & \hat{\beta}_0 \sum_{i=1}^{n} x_i^k + \hat{\beta}_1 \sum_{i=1}^{n} x_i^{k+1} + \cdots + \hat{\beta}_k \sum_{i=1}^{n} x_i^{2k} = \sum_{i=1}^{n} x_i^k y_i \end{aligned} \quad , \quad (8)$$

[2] Šošić. I., Primijenjena statistika, Zagreb, Školska knjiga, 2004., str. 44.

[3] Tomašević, M., Statističke metode u istraživanju, Split, Sveučilište u Splitu, Pomorski fakultet 2007., str. 375.

$$Y_i = \beta_0 + \beta_1 x_i + \beta_2 x_i^2 + \cdots + \beta_k x_i^k + e_i \quad (2)$$
$$i = 1, 2, ..., n$$

where are:

$Y_i - i$- dependent (regressand, explained) variable,

$x_i - i$- independent (regressor, explanatory) variable,

$\beta_0, \beta_1, ..., \beta_k$– regression parameters (regression coefficients),

e_i – stochastic variable that denotes the unsystematic effects on the dependent variable,

n – sample size.

The system of equations in a matrix notation is as follows:

$$Y = X\beta + e, \quad (3)$$

where:

$$Y = \begin{bmatrix} y_1 \\ y_2 \\ \vdots \\ y_n \end{bmatrix}, \quad X = \begin{bmatrix} 1 & x_1 & x_1^2 & \ldots & x_1^k \\ 1 & x_2 & x_2^2 & \ldots & x_2^k \\ \vdots & \vdots & \vdots & & \vdots \\ 1 & x_n & x_n^2 & \ldots & x_n^k \end{bmatrix},$$
$$\beta = \begin{bmatrix} \beta_0 \\ \beta_1 \\ \vdots \\ \beta_k \end{bmatrix}, \quad e = \begin{bmatrix} e_1 \\ e_2 \\ \vdots \\ e_n \end{bmatrix} \quad (4)$$

Hence Y is a vector of empirical values of the dependent variable, X is the matrix of a regression variable value, β is the vector of unknown parameter values, e is the vector of unknown values of random variables e_i, and hence $E[e_i] = 0$ is for each i.

Based on the sample, it is to find the best possible estimate $\hat{\beta}_0, \hat{\beta}_1, ..., \hat{\beta}_k$, of the corresponding coefficients $\beta_0, \beta_1, ..., \beta_k$ of the polynomial trend of degree k and thus determine the polynomial trend in the sample:

$$Y_i = \hat{\beta}_0 + \hat{\beta}_1 x_i + \hat{\beta}_2 x_i^2 + ... + \hat{\beta}_k x_i^k, \ i=1,2,...,n \quad (5)$$

where $\hat{Y}_i$ stands for the value Y which is located on the best adaptive regression spline, so it is called the adaptive value of Y.

The polynomial trend of the basic set and the sample is usually different, because the assessed values $\hat{\beta}_0, \hat{\beta}_1, ..., \hat{\beta}_k$ differ from the real parameter values $\beta_0, \beta_1, ..., \beta_k$. The vertical devi-

ili u matričnom zapisu [4]:

$$(X^T X) \cdot \hat{\beta} = X^T Y, \quad (9)$$

odnosno:

$$\hat{\beta} = (X^T X)^{-1} \cdot (X^T Y), \quad (10)$$

pri čemu je:

$$\hat{\beta} = \begin{bmatrix} \hat{\beta}_0 \\ \hat{\beta}_1 \\ \vdots \\ \hat{\beta}_k \end{bmatrix}; \quad X^T X = \begin{bmatrix} n & \Sigma x_i & \dots & \Sigma x_i^k \\ \Sigma x_i & \Sigma x_i^2 & \dots & \Sigma x_i^{k+1} \\ \vdots & \vdots & \vdots & \vdots \\ \Sigma x_i^k & \Sigma x_i^{k+1} & \dots & \Sigma x_i^{2k} \end{bmatrix};$$

$$X^T Y = \begin{bmatrix} \Sigma y_i \\ \Sigma x_i y_i \\ \vdots \\ \Sigma x_i^k y_i \end{bmatrix}, \quad (11)$$

Analiza varijance regresije dobiva se ovako:

$$ST = SP + SR \quad (12)$$

$$SP = \sum_{i=1}^{n} \left(\hat{Y}_i - \overline{Y}\right)^2 = \hat{\beta}^T \left(X^T Y\right) - n \cdot \overline{Y}^2 \quad (13)$$

SP – suma kvadrata protumačenog dijela odstupanja vrijednosti varijable $\hat{Y}_i$ od aritmetičke sredine $\overline{Y}$, pri čemu je $\overline{Y} = \frac{1}{N} \sum_{i=1}^{n} Y_i$

$$SR = \sum_{i=1}^{n} \left(Y_i - \hat{Y}\right)^2 = Y^T Y - \hat{\beta}^T \left(X^T Y\right) = \\ = \sum_{i=1}^{n} Y_i^2 - \hat{\beta}^T \left(X^T Y\right) \quad (14)$$

SR – suma kvadrata neprotumačenog (rezidualnoga) dijela odstupanja vrijednosti varijable Y_i od $\hat{Y}$.

$$ST = \sum_{i=1}^{n} \left(Y_i - \overline{Y}\right)^2 = \sum Y_i^2 - n\overline{Y}^2 \quad (15)$$

ST – suma kvadrata ukupnih odstupanja vrijednosti varijable Y_i od aritmetičke sredine $\overline{Y}$.

[4] Tomašević, M., Statističke metode u istraživanju, Split, Sveučilište u Splitu, Pomorski fakultet 2007., str. 376.

ation (difference) between real value Y_i and adaptive value $\hat{Y}_i$ is called residual and is denoted as e_i:

$$e_i = Y_i - \hat{Y}_i = Y_i - \left(\hat{\beta}_0 + \hat{\beta}_1 x_i + \hat{\beta}_2 x_i^2 + ... + \hat{\beta}_k x_i^k\right), \quad (6)$$

The parameters estimates $\hat{\beta}_0, \hat{\beta}_1, ..., \hat{\beta}_k$, of the required polynomials will be given by the least squares method, so, of all possible regression splines, the one with the smallest sum of squared residuals, i.e. find minimum expression[2] , will be selected

$$SQ = \sum_{i=1}^{n} e_i^2 = \sum_{i=1}^{n} \left(Y_i - \hat{Y}_i\right)^2 = \\ = \sum_{i=1}^{n} \left[Y_i - \left(\hat{\beta}_0 + \hat{\beta}_1 x_i + \hat{\beta}_2 x_i^2 + \cdots + \hat{\beta}_k x_i^k\right)\right]^2 \quad (7)$$

To get the minimum expression (7) it is neccessary to make $(k+1)$ partial derivative $\frac{\partial SQ}{\partial \hat{\beta}_0}, \frac{\partial SQ}{\partial \hat{\beta}_1}, \ldots, \frac{\partial SQ}{\partial \hat{\beta}_k}$ equals to zero, which leads to the system $(k+1)$- nonlinear equation, i.e. the system [3]:

$$\begin{aligned} n\hat{\beta}_0 + \hat{\beta}_1 \sum_{i=1}^{n} x_i + \cdots + \hat{\beta}_k \sum_{i=1}^{n} x_i^k &= \sum_{i=1}^{n} y_i \\ \hat{\beta}_0 \sum_{i=1}^{n} x_i + \hat{\beta}_1 \sum_{i=1}^{n} x_i^2 + \cdots + \hat{\beta}_k \sum_{i=1}^{n} x_i^{k+1} &= \sum_{i=1}^{n} x_i y_i \\ \cdots & \\ \hat{\beta}_0 \sum_{i=1}^{n} x_i^k + \hat{\beta}_1 \sum_{i=1}^{n} x_i^{k+1} + \cdots + \hat{\beta}_k \sum_{i=1}^{n} x_i^{2k} &= \sum_{i=1}^{n} x_i^k y_i \end{aligned}, \quad (8)$$

or in matrix notation [4]:

$$(X^T X) \cdot \hat{\beta} = X^T Y, \quad (9)$$

that is:

$$\hat{\beta} = (X^T X)^{-1} \cdot (X^T Y), \quad (10)$$

where:

[2] Šošić. I., Applied Statistics, Školska knjiga, Zagreb, 2004., pg. 44

[3] Tomašević, M., Statistical methods in research, Split, University of Split, Maritime Faculty 2007, pg. 375

[4] Tomašević, M., Statistical methods in research, Split, University of Split, Maritime Faculty 2007, pg. 376

Reprezentativnost regresije se mjeri koeficijentom determinacije, koji je omjer protumačenog zbroja kvadrata i ukupnog zbroja kvadrata odstupanja. On pokazuje koliko posto zbroja kvadrata odstupanja je protumačeno regresijskim modelom, a dobiva se ovako:

$$R^2 = \frac{\sum_{i=1}^{n}\left(\hat{\mathrm{Y}}_i - \overline{\mathrm{Y}}\right)^2}{\sum_{i=1}^{n}\left(\mathrm{Y}_i - \overline{\mathrm{Y}}\right)^2} \quad . \tag{16}$$

Koeficijent determinacije kreće se u intervalu $0 \le R^2 \le 1$. Regresijski model bit će reprezentativniji ako je R^2 bliži jedinici i obrnuto.

U nastavku je analizirano kretanje kontejnerskog prometa u lukama Rijeka i Kopar te je izvršena aproksimacija podataka danih u tablici 1. tako da se kretanje kontejnerskog prometa aproksimiralo općenito trend-polinomom *k*-tog stupnja, tj. formulom (2).

Nađen je trend-polinom *k*- tog stupnja na primjeru kontejnerskog prometa u lukama Rijeka i Kopar za razdoblje od 1999. do 2010. godine u TEU (Tablica 1). Trend-polinom drugog stupnja za luku Rijeka u danom razdoblju izgleda kao na grafikonu 3.

Koeficijent determinacije R^2=0,8822, što znači da je 88,22% zbroja kvadrata ukupnih odstupanja vrijednosti varijable Y od aritmetičke sredine protumačeno s trend-polinomom drugog stupnja, dok je preostalih 11,78% zbroja kvadrata ostalo neprotumačeno. S obzirom da se vrijednost koeficijenta determinacije nalazi blizu 1, može se zaključiti da je trend-polinom drugog stupnja reprezentativan

Slična analiza se može dati i za luku Kopar. Koeficijent determinacije za luku Kopar je R^2=0,976, a optimalan je trend-polinom drugog stupnja (Grafikon 4).

U tablici 2. izračunate su prognozirane vrijednosti $\hat{\mathrm{Y}}_i$, i = 13, 14,..., 20 kontejnerskog prometa u TEU za godine od 2011. do 2018. u lukama Rijeka (trend-polinom drugog stupnja grafikon 3) i Kopar (trend-polinom drugog stupnja grafikon 4).

Iz tablice 2. je vidljivo da je 2010. luka Kopar imala 3,5 puta veći promet od luke Rijeka. Prema izračunatim prilagođenim vrijednostima $\hat{\mathrm{Y}}_i$, 2014. g. luka Rijeka će imati za 3,4 puta manji kontejnerski promet od luke Kopar. Nadalje,

$$\hat{\beta} = \begin{bmatrix} \hat{\beta}_0 \\ \hat{\beta}_1 \\ \vdots \\ \hat{\beta}_k \end{bmatrix}; \quad \mathrm{X}^T\mathrm{X} = \begin{bmatrix} \mathrm{n} & \Sigma \mathrm{x}_\mathrm{i} & \dots & \Sigma \mathrm{x}_\mathrm{i}^{\mathrm{k}} \\ \Sigma \mathrm{x}_\mathrm{i} & \Sigma \mathrm{x}_\mathrm{i}^{2} & \dots & \Sigma \mathrm{x}_\mathrm{i}^{\mathrm{k+1}} \\ \vdots & \vdots & \vdots & \vdots \\ \Sigma \mathrm{x}_\mathrm{i}^{\mathrm{k}} & \Sigma \mathrm{x}_\mathrm{i}^{\mathrm{k+1}} & \dots & \Sigma \mathrm{x}_\mathrm{i}^{\mathrm{2k}} \end{bmatrix};$$

$$\mathrm{X}^T\mathrm{Y} = \begin{bmatrix} \Sigma y_i \\ \Sigma x_i y_i \\ \vdots \\ \Sigma x_i^k y_i \end{bmatrix}, \tag{11}$$

The analysis of the variance of regression is obtained in the following way:

$$ST = SP + SR \tag{12}$$

$$SP = \sum_{i=1}^{n}\left(\hat{\mathrm{Y}}_i - \overline{\mathrm{Y}}\right)^2 = \hat{\beta}^T\left(\mathrm{X}^T\mathrm{Y}\right) - n\cdot\overline{\mathrm{Y}}^2 \tag{13}$$

SP – sum of squares of explained part of deviation of the variable value $\hat{\mathrm{Y}}_i$ from the arithmetic mean $\overline{\mathrm{Y}}$, where $\overline{\mathrm{Y}} = \frac{1}{\mathrm{N}}\sum_{i=1}^{n}\mathrm{Y}_i$

$$SR = \sum_{i=1}^{n}\left(\mathrm{Y}_i - \hat{\mathrm{Y}}\right)^2 = \mathrm{Y}^T\mathrm{Y} - \hat{\beta}^T\left(\mathrm{X}^T\mathrm{Y}\right) = \tag{14}$$
$$= \sum_{i=1}^{n}\mathrm{Y}_i^2 - \hat{\beta}^T\left(\mathrm{X}^T\mathrm{Y}\right)$$

SR – sum of residual part of deviation of the variable value Y_i from $\hat{\mathrm{Y}}$.

$$ST = \sum_{i=1}^{n}\left(\mathrm{Y}_i - \overline{\mathrm{Y}}\right)^2 = \sum \mathrm{Y}_i^2 - n\overline{\mathrm{Y}}^2 \tag{15}$$

ST – sum of residual part of deviation of the variable value Y_i from the arithmetic mean $\overline{\mathrm{Y}}$.

The representativeness of regression is measured by the coefficient of determination, which is the ratio of the explained sum of squares and total sum of squares deviation. It shows how much percent of the sum of squares deviation is explained by the regression model, and is obtained like this:

$$R^2 = \frac{\sum_{i=1}^{n}\left(\hat{\mathrm{Y}}_i - \overline{\mathrm{Y}}\right)^2}{\sum_{i=1}^{n}\left(\mathrm{Y}_i - \overline{\mathrm{Y}}\right)^2} \quad . \tag{16}$$

2018. g. luka Kopar ostvarit će 4 puta veći promet od luke Rijeka. Kada se usporedi promet luke Rijeka u 2010. g. koji je iznosio 137.048 TEU-a te prognozirani kontejnerski promet u 2018. g. u iznosu od 307.068 TEU-a, proizlazi da će se u luci Rijeka udvostručiti kontejnerski promet. Luka Koper je 2010. godine ostvarila kontejnerski promet od 476.731 TEU jedinica, a u 2018. g. prognoziran je promet od 1 227 483 što je povećanje od 2,6 puta. Dakle, luka Kopar će ostvariti veće povećanje prometa u usporedbi s lukom Rijeka.

5. ZAKLJUČAK

Trend-polinomom drugog stupnja provedena je analiza kontejnerskog prometa riječke i koparske luke u razdoblju od 1999. do 2010. godine u TEU jedinicama te su izračunate prilagođene vrijednosti $\hat{Y}_i$, i = 13, 14,..., 20 za godine 2011. do 2018.

Statistička analiza paraboličnog trenda je provedena metodama regresijske analize. Izvršena je numerička analiza trend-polinoma drugog stupnja koja je obuhvatila procjenu nepoznatih parametara β_0, β_1,..., β_k te je određen pokazatelj reprezentativnost, odnosno koeficijent determinacije. Trend-polinomom drugog

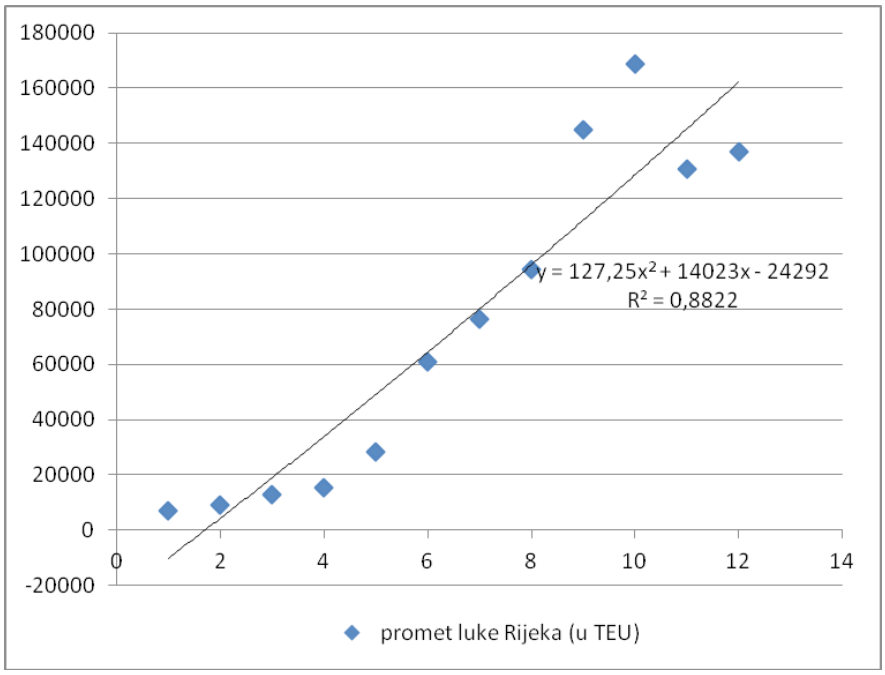
The coefficient of determination ranges in the interval $0 \leq R^2 \leq 1$. The regression model will be more representative if R^2 is closer to the unit and vice versa.

Below there is the analyse of the movement of container traffic in the port of Rijeka and Koper and furthermore approximation of the data given in Table 1 has been done so the movement of container traffic approximated generally by the polynomial trend of degree k, i.e. formula (2).

The polynomial trend of degree k was found in the example of the container traffic in the ports of Rijeka and Koper from 1999 to 2010 in the TEUs (see table 1). The polynomial trend of the second degree for the port of Rijeka in the given period is shown in graph 3.

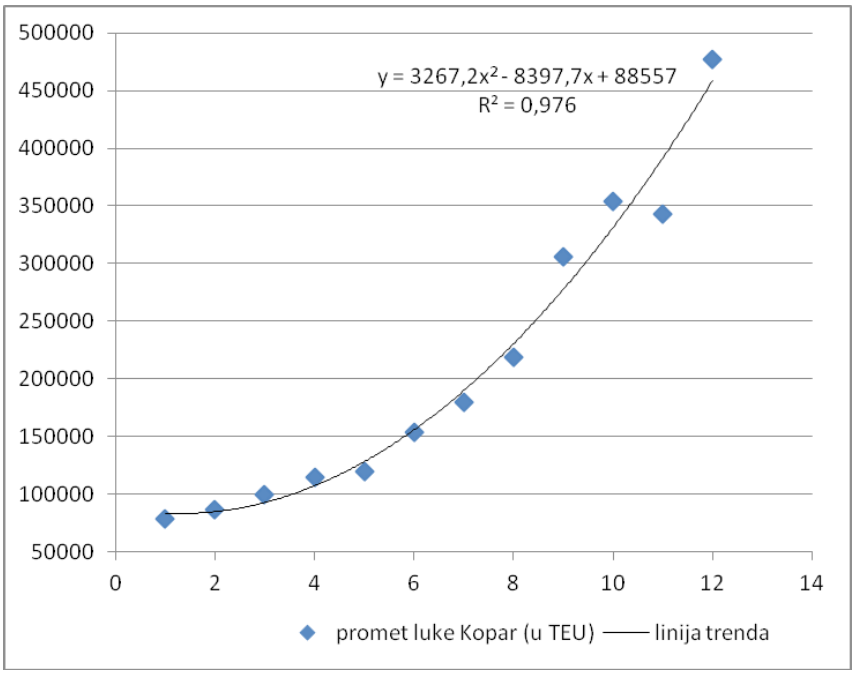
The coefficient of determination equals R^2=0,8822, which means that 88.22% of the total sum of the variable deviation squares from the arithmetic mean is analyzed by means of the polynomial trend of the second degree, while the remaining 11.78% of the sum of the squares remained unexplained. Since the coefficient of determination is close to 1, it can be concluded that the polynomial trend of the second degree is representative.

A similar analysis can be given for the port of Kopar. The coefficient of determination for the



Grafikon 3. Trend- polinom drugog stupnja za luku Rijeka u razdoblju 1999. – 2010. godine
Figure 3 *Polynomial trend of the second degree for the port of Rijeka in the period from 1999 to 2010*

Izvor: autor / ***Source:*** *author*



Grafikon 4. Trend-polinom drugog stupnja za luku Kopar u razdoblju 1999. – 2010. godine
Figure 4 *Polynomial trend of the second degree for the port of Koper in the period from 1999 to 2010*

Izvor: autor / ***Source:*** *author*

stupnja analizirano je kretanje kontejnerskog prometa u luci Rijeka, gdje je koeficijent determinacije R^2= 0,8822. Za luku Kopar optimalan je trend-polinom drugog stupnja, gdje je koeficijent determinacije R^2=0,976. Dakle, modelom trend- polinoma drugog stupnja kojim se vršila analiza kontejnerskog prometa u luci Rijeka protumačeno je 88,22% sume kvadrata odstupanja vrijednosti varijable Y od aritmetičke sredine. Nadalje, trend-polinomom drugog stupnja kojim se vršila analiza kontejnerskog prometa u luci Kopar protumačeno je 97,6%

port of Kopar is R^2=0,976 and the polynomial trend of the second degree is optimal (graph 4).

Table 2 Estimated values of the container traffic are calculated in TEUs $\hat{Y}_i$, i = 13, 14,..., 20 for the period from 2011 to 2018 for the port of Rijeka (polynomial trend of the second degree, figure 3) and for the port of Koper (polynomial trend of the second degree, figure 4)

Table 2 shows that the port of Koper had 3.5 times more traffic than the port of Rijeka in 2010. According to the calculated adaptive val-

Tablica 2.
Table 2

Godina ***Year***	**Rijeka**	**Kopar**
2010	137 048	476 731
2011	179 515	531 544
2012	196 971	611 360
2013	214 684	697 712
2014	232 652	790 597
2015	250 874	890 017
2016	269 351	995 971
2017	288 082	1 108 460
2018	307 068	1 227 483

Izvor / Source

sume kvadrata odstupanja vrijednosti varijable Y od aritmetičke sredine. Trend model je reprezentativniji ako je ovaj pokazatelj bliži 1. Budući da koeficijent determinacije iznosi 0,8822 za luku Rijeka i 0,976 za luku Kopar, proizlazi da je trend-polinom drugog stupnja reprezentativan.

Uporabom jednadžbe trend-polinoma drugog stupnja s procijenjenim parametrima izračunate su vrijednosti trenda i to uvrštavanjem u jednadžbu vrijednosti x_i, i = 13, 14,..., 20 što predstavlja vrijeme, odnosno godine od 2011. do 2018. Dakle, dobivene vrijednosti trenda, predstavljaju procjene kretanja kontejnerskog prometa u lukama Rijeka i Kopar u promatranom razdoblju.

S obzirom da je riječki kontejnerski terminal ograničen brojem smještajnih kapaciteta kontejnera, nužno je izvršiti proširenje istog ili skratiti vrijeme istovara, utovara i odvoza kontejnera. Tehnološku i organizacijsku modernizaciju treba obaviti prije nego se izađe iz recesije, jer od 2000. godine počinje naglo rasti broj kontejnera u riječkoj luci. U razdoblju od 2000. do 2008. godine kontejnerski promet u luci Rijeka je porastao s 8.925 TEU-a na 168.761 TEU-a, što je porast za 19 puta. U istom se razdoblju njegov udio na sjevernojadranskom prometnom pravcu povećao s 3% na 20 %. Model pokazuje da postoje tendencije daljnjeg porasta kontejnerskog prometa, kao i preusmjeravanje dijela kontejnerskog prometa iz konkurentne luke Kopar ka riječkom prometnom pravcu.

Iz tablice 1. može se zaključiti da ukupni kontejnerski promet luka u Rijeci i Kopru imaju rast od 18% 2001. s obzirom na 2 000. godinu, zatim rast od 15% 2002. s obzirom na 2001. godinu i rast od 14% 2003. s obzirom na 2002. g., 2004. s obzirom na 2003. g. je značajniji rast od 45%, a od 2004. g. i sve do 2007. g. bio je rast u rasponu od 20% do 44%. 2008. godine bio je niži rast od 16%. Međutim, 2009. s obzirom na 2008. godinu bio je pad od 9%. i konačno 2010. s obzirom na 2009. g. bio je rast prometa za 30%.

Razvojnim projektima na riječkom kontejnerskom terminalu potrebno je modernizirati lučku infrastrukturu, suprastrukturu i opremu, čime bi se stvorili preduvjeti za prihvat povećane količine kontejnera u narednim godinama. Prognozirano povećanje prometa na riječkom kontejnerskom terminalu te dobiveni rezultati

ues $\hat{Y}_i$, the port of Rijeka will have by 3.4 times less container traffic than the port of Koper in 2014.. Furthermore, in 2018. the port of Koper will achieve 4 times more traffic than the port of Rijeka.

When comparing the traffic in the port of Rijeka in 2010, which amounted to 137,048 TEUs, to the predicted container traffic in 2018., which is expected to be of 307,068 TEUs, it can be concluded that the port of Rijeka will double its container traffic. In 2010, the port of Koper realized the container traffic of 476,731 TEUs, and in 2018, the predicted container traffic will be of 1,227,483 TEUs, representing an increase by 2.6 times. Therefore, the port of Kopar will achieve a greater increase in the container traffic as compared to the port of Rijeka.

5. CONCLUSION

At the ports of Rijeka and Kopar, the container traffic statistic analysis is conducted by means of the polynomial trend of the second degree, when referring to the 1999 – 2010 period. The results are measured by the TEUs, but for the 2011 – 2018 period, the adaptive values were used $\hat{Y}_i$, i = 13, 14,..., 20.

The statistical analysis of the parabolic trend is conducted by means of the regression analysis methods. The numeric analysis of the polynomial trend of the second degree is conducted and it includes the estimation of the unknown parameters β_0, β_1,..., β_k. The indicator of representation, that is, the determination coefficient, is also present. The container traffic movement of the port of Rijeka is analyzed by means of the polynomial trend of the second degree, which shows that the determination coefficient is R^2= 0.8822. The polynomial trend of the second degree is optimal for the port of Kopar and its determination coefficient is R^2=0.976 Therefore, 88.22% of the total sum of the variable Y deviation squares from the arithmetic mean is accounted for by means of the polynomial trend of the second degree, which was used for the container traffic analysis at the port of Rijeka. Furthermore, 97.6% of the total sum of the variable Y deviation squares from the arithmetic mean is accounted for by means of the polynomial trend of the second degree, which was used for the container traffic analysis at the port of Kopar. The trend model is more representative if the value of the indicator is approximately 1. Since the determination coefficient

istraživanja su prikazani u tablici 2. Predviđeni promet kontejnerskog prometa u luci Rijeka za 2013. g. je oko 214.684 TEU-a, a za 2016. godinu je 269.351 TEU-a. Do 2016. g. se planira povećati kapacitet na 600 000 TEU-a, ali prema prognostičkim vrijednostima trend-polinoma drugog stupnja proizlazi da će promet biti 269.351 TEU-a, odnosno 45% kapaciteta neće biti iskorišteno.

Pozitivna tendencija rasta kontejnerskog prometa u luci Rijeka povoljno će se odraziti i na gospodarstvo Republike Hrvatske, doprinoseći razvoju lokalne zajednice, Županije te ostalih sudionika razvoja multimodalnog transporta.

Priznanje:

Rad je izrađen uz potporu Ministarstva znanosti, obrazovanja i športa RH, u okviru projekta broj: 112-1121722-1719.

value of the port of Rijeka is 0.8822 total, and the determination coefficient value of the port of Kopar is 0.976 total, it can be concluded that the polynomial trend of the second degree is quite representative.

The trend numbers were calculated by means of the polynomial trend of the second degree equation, that is, by the insertion of numbers in the equation x_i, i = 13, 14,..., 20 which represents the 2011 – 2018 period of time. Therefore, the calculated trend results represent the predicted container traffic movement at the port of Rijeka and Kopar in the given period of time.

Since the container terminal of the port of Rijeka has limited available space capacities for container handling, it is necessary to expand that space as well as to shorten the time of unloading, loading and transportation of the containers. It is necessary for the technological and organisational modernisation to take place before the recession time ends because there has been a rapid growth of the containers at the port of Rijeka since 2000. During the 2000 – 2008 period of time, the container traffic increased from 8,925 TEUs to 168,761 TEUs at the port of Rijeka, which means that it increased 19 times. During the same period the container traffic share increased from 3% to 20% on the northadriatic transport route. The trend indicates that there are tendencies towards a further container traffic growth and towards redirecting a share of the container traffic from the competing port of Koper towards the transport route of the port of Rijeka.

Table 1 demonstrates the total 18% container traffic growth at the port of Rijeka and Kopar in 2001 as compared to the year 2000, 15% in 2002 as compared to the year 2000, 14% in 2003 as compared to the year 2002. There is a more significant growth by 45% in 2004 as compared to the year 2003. In the 2004 – 2007 period of time, the growth was from 20% to 44% and in 2008, there was a lower growth, only by 16%. However, in 2009 there was a decrease by 9% as compared to the year 2008, and, finally, in 2010 there was a container traffic growth by 30% as compared to the year 2009.

It is necessary to modernize the port infrastructure, suprastructure and equipment through development projects. That would create the necessary prerequisites for the reception of the increased number of containers during the following years. The container traffic

growth is predicted at the container terminal of the port of Rijeka and the research results are presented in Table 2. In 2013, the amount of the predicted container traffic is about 214,684 TEUs at the port of Rijeka, and in 2016, the predicted amount is 269,351 TEUs. By the year 2016, it is planned to increase the capacity up to 600,000 TEUs, but the prognostic results of the polynomial trend of the second degree have indicated that the amount of the container traffic will be 269,351 TEUs, in other words, 45% of the capacity will not be used.

The positive tendency towards the container traffic growth in the port of Rijeka will positively reflect on the Croatian economic situation because of its contribution to the local community development, to the county and other participants in the multimodal transport.

Acknowledgement:

This material is based on the research supported by Ministry of Science, Education and Sports of the Republic of Croatia under the Project No.: 112-1121722-1719.

LITERATURA / ***REFERENCES***

[1] Barić, S., I. Devčić, M. Valenčić, Analiza kontejnerskog prometa luke Rijeka u usporedbi s konkurentskim lukama Kopar i Trst, Pomorski zbornik 45 (2008), 1, 165-179.

[2] Bendeković, J., A. Jolić, N. Jolić, Upravljanje kvalitetom lučkih usluga, Ekonomska misao i praksa, 19 (2010), 1, 85-104.

[3] Dundović, Č., et al., Integracija i koordinacija lučkog i prometnog sustava Republike Hrvatske, Rijeka, Pomorski fakultet u Rijeci, 2006.

[4] Grčić, B., Poslovna statistika u MS Excelu, Split, Veleučilište u Splitu, 2001.

[5] Hauselmaier, S, I. Lončarić, A. Mataruga, Strategija razvoja Luke Rijeka d. d., Pomorski zbornik 45 (2007), 1, 153-163.

[6] Hess, S., Planiranje prometne potražnje, Rijeka, Pomorski fakultet u Rijeci, 2010.

[7] Kesić, B., et al., Projekcija razvoja pomorskog gospodarstva Republike Hrvatske s posebnim osvrtom na mogućnost suradnje sa susjednim pomorskim zemljama/lukama (posebno na Jadranu), Studija, Rijeka, Pomorski fakultet Sveučilišta u Rijeci**,** 2008.

[8] Kesić, B., A. Jugović, Riječki prometni pravac, Rijeka, PGŽ, 2003.

[9] Kmenta, J., Počela ekonometrije, Zagreb, Mate, 1997.

[10] Salvatore, D., Ekonomija za menedžere, Zagreb, Mate, 1994.

[11] Šošić, I., Primijenjena statistika, Zagreb, Školska knjiga, 2004.

[12] Tomašević, M., Regresijka analiza i aproksimacija pomoću Čebiševljevih polonima, Informatologija, 42 (2009), 3, 166-172.

[13] Tomašević, M., Statističke metode u istraživanju, Split, Sveučilište u Splitu, Pomorski fakultet, 2007.

[14] Tomašević, M., Skupovi, brojevi, funkcije., Split, Sveučilište u Splitu, Pomorski fakultet, 2006.

[15] www.lukarijeka.hr

[16] www.portauthority.hr

[17] http://www.lukarijeka.hr/_Data/Files/186_20100722121029225/Konsolidirano%20godi%C5%A1nje%20izvje %C5%A1%C4%87e_%202009%20.pdf

[18] http://www.business.hr/hr/Kompanije/Vijesti/ICTSI-u-Luku-Rijeka-ulaze-70-milijuna-eura