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ANALIZA EFIKASNOSTI PUTNIČKIH LUKA U REPUBLICI HRVATSKOJ

ANALYSIS OF PASSENGER PORT EFFICIENCY IN THE REPUBLIC OF CROATIA

SAŽETAK

Putničke luke važan su gospodarski i pomorski podsustav Republike Hrvatske. U radu je analizirana relativna tehnička efikasnost pomorskoputničkih luka u Republici Hrvatskoj primjenjujući metodu omeđivanja podataka korištenjem ulaznih varijabli duljine i površine obale i izlaznih varijabli prometa putnika i vozila. Metoda omeđivanja podataka svrstava se u najkorištenije metode za procjenu relativne efikasnosti luka. Analizom su pomorskoputničke luke rangirane prema efikasnosti uz prikaz odstupanja ulaznih i izlaznih varijabli od potpune relativne tehničke efikasnosti.

***Ključne riječi*:** *pomorskoputničke luke, metoda omeđivanja podataka (DEA), efikasnost*

SUMMARY

Passenger ports are an important economic and maritime sub-system in the Republic of Croatia. This paper provides a study of the relative technical efficiency of sea passenger ports in the Republic of Croatia in which the data envelopment analysis (DEA), using the coastal length and surface area as input variables and passenger and vehicle traffic as output variables, has been applied. The DEA method is amongst the most frequently used methods of the port relative efficiency estimation. This analysis gives a ranking of the sea passenger ports by efficiency showing deviations of input and output variables from the total relative technical efficiency.

Key words: *sea passenger ports, data envelopment analysis (DEA) method, efficiency*

1. UVOD

U Republici Hrvatskoj postoji nekoliko pokretača pomorskog putničkog prometa, a najznačajniji od njih je turizam. Pomorskoputnički promet dijeli se na linijski i turistički. U linijskom prometu ističe se promet s otocima, a u turističkom, promet putnika brodovima na međunarodnim kružnim putovanjima, kabotažnim kružnim putovanjima i dnevnim izletima. Jedna od sastavnica pomorskoputničkog prometa su i pomorskoputničke luke.

Za razliku od teretnih luka, pomorskoputničke luke vrlo su malo obrađivane u stranoj znanstvenoj literaturi i njihova produktivnost i efikasnost nije značajnije tretirana. Jedan od rijetkih autora je Pantouvakis (2006) koji analizira kvalitetu lučke usluge i profil pomorskog putnika ili Chlomoudis, et al. (2004) u čijem se radu specificira ograničeni broj usluga putničke luke. Uviđajući značaj pomorskoputničkih luka u RH, hrvatski autori Kesić, Jugović (2006), Jugović, et al. (2007), Jugović, Lončar (2008), Kolanović (2007), Kolanović et al. (2009) daju značajan doprinos istraživanju ove teme.

Produktivnost i efikasnost teretnih luka značajnije se proučava od druge polovice prošlog stoljeća, dok su za pomorskoputničke luke u razdoblju od 1997. do 2007. evidentirane svega dvije studije pomorskoputničkih luka [25]. Također, ni brojna literatura na temu pomorskoputničkih luka u RH nije se detaljnije bavila njihovom produktivnosti i efikasnosti. U pomorskoputničkim lukama pruža se usluga brodovima, putnicima i vozilima koji se njima prevoze. Iako je usluga nematerijalna po svojoj prirodi, ona se proizvodi na skupim nekretninama lučke podgradnje i nadgradnje, koje se, da bi bile i gospodarski opravdane, trebaju efikasno koristiti.

Mjerenje produktivnosti i efikasnosti pojedine luke zahtijeva stavljanje u odnos količine proizvedene usluge i količine upotrijebljenog utroška. Tradicionalno, mjere produktivnosti kao što su produktivnosti rada, utrošak energije i slično, mjere su parcijalne produktivnosti [4]. Za mjerenje relativne efikasnosti luka korištenjem više ulaznih i izlaznih varijabli od početka devedesetih godina prošlog stoljeća [27], najčešće se koristi metoda analize omeđivanja podataka (data envelopment analysis – DEA).

U ovome se radu analizira relativna tehnička efikasnosti pomorskoputničkih luka primjenjujući DEA metodu. U drugom dijelu rada dane

1. INTRODUCTION

There are several initiators of maritime passenger transportation in the Republic of Croatia (RC), the most important being the tourist industry. Maritime passenger transportation is divided into two categories: shipping line and tourist traffic. A prominent feature of line traffic is traffic to islands, whereas the main features of tourist traffic are international cruise tours, coastal cruise tours and daily excursions. One of the components of maritime passenger transportation are sea passenger ports.

Unlike cargo ports, sea passenger ports have not often been subject of study by foreign researchers and their productivity and efficiency have not been seriously analysed. Among the few authors are Pantouvakis (2006) who analyses the quality of port service and profile of a sea passenger, and Chlomoudis et al. (2004) whose paper specifies the limited number of a sea passenger port services. Realizing the significance of sea passenger ports in the RC, Croatian authors Kesić, Jugović (2006); Jugović et al. (2007); Jugović, Lončar (2008); Kolanović (2007) and Kolanović et al. (2009) have made a major contribution to the research of this issue.

Productivity and efficiency of cargo ports has been a major subject of study since the second half of the past century whereas there were only two studies on sea passenger ports recorded in the period from 1997 to 2007 (Pallis et al. 2010). Moreover, a considerable number of studies on sea passenger ports in the RC have not been concerned with their productivity and efficiency. In sea passenger ports the service is rendered to vessels and passengers and vehicles carried on board them. Although such a service is intangible by its nature, it is supplied on the expensive property of port sub- and superstructure which, in order to be economically justified, should be used efficiently.

The measuring of a particular port productivity and efficiency requires putting into relation the quantity of service produced and the quantity of consumption used. The traditional measures of productivity such as productivity of labour, consumption of energy etc. are measures of partial productivity (Coelli, T., J. et al., 2005). Since the early 90's of the past century (Roll, Hayuth, 1993), the most frequently used method of measuring port relative efficiency using multiple input and output variables has been the data envelopment analysis (DEA).

su osnove o poslovanju pomorskoputničkih luka, uslugama koje one pružaju i mjerenju efikasnosti. Kratki prikaz DEA metode i njene dosadašnje primjene u lučkom gospodarstvu opisani su u trećem dijelu. Primjena metode na pomorskoputničkim lukama u RH prikazana je u četvrtom dijelu, dok je u petom dijelu izvršena analiza dobivenih rezultata.

2. PUTNIČKE LUKE U RH

Putnička luka posebna je podvrsta ili podsustav lučkog sustava u kojoj se, na specijaliziranim terminalima, obavlja ukrcaj i iskrcaj putnika, prtljage i automobila [16]. Jedan od kriterija za podjelu luka je prema vrsti putničkog prometa na: luke za brodove u linijskom prijevozu i luke za brodove na kružnim putovanjima. Podgradnja i nadgradnja luke ili terminala radi specifičnosti vrste prometa koji se u njoj obavlja prilagođena je zahtjevima pojedine vrste prometa. Promet pomorskoputničkih luka izvedena je potražnja iz drugih gospodarskih sustava, između ostalog i sustava turizma gdje je promet elementarni podsustav, a unutar njega i podsustav pomorskih luka.

RH je 2008. godini po broju pomorskih putnika u EU27 i Norveškoj (Tablica 1) zauzimala

This paper provides a study of the relative technical efficiency of sea passenger ports applying the DEA method. In the second part of the study, the author lays down the principles of sea passenger port operations, services supplied and measurement of efficiency. An outline of the DEA method and its past applications in the port economy are described in the third part. The application of the method to the sea passenger ports in the RC is given in the fourth part, while the fifth part contains the analysis of the results obtained.

2. PASSENGER PORTS IN THE RC

A passenger port is a specific sub-type or sub-system of the port system, in which embarkation and disembarkation of passengers and loading and unloading of luggage and cars are carried out at specialised terminals (Kesić, Jugović, 2006). One of the criteria used for the classification of ports is according to the type of passenger transportation, thus: ports for ships in line transportation and ports for cruise tours ships. Due to the specific character of the traffic carried on in a port, sub- and superstructures of such a port or terminal are designed to meet the requirements of the specific type of transportation. Sea passenger port traffic is a

Tablica 1. Vodeće države Europe 2008. (EU27+NO) po broju pomorskih putnika u lukama (u tisućama)
Table 1 *The 2008 European leading countries (EU27+NO) by number of maritime travellers in ports (in thousands)*

	1	2	3	4	5	6
Redoslijed prema broju putnika *Order by number of passengers*	Država *Country*	Broj putnika *Number of passengers*	Broj Stanovnika *Number of inhabitants*	2/3	Redoslijed prema kol. broj 4 *Order by Column 4*	Udio u EU27 i Norveškoj (%) *Share in EU27 and Norway (%)*
1	Greece	91.101	11.262	8,09	3	21,74
2	Italy	90.156	58.145	1,55	6	21,51
3	Denmark	46.657	5.447	8,57	2	11,13
4	Sweden	32.745	9.208	3,56	5	7,81
5	UK	29.555	61.612	0,48	7	7,05
6	Germany	28.945	83.500	0,35	9	6,91
7	France	26.813	63.714	0,42	8	6,40
8	Croatia	26.044	4.492	5,80	4	6,21
…..	…….					
12	Malta	8.132	414	19,64	1	1,94

Izvor: http://epp.eurostat.ec.europa.eu/portal/page/portal/eurostat/home/ 25. 08. 2010.
Source: *http://epp.eurostat.ec.europa.eu/portal/page/portal/eurostat/home/ 25/08/2010*

Tablica 2. Pomorski putnici u unutarnjem i međunarodnom prometu u lukama RH (u tisućama)
Table 2 *Maritime passengers in home and international transportation in ports of the RC (in thousands)*

	Putnici u unutarnjem prometu ***Home passengers***	**Putnici u međunarodnom prometu** ***International passengers***	**Ukupno putnika** ***Total passengers***	**Ver. indeks putnika u unut. Prometu** ***Chain index home passengers***	**Ver. indeks putnika u međunarodnom prometu** ***Chain index international passengers***	**Ver. indeks ukupno Putnika** ***Chain index total passengers***
1997	12.209	323	12.532			
1998	12.420	332	12.752	101,7	102,8	101,8
1999	12.888	237	13.125	103,8	71,4	102,9
2000	14.576	364	14.940	113,1	153,6	113,8
2001	16.358	475	16.833	112,2	130,5	112,7
2002	17.809	601	18.410	108,9	126,5	109,4
2003	18.718	766	19.484	105,1	127,5	105,8
2004	20.774	1.836	22.610	N/A	N/A	N/A
2005	21.459	1.960	23.419	103,3	106,8	103,6
2006	22.462	2.073	24.535	104,7	105,8	104,8
2007	23.913	2.383	26.296	106,5	115,0	107,2
2008	25.541	2.741	28.282	106,8	115,0	107,6
2009	25.509	2.748	28.257	99,9	100,3	99,9

Izvor: Statistički ljetopis RH 2007., DZS, 2007. str. 360., Statistički ljetopis RH 2010., DZS, 2010., str. 349.
Source: *2007 Statistical Yearbook of the RC, CBS, 2007, p. 360; 2010 Statistical Yearbook of the RC , CBS, 2010, p. 349*

osmo mjesto, ali po odnosu broja stanovnika i prevezenih putnika na četvrtom je mjestu s 5,8 putnika/stanovniku, iza Grčke i Danske s razvijenijim gospodarstvom na otocima i otočne države Malte. Prema EU statistici u RH je 2008. prevezeno 6,21% od ukupnih putnika u EU27 s uključenom Norveškom.

Evidentan rast prometa putnika u pomorskim lukama u razdoblju od 1997. do 2009. godine (Tablica 2), bez obzira na promjenu metodologije evidentiranja 2004., ukazuje na rast putničkog lučkog prometa. Jedan od najbržih rastućih turističkih podsustava je podsustav putničkih brodova na kružnim putovanjima čiji se dolasci u RH statistički evidentiraju od 2002. godine.

Kružna putovanja u promatranom razdoblju bilježe značajne stope rasta u svim svojim pokazateljima, a najviše u broju putnika (Tablica 3) koji se u 2009. godini u odnosu na 2002. povećao za 240%. Osim rastućeg broja dolazaka i broja putnika, uočava se i stalan rast broja putnika po putovanju ukazujući na porast veličine brodova povećavajući tako zahtjeve pred lučku podgradnju, nadgradnju i logistiku.

demand derived from other economic systems, among others from the tourist industry system in which transportation is the elementary sub-system that also encompasses the sub-system of seaports.

In 2008, the RC occupied the eighth place in the number of maritime passengers in the EU27 and Norway (Table 1), but by relation of the number of inhabitants to the transported passengers, with 5.8 passengers, it holds the fourth place, behind Greece and Denmark with more developed insular economy, and insular country Malta. According to the EU statistics, in 2008 the RC had 6.21% of the total number of passengers transported in the EU27, Norway included.

A marked growth of passenger traffic in sea ports in the period from 1997 to 2009 (Table 2), regardless the change of the recording methodology in 2004, indicates the growth of the passenger port traffic. One of the fastest growing tourist sub-systems is the sub-system of cruise tour ships, the arrivals whereof in the RC have been statistically recorded since 2002.

Cruise tours in the observed period of time record significant growth rates in all their indicators, and most in the number of passengers (Table 3), which in 2009 shows a 240% increase on 2002. In addition to the increasing number

Tablica 3. Dolasci stranih brodova na kružnim putovanjima u luke RH
Table 3 *Arrivals of foreign cruise tour ships in the ports of the RC*

1	2	3	4	5	6	7	8
Godina ***Year***	Broj putovanja ***Number of cruise tours***	Broj putnika ***Number of passengers***	Broj dana boravka ***Number of stay days***	Ver. indeks (kol. 2) ***Chain index (Column 2)***	**Ver. indeks (kol. 3)** ***Chain index (Column 3)***	**Dani boravka po putovanju** ***Stay days per tour***	**Broj putnika po putovanju** ***Number of passengers per tour***
2002	421	290.346	791			1,88	689
2003	430	420.542	530	102	145	1,23	978
2004	420	440.254	528	98	105	1,26	1.048
2005	456	511.417	658	109	116	1,44	1.121
2006	565	597.708	800	124	117	1,42	1.057
2007	628	694.104	990	111	116	1,58	1.105
2008.	822	939.848	1.569	131	135	1,91	1.142
2009	754	989.272	1.264	92	105	1,68	1.312
Bazni indeks 2009. (2002.=100) ***Fixed base index 2009 (2002=100)***	179,09	340,72	159,80				190,43

Izvor: Statistički ljetopis 2008., DZS, 2008., str. 449., Priopćenje: Kružna putovanja stranih brodova u RH u 2009. br. 4.4.7/8, DZS, 2010.
Source: *2008 Statistical Yearbook, CBS, 2008, p. 449; Statement: Cruise tours of foreign ships in RC 2009, No. 4.4.7/8, CBS, 2010*

Tablica 4. Promet putnika u morskim lukama po mjesecima u 2009.[1]
Table 4: *Monthly passenger traffic in sea ports in 2009*[2]

Mjesec / ***Month***	**Broj putnika** / ***Number of passengers***	**Udio (%)** / ***Share (%)***
I	766,413	2.7
II	729,731	2.6
III	939,581	3.3
IV	1,559,553	5.5
V	2,389,939	8.5
VI	3,242,161	11.5
VII	5,434,387	19.2
VIII	6,438,497	22.8
IX	3,176,993	11.2
X	1,754,877	6.2
XI	1,017,255	3.60%
XII	807,493	2.86%
Ukupno / ***Total***	28,256,880	100.00%
Indeks VIII./I. / ***Index Aug./Jan.***	840	

Izvor: Transport i komunikacije u 2009., Statistička izvješća, DZS, 2010., str. 121.
Source: *Transport and communications in 2009, Statistical reports, CBS, 2010, p. 121*

[1] Uključeni su putnici na brodovima za kružna putovanja koji su se iskrcali radi obilaska te se ponovo ukrcali i nastavili kružno putovanje. Podaci sadrže njihov iskrcaj i ponovni ukrcaj.
[2] Included are cruise tour ship passengers who disembarked for city tours and re-embarked to continue the cruise tour. Data contain their disembarkation and re-embarkation

Činjenica stalnog porasta broja putnika i vozila u putničkim lukama i njihov odnos s obzirom na broj stanovnika ukazuju na značaj pomorskoputničkih luka u ukupnom gospodarstvu RH. Znatan dio prometa generiran je turizmom, značajnom gospodarskom granom u primorskim mjestima. Jedna od općih karakteristika turizma je sezonska varijacija koja je u Hrvatskoj povezana s ljetnom sezonom zbog povećanog broja dolazaka turista vezanih uz ljetne aktivnosti. Indeks sezonalnosti (Tablica 4) mjeren odnosom putnika u pomorskim lukama u kolovozu u odnosu na siječanj 2009. iznosio je 840, i očigledan je pokazatelj razlike opterećenja luka za vrijeme i izvan turističke sezone. Jedna od karakteristika objekata podgradnje je njezino dimenzioniranje prema vršnom opterećenju, čime se kod ovako izraženih sezonskih varijacija putnika stalno preispituje efikasnost poslovanja luke.

Efikasnost ili produktivnost je odnos količine proizvedenih proizvoda ili usluga, u ovom slučaju ukrcanih, iskrcanih putnika i vozila, s količinom uloženog utroška lučkog poslovanja. Ova jedinična ili parcijalna mjerenja produktivnosti računaju se bilo u monetarnim ili fizičkim jedinicama. Problem s jediničnim ili parcijalnim indikatorima je kod višeulaznih ili višeizlaznih varijabli lučke proizvodnje, kad koncept mjerenja produktivnosti jednim ili setom ulaznih/izlaznih varijabli odnos volumena više nije valjan i ne prikazuje ispravno ukupnu produktivnost faktora (total factor productivity – TFP) [2]. Od kada su Roll i Hayuth (1993) teoret-skim modelom bez korištenja stvarnih podataka primijenili metodu omeđivanje podataka (data envelopment analysis – DEA) na lučku djelatnost, metoda je postala najčešće primjenjivana za mjerenje ukupne relativne efikasnosti luka.

3. OPIS DEA METODE

Statističke regresijske metode mjere produktivnosti ili efikasnost "jedinica za donošenje odluke" (decision making unit – DMU) u odnosu na prosjek ili trend. Za razliku od stati-stičkih metoda, DEA metoda identificira najboljeg/najbolje iz skupa uspoređivanih DMU smještenog/ih na granici efikasnosti što omeđuje ostale manje efikasne, a koje uspoređuje s najboljim DMU . Jedinica za donošenje odluka (DMU) općenito se smatra subjekt koji je odgovoran za pretvaranje utroška u proizvod i čije izvršenje

of arrivals and passengers, there is evidence of a continuous rise in the number of passengers per tour, which implies that ships become larger in size. This again means that larger demands are put before the port sub-structure, superstructure and logistics.

The fact that the number of passengers and vehicles in passenger ports has been constantly growing, and their relation compared to the number of inhabitants, show the significance of sea passenger ports in the aggregate economy of the RC. A considerable portion of traffic is generated by tourism, a prominent branch of economy in coastal towns. One of the general characteristics of tourism is seasonal variation. In Croatia, it is associated with the summer season due to the increased arrivals of tourists connected with summer activities. Seasonality index (Table 4), measured by relation between passengers in sea ports in August compared to January 2009, was 840 and is an unmistakable indicator of a difference in port loads during high and off tourist seasons. One of the characteristics of substructure facilities is its dimensioning towards peak load, whereby in such distinct seasonal variations of passengers, the efficiency of port operations is repeatedly examined.

Efficiency or productivity is the ratio of the quantity of products or services produced, in this case embarked/disembarked passengers and loaded/unloaded vehicles, to the amount of invested port operations expenditure. These single or partial productivity measurements are calculated either in monetary or physical units. The problem with single or partial indicators with multiple-input or multiple-output variables of port production is that the concept of productivity measured with one or a set of output/input volume ratios is no longer valid and fails to reflect the total factor productivity (TFP). (Bichou, 2009) Since Roll and Hayuth (1993) applied the DEA method to port sector employing a theoretical method without the use of factual data, the DEA has become a most frequently used method applied in the measurement of the total relative efficiency of ports.

3. DESCRIPTION OF THE DEA METHOD

The statistical regression methods measure the productivity or efficiency of decision-making units (DMUs) in relation to the average or trend. In distinction from statistical methods,

je potrebno ocijeniti [6]. Bit analize je pronalaženje najbolje "virtualne" DMU smještene na granici efikasnosti za svaku stvarno uspoređivanu DMU. Ako je "virtualna" DMU bolja od stvarnog DMU proizvodeći veće količine proizvoda/usluga s istim utroškom ili proizvodnjom iste količine proizvoda/usluga s manje utroška tada je promatrana DMU neefikasna. Kod tehničkih znanosti teoretski moguću razinu efikasnosti moguće je dobiti računskim metodama, dok u većini menadžerskih ili društvenih znanosti to nije moguće. Stoga je za ove znanosti tehnička definicija efikasnosti prilagođena upotrebi samo s empirijski dostupnim podacima. Prema takvom stajalištu, definicija za relativnu efikasnost glasi: **Jedinica donošenja odluke (DMU) bit će označena kao potpuno efikasna (100%) na temelju dostupne evidencije samo ako ostvarenja drugih jedinica donošenja odluke ne pokazuju da se isti utrošak ili količinu proizvoda može poboljšati bez pogoršanja nekog od drugih utrošaka ili količine proizvoda [5].**

Metoda je utemeljena na linearnom programiranju za mjerenje relativnih ostvarenja DMU, gdje je zbog višestrukih ulaznih i izlaznih varijabli usporedba otežana. Na temelju definicije efikasnosti "efikasnost = izlazna varijabla/ulazna varijabla" na efikasnost se može djelovati promjenom ulaznih ili izlaznih varijabli. Sukladno tome definirane su i dvije osnovne varijacije DEA tehnike na: orijentirane ulaznim varijablama i orijentirane izlaznim varijablama.

DEA metodu inicijalno su predložili Charnes, Cooper i Rhodes 1978., po kojima je i nazvan osnovni CCR model. Naknadno je razvijeno još alternativnih modela u svrhu dobivanja što kvalitetnijih rezultata istraživanja. Jedan od njih je i model Bankera, Charnesa i Coopera, (BCC), publiciran 1984. koji umjesto pravolinijske granice efikasnosti s polazištem iz ishodišta, granicu efikasnosti prikazuje u obliku krivulje, približavajući je tako stvarnim situacijama (Slika 1). Metoda daje rezultate u pozitivnim granicama 0 – 1, gdje je 1 relativno najefikasnija DMU.

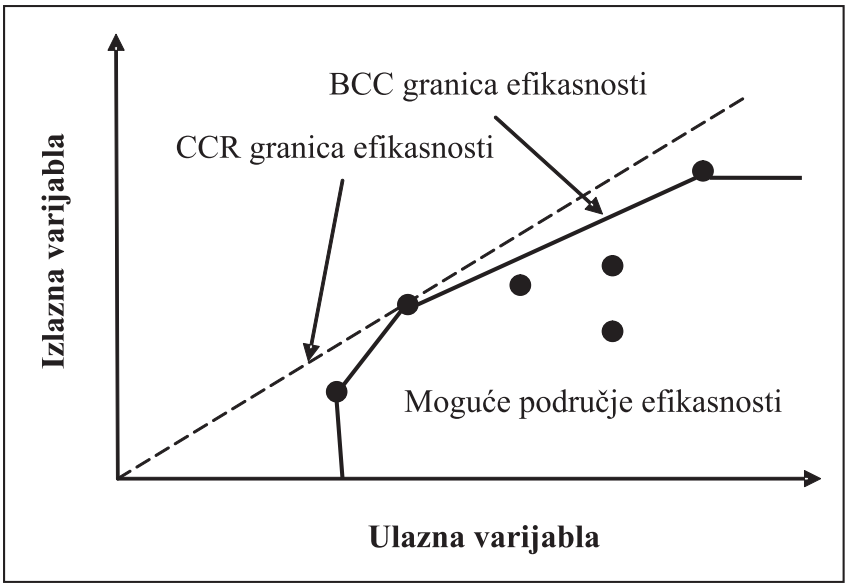
Osnovne prednosti DEA metode su:

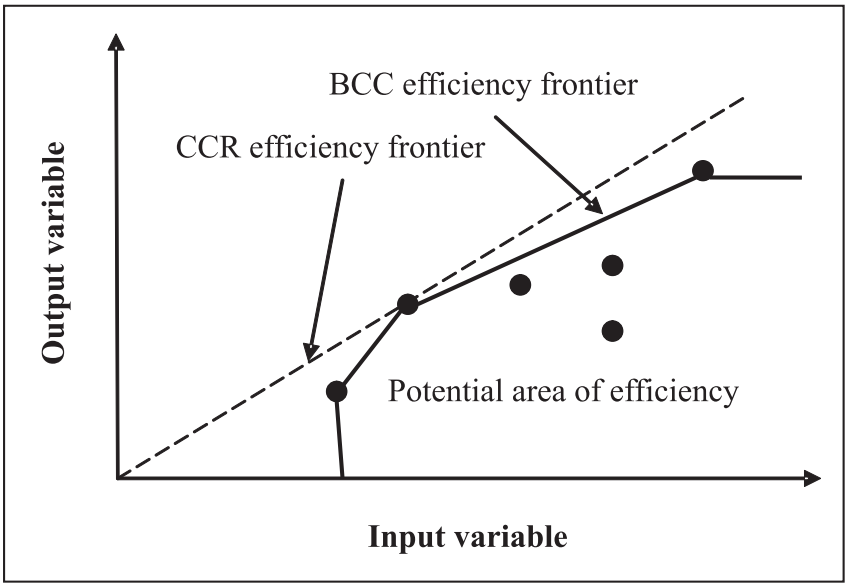
- ne zahtijeva funkcionalne forme koje se odnose na ulazne ili izlazne varijable,
- jedinice za donošenje odluka izravno se uspoređuju s drugom ili drugima,
- ulazne i izlazne varijable mogu imati sasvim različite jedinice,
- dok su nedostaci sljedeći:

the DEA method identifies the best one from the group of the DMUs compared, positioned on the efficiency frontier that encompasses other less efficient ones that are compared to the best DMU. A DMU is generally considered to be a subject responsible for turning expenditure into product and the performance whereof should be assessed (Cooper et al. 2007). The essential aim of the analysis is to detect the best "virtual" DMU on the efficiency frontier for each factually compared DMU. If the "virtual" DMU, producing larger quantities of products/services at the same consumption or the same quantities of products/services at lower consumption, appears better of the factual DMU, then the observed DMU is inefficient. In technical sciences, a theoretically possible level of efficiency can be obtained by using computational methods, whereas it is not possible to be done in most sciences of management or social sciences. Therefore, where such sciences are concerned, the technical definition of efficiency is employed only with the available empirical data. According to such approach, the definition of a relative efficiency reads as follows: **A decision making unit will be marked as fully efficient (100%) on the basis of data available only unless performances of other DMUs show that the same expenditure or quantity of products may be improved without affecting any of the other expenditures or quantity of products** (Cooper et al. 2004).

The method is based on linear programming for the estimation of the relative efficiency of DMU; however, multiple input and output variables make the comparison a bit difficult. Relying on the definition of efficiency "Efficiency = output variable/input variable", efficiency may be affected by altering input or output variables. Consequently, two basic variations of the DEA technique have been defined: input-variable oriented and output-variable oriented.

Initially, the DEA method was put forward by Chames, Cooper and Rhodes in 1978, after who the basic CCR model was named. Other alternative models were developed later with the aim to obtain the best possible research results. One of those is the model published in 1984, the BCC model by Banker, Chames and Cooper, which instead of a linear efficiency frontier with the starting point in the origin, shows the efficiency frontier in the form of a curve, thus approaching real situations (Figure 1). The method provides results in positive limits 0-1, where 1 is relatively the most efficient DMU.





Slika 1. Granica efikasnosti DEA CCR i BCC modela
Figure 1 *Efficiency frontier DEA of CCR and BCC models*

Izvor: autor prema Cooper, et al., 2007., str. 88.
Source: *The author according to Cooper et al, 2007, p. 88*

- budući da je DEA tehnika ekstremnih točaka, pogreška u mjerenju može uzrokovati značajan problem,
- DEA je dobra za procjenu relativne efikasnosti, ali ne i apsolutne efikasnosti, odnosno "teoretskog maksimuma",
- s obzirom je DEA neparametrijska tehnika, statistički testovi hipoteze su komplicirani i još se istražuju,
- budući da standardna formulacija DEA kreira odvojeni linearni program za svaku DMU, velike usporedbe mogu računski biti vrlo zahtjevne.

The basic advantages of the DEA method are:

- no need for functional forms related to input or output variables,
- decision-making units are directly compared to other(s),
- input and output variables may have completely different units,
- whereas disadvantages are the following:
- since the DEA is a technique of extreme points, an error in measurement may cause a serious problem,

U pomorstvu DEA metoda se uglavnom koristila za relativnu usporedbu teretnih luka, dok je manji broj studija izrađen za usporedbu brodarskih društava (Lin, W. C., Liu C.F, 2005; Chung, Hwang, 2005). Gonzales, Trujillo (2007) navode ukupno 14 studija u kojima se DEA metoda primjenjuje za mjerenje prosječne lučke efikasnosti, ekonomske efikasnosti ili indeksa efikasnosti. Predmet ovih studija bile su luke Španjolske, Australije, Portugala, Koreje i Meksika, a šest studija bavilo se međunarodnom usporedbom luka.

4. MJERENJE RELATIVNE TEHNIČKE EFIKASNOSTI POMORSKOPUTNIČKIH LUKA

Prema pretraživanjima dostupne literature i interneta, nije evidentirano da je DEA metoda korištene za procjenu relativne tehničke efikasnosti pomorskoputničkih luka. Razlozi za ovo istraživanje nalaze se u: a) znatnim financijskim sredstvima koja se ulažu u putničke luke u RH, b) značaju luka za turizam, c) izgradnji autoceste A1 i A6 i njihovom utjecaju na promet putnika i vozila u hrvatskim lukama, d) značaju putničkih luka za održivost otoka, e) očekivanom skorašnjem ulasku RH u EU i promjenama koje će nastupiti otvaranjem tržišta koncesija i pomorskog dobra, f) značaju putničkih luka u hrvatskom gospodarstvu i širem društvenom kontekstu i g) položaju pomorskoputničkih luka u odnosu na vrijednost zemljišta koje koristi.

DEA metoda zahtijeva višestrukost ulaznih i izlaznih varijabli, a njihov izbor treba reflektira-

- DEA is useful in the estimation of the relative efficiency, but not of the absolute efficiency i.e. “theoretical maximum”,
- considering that DEA is a nonparametric technique, statistical tests of assumption are complicated and are still being researched,
- as the DEA standard formulation creates a separate linear programme for each DMU, extensive comparisons may be very demanding.

The DEA method in the shipping industry was mainly used in the relative comparison of cargo ports, whereas a minor number of studies was made for the purpose of comparing shipping companies (Lin, W.C., Liu, C.F., 2005; Chung, Hwang, 2005). Gonzales, Trujillo (2007) mention altogether 14 studies that use the DEA method in the measurement of the average port efficiency, economic efficiency or efficiency index. The objects of these studies were ports of Spain, Australia, Portugal, Korea and Mexico, while six studies dealt with international ports comparison.

4. MEASUREMENT OF RELATIVE TECHNICAL EFFICIENCY OF SEA PASSENGER PORTS

A search of available bibliography and Internet search have found no evidence to confirm that the DEA method had been used for the estimation of the relative technical efficiency of sea passenger ports. The reasons for this research lie in: a) considerable funds invested in

Tablica 5. Statistički prikaz prometa putnika i vozila u obrađivanim lukama u razdoblju 2004. – 2007. u tisućama
Table 5 *Statistical presentation of passenger and vehicle traffic in the researched ports 2004 – 2007 in thousands*

	2004.		**2005.**		**2006.**		**2007.**		**Aritmetička sredina 04-07** *Mean 2004-2007*	
	Put. ***Psgr.***	**Voz.** ***Vhcl.***	**Put.** ***Psgr.***	**Voz.** ***Vhcl.***	**Put.** ***Psgr.***	**Voz.** ***Vhcl.***	**Put.** ***Psgr.***	**Voz.** ***Vhcl.***	**Put.** ***Psgr.***	**Voz.** ***Vhcl.***
DU	757	30	827	33	896	27	961	26	860	29
ST	3.184	573	3.483	646	3.541	645	3.776	672	3.496	634
ŠI	522	1	524	1	526	2	530	5	526	2
ZD	1.769	263	2.142	316	2.253	323	2.369	352	2.133	313
RI	198	21	216	14	222	11	212	11	212	14

Izvor: Lučka uprava Dubrovnik, 2009., Lučka uprava Split, 2009., Lučka uprava Šibenik, 2009., Lučka uprava Zadar, 2009., Lučka uprava Rijeka, 2009.
Source: *Dubrovnik Port Authority, 2009, Split Port Authority, 2009, Šibenik Port Authority, 2009, Zadar Port Authority, 2009, Rijeka Port Authority, 2009*

ti ciljeve istraživanja. Analizirajući do sada rađene studije s primjenom DEA metode na procjenu efikasnosti kontejnerskih terminala i luka, za ulazne varijable korištene su duljine obale, površine terminala, broj vezova, broj dizalica ili lučkih sredstava, a za izlazne, promet kontejnera i/ili njihova težina.

Promet putnika i vozila u lukama statistički evidentiraju lučke kapetanije, ali zbog nepodudaranja prostornih granica nadležnosti izvještavanja s područjem pod nadležnosti lučkih uprava, čije su ulazne varijable korištene, podaci prometa putnika i vozila dobiveni su od lučkih uprava. U izračunu su obrađene samo luke od osobitog interesa za RH, s obzirom na njihov prometni značaj u pomorskom putničkom prometu, veličinu i društveni značaj njihove infrastrukture, a to su: Dubrovnik (DU), Split (ST), Šibenik (ŠI), Zadar (ZD), Rijeka (RI). U radu nije obrađivana luka Ploče zbog njenog zanemarivog prometa putnika i vozila. U svrhu dobivanja reprezentativnog uzorka koristit će se aritmetička sredina izlaznih varijabli prometa putnika i vozila za pojedine luke za razdoblje 2004. – 2007., kao što je prikazano u tablici 5. Za dobivanje kvalitetnijih rezultata analize potrebno je u daljnjim istraživanjima koristit veći uzorak luka.

Za ulazne varijable putničkih luka odabrani su ukupna duljina vezova i ukupna kopnena površina luke (Tablica 6). Promatrane putničke luke smještene su u neposrednoj blizini središta gradova ili pak one same čine središta oko kojih su nastali gradovi. Vrijednosti zemljišta i nekretnina u neposrednoj blizini luka najviše su u promatranim gradovima. Jedan od čimbenika kojim se može valorizirati efikasno iskorištavanje lučkog područja jest provjera usporedbom s

passenger ports of the RC; b) importance of the ports for the tourism; c) construction of the A1 and A6 motorways and their impact on passenger and vehicle traffic in Croatian ports; d) significance of passenger ports for the sustainability of islands; e) expected imminent entry of the RC into the EU and changes that will occur owing to the opening of the franchise and maritime demesne markets; f) role of passenger ports in the Croatia economy and wider social context, and g) position of sea passenger ports in relation to the value of land they utilize.

The DEA method requires multiple input and output variables and the choice thereof ought to reflect the aims of the research. In the past studies applying the DEA method to the estimation of container ports and terminals efficiency, wharf length, surface area of terminals, number of berths and number of cranes or port appliances were taken as input variables, and container traffic and/or their weight as output variables.

Statistical records of passenger and vehicle traffic in ports are kept by the harbour master's offices, but since spatial limits of the reporting authority do not correspond to the territories under the jurisdiction of port authorities whose input variable were used, the passenger and vehicle traffic data have been obtained from the port authorities. The estimation has included only the ports of a particular interest to the RC considering their traffic significance in sea passenger transportation as well as their size and social significance of their infrastructure. Those ports are: Dubrovnik (DU), Split (ST), Šibenik (ŠI), Zadar (ZD) and Rijeka (RI). The paper has not included the Port of Ploče because its negligible passenger and vehicle traffic. In or-

Tablica 6. Ulazne varijable pojedinih luka
Table 6 *Input variables of individual ports*

DMU ime DMU	Duljina obale m Length of wharf in m	površina luke m^2 Port area in m^2
Dubrovnik-Gruž	1,500	73,460
Split-grad ***(city)***	2,226	79,000
Šibenik	335	24,156
Zadar-grad ***(city)***	980	8,525
Rijeka	1,049	40,000

Izvor: Lučka uprava Dubrovnik, 2009., Lučka uprava Split, 2009., Lučka uprava Šibenik, 2009., Lučka uprava Zadar, 2009., Lučka uprava Rijeka, 2009.
Source: *Dubrovnik Port Authority, 2009, Split Port Authority, 2009, Šibenik Port Authority, 2009, Zadar Port Authority, 2009, Rijeka Port Authority, 2009*

oportunitetnim troškovima zemljišta za druge djelatnosti, uz uvjet mogućnosti preseljenja luke na drugu odgovarajuću lokaciju. Prema tome, za jednu ulaznu varijablu odabrana je površina luke. Duljina obale je veličina prema kojoj pojedine kategorije brodova plaćaju lučke pristojbe ili naknade, ali je i istovremeno i značajan trošak gradnje, te će se stoga koristiti kao druga ulazna varijabla. Ulazne varijable odnose se isključivo na lučki bazen gdje se obavlja promet putnika i vozila, a ne i teretni promet.

Za mjerenje relativne tehničke efikasnosti moguće je koristiti ulazno ili izlazno orijentirani DEA model. Cullinane et al. (2005) za mjerenje kontejnerskih terminala preferira korištenje ulaznog modela. Autori Marlow i Paixao (2002) nerasipnu upotrebu resursa i brzinu reakcije na nestalnom tržištu postavljaju kao ključne elemente opstanka luke. Nerasipna upotreba resursa preduvjet je brzoj reakciji na tržištu. S obzirom da je nerasipna upotreba resursa pod kontrolom operativnog i strateškog menadžmenta, to je lakše s njome upravljati nego brzinom reakcije na tržištu. Autori dalje argumentiraju kako luke mogu relativno dobro procijeniti budući promet kontejnera za najmanje godinu dana, s obzirom na stalnost baze brodarskih linija i temeljem povijesnih podataka. Slijedom ovih argumenta autori sugeriraju korištenje ulazno orijentiranog DEA modela. Analogija se može primijeniti i na pomorsko-putničke luke, gdje je nerasipna upotreba resursa u obuhvatu operativnog i strateškog menadžmenta, a pomorske putničke linije, pa čak i brodovi na kružnim putovanjima, poznate su lučkom menadžmentu najmanje godinu dana unaprijed.

5. REZULTATI ANALIZE EFIKASNOSTI

Pripremljena i objedinjena tablica 7. s ulaznim varijablama duljine obale i površine luke, te izlaznim varijablama broja putnika i broja vozila obrađena je potom programom DEA-Solver LV (3.0), [28]. Za računalnu platformu program koristi Excel, a upute za instalaciju i korištenje programa dane su u [6]. Primijenjen je osnovni DEA model CCR – ulazno orijentiran.

Dobiveni rezultati u tablici 8. za svaku luku prikazani su u trima kolonama: koeficijenta relativne efikasnosti, redoslijedom uspješnosti, i referentnim nizom (λ). Prema dobivenim rezultatima

der to obtain a representative sample, the mean of output variables of passenger and vehicle traffic for particular ports in the period from 2004 to 2007 was used as shown in Table 5. To obtain more reliable results in further research, it is necessary to use a large sample of ports.

Input components include the total length of berths and the total port area (Table 6) The observed passenger ports are situated just off city centres or else, they themselves are centres around which cities have developed. The value of land and real property in the immediate vicinity of ports is the highest in the observed ports. One of the factors in evaluating the efficient utilization of the port area is testing by comparison with opportune land costs for other activities on condition that the port may be moved to another adequate location. Therefore, port surface area has been taken as one input variable. The wharf length is a category by which particular classes of ships pay port fees or charges but it is at the same time a significant construction cost; therefore, it will be used as the second input variable. Input variables relate solely to the port basin where passenger and vehicle and not cargo transport take place.

To measure the relative technical efficiency, it is possible to employ the input oriented or output oriented DEA model. Cullinane et al. (2005) prefer the input model in measuring container terminals. Authors Marlow and Paixao (2005) set the economical use of resources and speed of response in an unstable market as key elements of the port existence. The economical use of resources is a prerequisite of the fast response on the market. As the economical use of resources is under the control of the executive and strategic management, it is more easily managed than the speed of reaction in the market. Further on, the authors argue that ports are able to make a relatively good estimation of the future container traffic for at least a year considering the steadiness of the shipping lines base, and also on the basis of historical data. On the ground of these arguments the authors suggest that the input oriented DEA model should be applied. An analogy may be applied to sea passenger ports, where the economical use of resources is within the scope of port management functions, and the information about the maritime passenger lines and cruise tour ships are available to the port management at least a year in advance.

Tablica 7. Objedinjena tablica ulazne/izlazne varijable pripremljena za analizu
Table 7 *Unified table of input/output variables prepared for analysis*

Luka *Port*	**Duljina obale** *Wharf length*	**Površina luke** *Port area*	**Aritmetička sredina broj putnika 2004. – 2007.** *Mean number of passengers 2004-2007*	**Aritmetička sredina broj vozila 2004. – 2007.** *Mean number of vehicles 2004-2007*
Dubrovnik-Gruž	1,500	7,.460	859,971	28,903
Split-grad *(city)*	2,226	79,000	3,495,944	634,103
Šibenik	335	24,156	525,670	2,276
Zadar-grad *(city)*	980	8,525	2,133,450	313,489
Rijeka	1,049	40,000	211,985	14406

Izvor: Izradio autor prema Cooper et al. 2007. str. 456, i podacima Lučke uprave Dubrovnik, 2009., Lučke uprave Split, 2009., Lučke uprave Šibenik, 2009., Lučke uprave Zadar, 2009., Lučke uprave Rijeka, 2009.
Source: *The author according to Cooper et al. 2007, p. 456, and data from: Dubrovnik Port Authority, 2009, Split Port Authority, 2009, Šibenik Port Authority, 2009, Zadar Port Authority, 2009, Rijeka Port Authority, 2009*

Tablica 8. Rezultati DEA CCR-I modela
Table 8 *Results of the DEA CCR-I model*

No.	**DMU**	**Koeficijent relativne efikasnosti** *Coefficient of relative efficiency*	**Redoslijed** *Order*	**Referentni niz (λ)** *Reference range* **(λ)**	
1	Dubrovnik-Gruž	0,26335	4	Zadar-grad *(city)*	0.40309
2	Split-grad *(city)*	0,89051	2	Zadar-grad *(city)*	2.02273
3	Šibenik	0,72079	3	Zadar-grad *(city)*	0.24639
4	Zadar-grad *(city)*	1	1	Zadar-grad *(city)*	1
5	Rijeka	0,09280	5	Zadar-grad *(city)*	0.09940

Izvor: Izradio autor korištenjem DEA-Solvera-LV (3.0), [28]
Source: *prepared by the author using DEA-Solver-LV (3.0), Tone, K. 1999*

tatima jedina relativno potpuno efikasna putnička luka ili DMU, iz skupa obrađivanih pomorskoputničkih luka je Zadar-grad s koeficijentom relativne efikasnosti "1", dok su sve ostale u odnosu na nju manje efikasne s pozitivnim koeficijentom manjim od "1". Razlozi najbolje relativne efikasnost luke Zadar nalaze se u odnosu veličina ulaznih varijabli, duljini obale i površini luke, u odnosu na veličine izlaznih varijabli, broja putnika i vozila. Kao jedina efikasna luka ona je ujedno i referentna luka za sve druge luke, što je prikazano u koloni "referentni niz (λ)". Vrijednost (λ)"je ponder kojim treba proporcionalno djelovati na obje ulazne varijable luke Zadar-grad za dobivanje pojedinih "virtualnih luka" za stvarne luke, a sukladno njihovim izlaznim varijablama. Najmanje efikasna pomorskoputnička luka je Rijeka s koeficijentom relativne tehničke efikasnosti od 0,09280. Ovdje treba imati na umu da je riječ o relativnoj efikasnosti između uspoređivanih luka dobivenoj na temelju empirijskih rezulta-

5. RESULTS OF EFFICIENCY ANALYSIS

The data in the prepared unified Table 7, with the length of the wharf and the surface of port taken as input variables, and numbers of passengers and vehicles as output variables, have then been processed in the DEA-Solver LV (3.0) programme by Tone, K. (1999). The programme uses Excel as a computer platform, while instructions for the installation and use of the programme were provided in Cooper et al. (2007). The basic CCR input oriented DEA model has been applied.

The results obtained for each port are presented in Table 8 in three columns: Coefficient of relative efficiency, Order of performance and Reference range (λ). According to the obtained results, the only relatively entirely efficient passenger port or the DMU from the set of the analysed ports is Zadar-City with a coefficient of the

Tablica 9. CCR-I projekcija ulaznih varijabli virtualnih luka
Table 9 *CCR-I projection of input variables of virtual ports*

No.	DMU	Koeficijent relativne efikasnosti *Coefficient of relative efficiency*			
	Ulazna /izlazna varijabla *Input/output variable*	**Podaci ulaznih i izlaznih varijabli** *Input/output variables data*	**Projekcije varijabli za virtualne luke** *Projections of variables for virtual ports*	**Razlika** *Difference*	**Potrebna promjena %** *Change needed %*
1	Dubrovnik-Gruž	0,26			
	duljina obale m *length of wharf m*	1.500	395	- 1.105	-73,7
	površina luke m² *port surface m²*	73.460	3.436	- 70.024	-95,3
	broj putnika *No. of passengers*	859.970	859.971	-	0,0
	broj vozila *No. of vehicles*	28.903	126.364	97.461	337,2
2	**Split – grad *(city)***	**0,89**			
	duljina obale m *length of wharf m*	2.226	1.982	- 244	-10,9
	površina luke m² *port surface m²*	79.000	17.244	- 61.756	-78,2
	broj putnika *No. of passengers*	3.495.943	4.315.394	819.451	23,4
	broj vozila *No. of vehicles*	634.102	634.103	-	0,0
3	Šibenik	0,72			
	duljina obale m *length of wharf m*	335	241	- 94	-27,9
	površina luke m² *port surface m²*	24.156	2.101	- 22.055	-91,3
	broj putnika *No. of passengers*	525.670	525.670	-	0,00
	broj vozila *No. of vehicles*	2.275	77.242	74.966	999,9
4	**Zadar – grad *(city)***	**1,00**			
	duljina obale m *length of wharf m*	980	980	-	0,00
	površina luke m² *port surface m²*	8.525	8.525	-	0,00
	broj putnika *No. of passengers*	2.133.450	2.133.450	-	0,00
	broj vozila *No. of vehicles*	313.488	313.488	-	0,00
5	Rijeka	0,09			
	duljina obale m *length of wharf m*	1.049	97	- 952	-90,7
	površina luke m² *port surface m²*	40.000	847	- 39.153	-97,9
	broj putnika *No. of passengers*	211.984	211.984	-	0,0
	broj vozila *No. of vehicles*	14.405	31.149	16.744	116,2

Izvor: Izradio autor korištenjem DEA-Solvera-LV (3.0), [28]
Source: *prepared by the author using DEA-Solver-LV (3.0), Tone*

ta, a ne o apsolutnoj efikasnosti. Analizirajući dobivene koeficijente relativne efikasnosti uočava se njihov veliki raspon. Luke Split i Šibenik svojim rezultatima manje odstupaju od najefikasnije luke Zadar, dok luka Dubrovnik-Gruž i Rijeka imaju znatna odstupanja. Radi usporedbe rezultata daljnjih istraživanja potrebno je analizu efikasnosti, zbog približavanja što realnijim situacijama, izvršiti metodom BCC.

Tablica 9. uz ulazno/izlazne varijable luka i njihove koeficijente relativne efikasnosti dobivene DEA CCR-I modelom, u koloni "projekcije varijabli za virtualne luke" sadrži zahtijevane veličine, pojedinih ulazno/izlaznih varijabli tzv. "virtualnih luka" koje je potrebno postići kako bi svaka od njih postigla potpunu relativnu efikasnost. Kolona "razlika" prikazuje veličinu za koju je potrebno smanjiti ili povećati ulaznu ili izlaznu varijablu za postizanje potpune relativne efikasnosti, dok kolona "potrebna promjena %" ovo smanjenje ili povećanje prikazuje u postotcima. Tako bi na primjer za drugu po efikasnosti luku Split trebalo smanjiti duljinu obale za 243,72 m ili 10,95% i površinu kopnenog lučkog područja za 61.756,22 m^2 ili 78,17% uz istovremeno povećanje prometa putnika za 23,44% kako bi se postigla potpuna relativna efikasnost. Iz odstupanja ulaznih varijabli pojedinih luka prema referentnoj luci Zadar-grad uočavaju se razlozi za njihovu relativnu neefikasnost, odnosno slabu iskorištenost obale i površine.

Uspoređujući projekcije svih virtualnih luka s realnim, evidentno je da su odstupanja najznačajnija u varijabli površine luka i ona je za sve luke, osim luke Split, iznad 90%, a za najmanje relativno efikasnu luku Rijeka 97,88%. Ova činjenica, s obzirom na izlazne varijable srednjeg godišnjeg prometa putnika i automobila, ukazuje na nedovoljnu iskorištenost kopnenih površina luke, što lučke uprave ublažavaju koristeći lučke površine u druge namjene osim lučkih kao što su javna parkirališta, autobusni kolodvor/terminal, opskrbne centre ili povremene dječje zabavne parkove. Činjenica o višenamjenskoj korištenju lučkih površina, osim u svrhu prometa putnika i vozila radi njihova ukrcaja/iskrcaja na/s brod/a, umanjuje valjanost površine luke za ulaznu varijablu izračuna relativne tehničke efikasnosti DEA metodom, u odnosu na njeno korištenje u primjeni metode za kontejnerske luke i terminale [19] [29].

Luka kao prometna podgradnja ne gradi se za prosječnu veličinu potražnje, već se često di-

relative efficiency "1", whereas all other ports compared to it are less efficient with a positive coefficient below "1". The reasons for the best relative efficiency of the Port of Zadar lie in the ratio of the input variables (wharf length and port area) to the output variables (number of passengers and vehicles). As the only efficient port, it is at the same time the reference port to all other ports, which is shown in the "Reference range (λ)". To obtain specific "virtual" ports for the real ones, both input variables of the Port of Zadar are to be proportionally weighted with "value (λ)" in accordance with their output variables. The least efficient sea passenger port is Rijeka with a coefficient of the relative technical efficiency of 0.09280. Here one should bear in mind that this is a relative efficiency of the compared port obtained as the result of empirical measuring, and not the absolute efficiency. The analysis of the obtained coefficients of the relative efficiency reveals their wide range. The results of the ports of Split and Šibenik show lesser deviations from the most efficient Port of Zadar, whereas the ports of Dubrovnik-Gruž and Rijeka show marked deviations. In order to get close to the as factual situations as possible and to perform data comparison by further research, efficiency analysis needs to be made using the BCC method.

In addition to the input/output port variables and their coefficients of the relative efficiency obtained with the DEA CCR-I model, Table 9 in column "Projections of variable for virtual ports" contains the required values of specific input/output variables of the so called "virtual ports" that should be achieved so as each of them can reach the full relative efficiency. Column "Difference" shows the quantity by which an input or output variable needs to be reduced or enlarged to achieve the complete relative efficiency, whereas column "Change needed %" shows such reduction or increase in percentages. Thus, for example, to achieve a complete relative efficiency in the second port by efficiency, Split, the length of wharf should be shortened by 243.72 m or 10.95%, the surface of the port's land area reduced by 61,756.22 sq m or 78.17%, with simultaneous increase of passenger traffic by 23.44%. The deviations of particular ports input variables from the reference port of Zadar-City are observed as reasons for their relative inefficiency i.e. low utilisation of the wharfs and the surfaces.

It is evident from the comparison of all virtual port projections to the factual ones that deviations are most marked in the port surface vari-

menzionira za maksimalnu veličinu očekivane potražnje [24]. U pomorskoputničkim lukama zbog utjecaja turizma sezonske oscilacije su znatne i moguć je njihov utjecaj na promjene odnosa relativne tehničke efikasnosti između luka, a što je predmet daljnjih istraživanja. Dobiveni rezultati korištenjem ulaznih varijabli duljine obale i površine luke s prosječnim godišnjim prometom putnika i vozila ukazuju na odnose relativne tehničke efikasnosti između luka, ali zbog veličine i broja brodova koji vršno opterećuju luku ne mogu se primijeniti u praksi, a naročito izmjene duljine obale.

6. ZAKLJUČAK

U radu je istraživana relativna tehnička efikasnost pomorskoputničkih luka od osobitog interesa za RH. Korištena je metoda omeđivanja podataka – model CCR – orijentiran ulaznim varijablama. Prema dobivenim podacima luka Zadar-grad relativno je tehnički najefikasnija luka, dok je luka Rijeka najmanje efikasna. Alternativno korištenje drugih DEA modela koji su zbog oblika svojih granica efikasnosti bliži realnim situacijama, doprinijelo bi kvalitetnijim rješenjima. Ujedno je potrebno istražiti mogućnosti uvođenja novih ulaznih varijabli koje će bolje reflektirati izlazne varijable putničke luke. Radi utvrđivanja utjecaja sezonskih promjena izlaznih varijabli na promjene relativne tehničke efikasnosti pomorskoputničkih luka, u daljnjim istraživanjima potrebno je analizirati razna godišnja razdoblja korištenjem DEA metode kako bi se dobili usporedni rezultati efikasnosti.

able, where they are above 90% in all ports except for the port of Split, and 97.88% in the least efficient Port of Rijeka. This fact, considering the output variables of the mean annual traffic of passengers and vehicles, indicates unsatisfactory utilisation of the ports' land surfaces. In the attempt to remedy such situation, port authorities use the port surfaces for other non-port purpose such as public car parks, bus terminal, shopping centres or occasional children's amusement parks. This multipurpose utilisation of the port surface, beside the transportation of passengers/vehicles for their embarkation/loading/ and disembarkation/ unloading, diminishes the validity of the port surface as the input variable in measuring the relative technical efficiency with the DEA method in relation to its use in the application of the method for container ports and terminals (Wang et al., 2003; Lin, Tseng, 2005).

A port as a transportation substructure is not constructed for an average quantity of demand, but is often designed for the maximum quantity of the expected demand (Padjen, 1996). Owing to the effect of tourism, seasonal oscillations in sea passenger ports are considerable (Table 4) and they are likely to have an effect on the changes of the relative technical efficiency relations between ports, which is, however, a subject of further research. The results obtained by using the length of the wharf and the surface of the port as input variables with the average annual passenger and vehicle traffic point to the relations of the relative technical efficiency between the ports, but due to the size and number of ships that place the peak load on the port, they cannot be applied in practice, particularly so the changes of the wharf length.

6. CONCLUSION

The study has researched the relative technical efficiency of sea passenger ports of a particular interest to the RC. The method employed was the DEA (data envelopment analysis), CCR model, input-variable oriented. According to the data obtained, the Zadar-City Port is relatively technically the most efficient port, whereas the Port of Rijeka is the least efficient. The alternative use of other DEA models that are closer to factual situations owing to the shape of their efficiency frontiers would contribute to some better solutions. At the same time, it is necessary to examine the possibilities of introducing new input variables that will better reflect the output

variables of a passenger port. For the purpose of defining effects of seasonal changes on changes in the relative technical efficiency of sea passenger ports, it is necessary, in further research, to analyse the different periods of the year by using the DEA method in order to obtain comparative efficiency results.

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