The application of the Lorenz curve in identifying infrastructural deficiencies in the tourist offer of the Republic of Croatia

Ante Toni Vrdoljak

Abstract— This paper demonstrates the application of the Lorenz curve and the Gini coefficient in identifying infrastructural deficiencies in the tourist offer of the Republic of Croatia. In the category of infrastructural development, road traffic is the most dominant form of tourist transport in Croatia. With the construction of the Lorenz curve and calculating the Gini coefficient we can detect the uneven development of the road network and identify it as an infrastructural deficiency.

Index Terms—Gini coefficient, infrastructural development, Lorenz curve

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1 INTRODUCTION

CROATIA is a recognizable and world famous tourist destination and the fact of it is shown in the uninterrupted multiannual growth of guest arrivals and overnight stays. In 2016 we have achieved 16.3 million arrivals and 91.3 million overnight stays [1]. The ratio of the number of inhabitants and the number of overnight stays is 21.89 which puts the Republic of Croatia at the top of the world tourist destinations.

The main influences on the development of tourism are: globalization, socio-demographic changes, ecology, cadres, policy on tourism, the market, technology and economic development [9]. According to new methodology, the Travel and Tourism Competitiveness index [13], contains fourteen pillars divided into four categories: enabling environment, policy and enabling conditions, infrastructure and natural and cultural resources. Three of the pillars are concerned with infrastructure: air transport infrastructure, ground and port infrastructure and tourist service infrastructure.

The availability or the transport interconnection of the destinations and the tourist attractions is of the utmost importance for the travel and tourism sector. Of the entire cross-border traffic, 93.46% (Table 1) falls on users of road traffic so it is justifiable to consider road traffic as the dominant form of transport in the infrastructure category.

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• A. T. Vrdoljak, Associate professor, Faculty of Economics, Business and Tourism, University of Split, Croatia
E-mail: atvrdoljak@gmail.com   avrdol00@efst.hr

TABLE 1
BORDER CROSSING OF VEHICLES AND PASSENGERS

Border crossing of vehicles and passengers (in 000)		% share in total
Road cross-border traffic	76 294	93.46
Railway cross-border traffic	375	0.46
River cross-border traffic	31	0.04
Maritime cross-border traffic	1 441	1.77
Air cross-border traffic	3 489	4.27
Total	81 631	100

Source: Author according to Croatian National Tourist Board, Tourism in figures, 2016 [2].

The role of the government on the macro scale and the cities and municipalities on the micro scale is crucial for the advancement of infrastructural capabilities. The identification of deficiencies in infrastructure is the necessary starting point for removing those same deficiencies. To do that, we will use the Lorenz curve which will demonstrate the degree of inequality between road infrastructure on the county level and the number of overnight tourist stays.

2 DATA AND METHODOLOGY

We don't have much information on developmental coefficients of road infrastructure on the level of cities and municipalities in the Republic of Croatia. There exists only gen-

eral descriptive information on the length of road networks per number of inhabitants and surface area by European Union Road Federation [4]. The regular indicators with which one can measure the level of development of a road network are: the length of the road network, the length of the road network per number of inhabitants and surface area, the scale of motorization and the number of traffic accidents [7]. The data on the length of differently classified public roads (highways, state, county and local roads) are taken from the web-pages of the Ministry of the Sea, Transport and Infrastructure. The data on the number of overnight stays in 2016 are taken from the Croatian Bureau of Statistics and can be found in Table 2.

TABLE 2
TOTAL PUBLIC ROADS AND TOURIST NIGHTS PER COUNTIES

County	high ways	state roads	count y roads	lo-cal roa ds	Total lengt h in km	Tour-ist nights
County of Zagreb	134	263	674	550	1 621	111629
County of Krapina-Zagorje	38	275	405	246	964	215831
County of Sisak-Moslavina	87	385	714	626	1 812	82198
County of Karlovac	83	383	489	538	1 493	395348
County of Varaždin	45	198	446	475	1 164	129882
County of Koprivnica-Križevci	0	273	361	508	1 142	28017
County of Bjelovar-Bilogora	0	298	544	505	1 347	62864
County of Primorje-Gorskikotar	137	518	561	320	1 536	13070148
County of Lika-Senj	118	527	496	650	1 791	2198348
County of Virovitica-Podravina	0	196	365	319	880	28909
County of Požega-Slavonia	0	219	199	263	681	24356
County of Slavonski-Brod-Posavina	128	135	448	195	906	42889
County of Zadar	74	507	563	636	1 780	7816872
County of Osijek-Baranja	72	466	652	485	1 675	158226
County of Šibenik-Knin	43	328	427	327	1 125	4822542
County of Vukovar-Sirmium	50	256	434	204	944	94519
County of Split-Dalmatia	131	763	827	905	2 626	13288805
County of Istra	125	354	619	661	1 759	20966561
County of Dubrovnik-Neretva	81	386	276	339	1 082	6135891
County of Međimurje	22	109	202	227	560	127190
City of Zagreb*	44	28	0	0	72	1804290
Total	1 412	6 867	9 702	8 979	26 960	71605315

*Source: Author according to ''The strategy of transport development of the Republic of Croatia'', Ministry of the Sea, Transport and Infrastructure, 2016 [10]; Croatian Bureau of Statistics," Tourist arrivals and nights in 2016", 2017 [1]; *the City of Zagreb has the status of a county according to the organization of self-governing state units*

We will use the Lorenz curve for the identification of infra-structural deficiencies. The Lorenz curve is a graphical representation of the connection of cumulative percentages of the bearers of income with the cumulative percentages of income aggregate. Max Otto Lorenz developed the curve in 1905 to describe income inequalities and it is closely connected to the concentration index which was introduced by Corrado Gini in 1912.

„The principle features of the Lorenz curve is a geometric figure which visually represents the cumulative proportion of population (x), ranked from the lowest income to the highest income, against the cumulative proportion of income (y) (Figure 1). Lorenz curves are generally convex to they-axis, of which the upper limit is uniform distribution (45 degrees) line when x equals y. Concerning the economics, nearer the Lorenz curve gets to the uniform distribution line, the smaller is the income gap; and vice versa" [11].
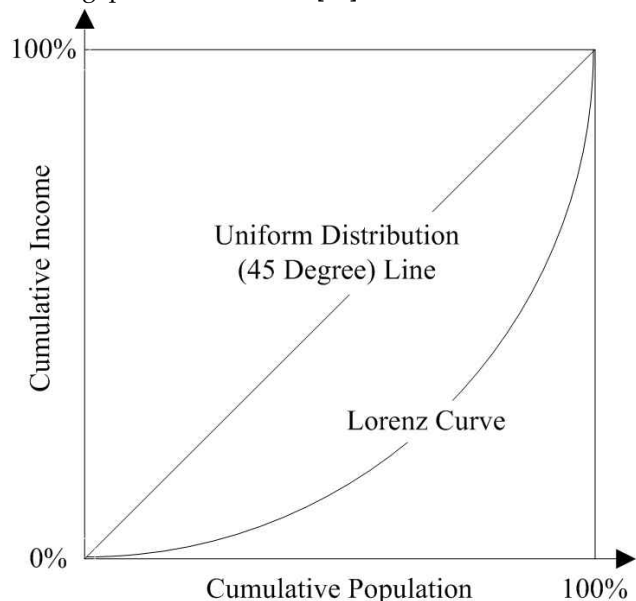

Figure 1. The Lorenz curve

3 RESULTS

In this paper we will construct a curve of cumulative proportions of all road network lengths (as an indicator of the state of road infrastructure development) and the number of overnight tourist stays per county.

First, the proportions of the length of total public roads per county were ranked from the lowest to largest. Second, the cumulative percentage of the product of tourist nights and total length of public roads in a certain county (*y*) was plotted against the cumulative percentage of the total public roads in a certain county (*x*). The resulting Lorenz curve is shown on Figure 2.
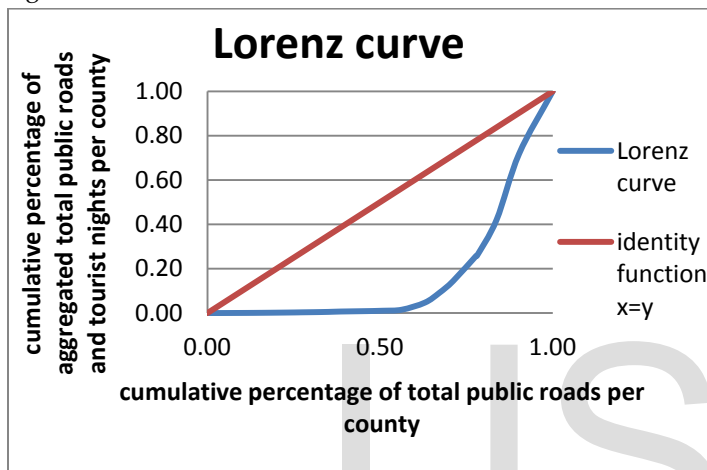

Figure 2. The resulting Lorenz curve

„The Gini coefficient, which is a comprehensive indicator used to quantitatively analyse the income differences, was first proposed by Italian statistician Gini, and equals the ratio between the closed area of the 45 degree line and the Lorenz curve and the area of the right triangle under the 45 degree line. So, the Gini coefficient is in the range between 0 and 1. The more the Gini coefficient closes to 0, the more equal the income distribution is; on the contrary, it will indicate that the difference in income distribution is becoming large. The formula used in this study is as following" [11]:

$$Gini = \sum_{i=1}^{n} (X_{i-1}Y_i - X_iY_{i-1}),$$

where *Xi* is the cumulative percentage of the total public roads per county, and *Yi* is the cumulative percentage of aggregated total public roads and tourist nights per county.

After summing up the differences of these products, we get the Gini coefficient of 66.71%.

4 CONCLUSION

The shape of the Lorenz curve demonstrates a significant disparity between road development (measured in the total length of the road network per counties) and the tourist offer (measured in the number of overnight tourist stays). For instance, the curve shows that 63% of the road network is used by less than 5% of tourists. With a further increase of the percentage of road development the curve becomes extremely steep and leads to the conclusion that the road networks suddenly become congested with tourist traffic. The same measure of unequal distribution is shown by the Gini coefficient which is very high. Further county by county analysis shows a large difference in road development between continental and coastal Croatia according to the number of overnight tourist stays. As expected, the largest number of overnight stays can be found in coastal Croatia, but the connection between continental and coastal Croatia, being the dominant route used by the tourists, is the weakest. Only a few roadways leading ''to the sea'' exist and during the tourist season they are overburdened (HAK 2014-2017). The goal of the government should be to lessen the burden carried by these roads and equalizing road development and the tourist offer. The road network is not sufficiently well-branched and represents a dominant infrastructural deficiency. With a further application of the Lorenz curve we can see infrastructural deficiencies even on the levels of cities and municipalities. The application of the Lorenz curve represents a good starting position for future infrastructural planning and the identification of existing deficiencies.

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