TRAFFIC DEMAND DEVELOPMENT ON CROATIAN MOTORWAYS

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Abstract

The aim of this paper is to research and analyse traffic demand development on Croatian motorways in the period from 2007 to 2018. The purpose of the paper is to produce a forecast of traffic demand development on Croatian motorways until the year 2030 based on the noticed trends. Research results are based on descriptive statistics methods and on the average growth rate method. Major findings of this paper can be of help to traffic managers of all levels.

Key words: traffic, motorways, traffic demand

1. INTRODUCTION

One of the most important changes in the Croatian traffic system is the construction of modern motorways. This is a change supported by numerous policies (economy policy, traffic policy) that has been unfolding for more than two decades. Similar changes have also taken place in countries of the region thus determining both traffic and economic development. In considering the relationship between the offer of traffic infrastructure and traffic demand in the Croatian public and region (Božić, 2011; Dančevska, 2012; Drašković & Drašković, 2016; Marton, 2019) the opinion is permanently present that an inadequate offer of traffic infrastructure is the cause of

lacking traffic demand and that the development strategy using the surplus of infrastructural capacities can create traffic demand and kick-start economic development. National interests in a certain period can justify a certain deviation from congruence of relationships between transport offer and transport demand, however a permanent and only rational traffic policy should be a congruent relationship between transport demand and transport offer (Padjen, 2003). Likewise, the new Traffic Development Strategy of the Republic of Croatia (2017) points out that further development of road network imposes the need to set priorities in terms of profitability of executing sections in accordance with transport needs.

Traffic demand is made apparent in a certain time period and is connected to economic activities (Pupavac, 2017). In some cases, traffic demand is stable and repeating so that it can be forecasted for future period absolutely correctly. In other cases, traffic demand can be unstable and unpredictable so that it is hard to be forecasted as well as it is hard to define an appropriate level of service. Modern social, economic and traffic development is marked with numerous and dramatic changes requiring continuous and repeated questioning of validity and sustainability of decisions that are based on assumptions from the past. In this context, in the Traffic Development Strategy of the Republic of Croatia (1999) for the road traffic forecast until 2010 (2020) annual growth rates of 5, 6 and 7 % are proposed for continental-coastal corridors and 4, 5 and 6 % for continental corridors. Consequently, this paper rests on the position that the decisions on traffic estimation on Croatian motorways were too optimistic and that within themselves they did not contain any possible disorders in traffic demand and economy, which is the main reason for misbalance between the planned and realized traffic. The aim of this paper is to research and analyse traffic demand development on Croatian motorways in the last decade so that we can produce a realistic forecast of traffic demand development on Croatian motorways until the year 2030 based on the noticed trends. The hypothesis of this paper is that future traffic experts' decisions on Croatian motorways business should be based on realized average annual growth rates from 2007 to 2018 since they within themselves include both positive and negative changes in the social, economic and traffic system. In order to prove the hypothesis the methods of descriptive statistics and average growth rate method have been employed.

2. THEORETICAL FRAMEWORK AND RESEARCH PROBLEM

In the 20th and early 21st century many countries experienced a large increase in both number and duration of travel. A significant part of this increased travel number is caused by population increase, income growth, modern infrastructural and supra-structural means and a significant decrease in transport costs. High passengers' and commodities' mobility followed by transit and tourist traffic are major determinants for transport demand in the Republic of Croatia. Falling behind in any of these implies Croatian traffic lagging behind developed European countries.

A particular problem poses an insufficient traffic quantity on road routes, which results in unsatisfactory income from road tolls. This problem has been present not only on motorways owned by the government but also on the motorways managed by

the concession holders. The Republic of Croatia entered into agreements on granting concession for the motorway A8 and A9 and the Učka tunnel to the company Bina-Istra d.d. and the motorway A2 to the company Autocesta Zagreb-Macelj d.o.o. Within the period from 2009 and 2014 the Republic of Croatia paid the private concession holders on the concession agreement account HRK 1 198 984 477. The amounts are paid based on the execution of the concession agreement. In other words, the country of the Republic of Croatia as the concession grantor assumed unfavourable obligations regarding road toll collection, monetary and other guarantees to the concession holders in order that they, due to unsatisfactory expectations in the traffic volume of vehicles and the amount of paid freight rate, may achieve acceptable profitability and opt for the construction of motorways.

With regard to the construction of motorways, world standards are as follows (Samodol, 2002: 1) it is optimal to construct three kilometres of a four-lane motorway on one million inhabitants per year, 2) about 2% is invested into traffic infrastructure including railway, aviation and other per year, 3) a motorway is constructed when its average annual daily traffic lies between 12 000 and 15 000 vehicles, 4) a motorway is not for local traffic. Every 50 km an accessory road is made to not slow down the traffic. The speed should not fall under 80 km/h. Financing motorways with loans takes from 20 to 25 years; 5) a motorway is usually a political decision and the base document is a feasibility study that is a beginning of every decision. In the first half of the project period loans cannot be paid off and every deviation in time and value leads to the cutting of internal profitability rate and brings the project into danger, which leads to investment failure.

Long-term forecasts in the field of road traffic are unrewarding and require the forecasting of life style, taste, development of political situation, new technologies and economic development. A quite illustrative traffic demand development measured by annual daily traffic for a 36-year period through the Učka tunnel is given in Figure 1.

Figure 1. Average annual daily traffic through the Učka tunnel from 1982 to 2018
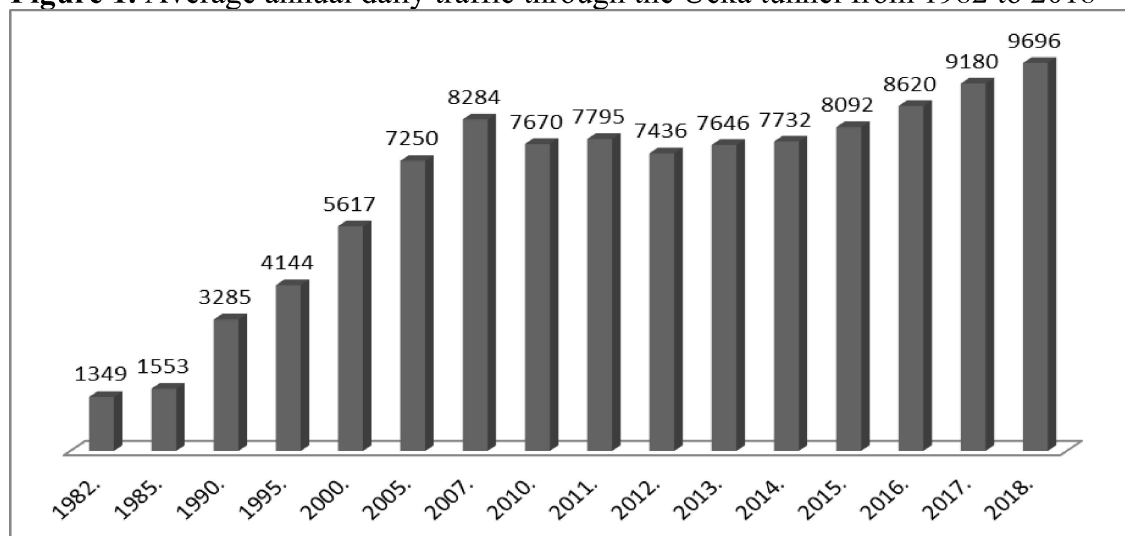
Source: hrvatske-ceste.hr/hr/stranice/promet-i-sigurnost/dokumenti/14-brojenje-prometa
(7.4.2020.)

Based on information from Figure 1 it is evident that average traffic through the Učka tunnel has increased by more than seven times (7,18) in 36 years. Due to the big economic crisis from 2008 the traffic firstly decreased and then stagnated so that average annual daily traffic through the Učka tunnel reached the pre-crisis value not sooner than in 2016. The aforementioned points to the conclusion that a century was lost. Afterwards, traffic growth increases heavily and terms and conditions from the concession agreement between the Republic of Croatia and Bina Istra are met defining that the four-lane motorway will be constructed when the number of vehicles through the Učka tunnel reaches 10.000 vehicles a day and in the tourist season 16.000. In other words, in the most frequent tourist season days already in the crisis period more than 14 thousand vehicles a day passed through the Učka tunnel (cf. figure 2).

Figure 2. Peak daily traffic through the Učka tunnel (vehicles/day)
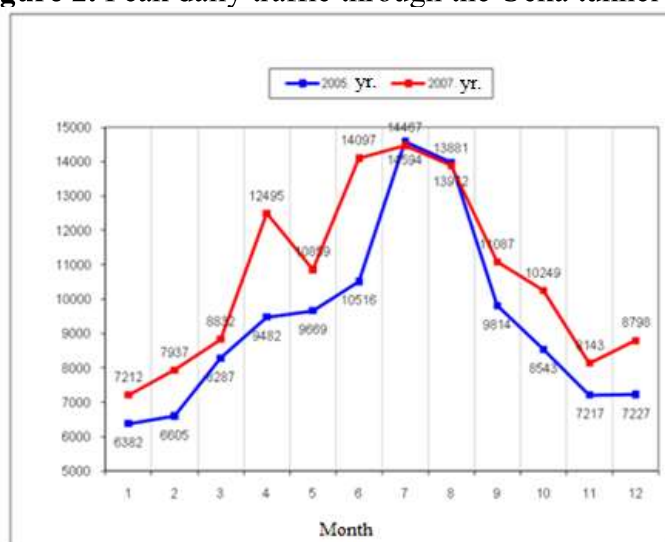
	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Month
21.	11.	24.	29.	25.	24.	30.	12.	02.	28.	04.	23.	Date 2005
19.	23.	16.	27.	25.	21.	27.	03.	07.	05.	09.	21.	Date 2007

Source: Prepared by author according to: http://www.istra-istria.hr

Based on Figure 2 a negative effect of the 2008 economic crisis is evident on traffic demand development measured by the number of vehicles passing through the Učka tunnel and the effect of the recent crisis caused by the Covid-19 virus will be even bigger when taken in the short term. The negative effect of the 2008 economic crisis measured by average annual daily traffic was evident on almost all Croatian motorways (cf. Table 1).

Table 1. Average annual daily traffic on Croatian motorways, 2007-2014

Motorway	2007	2008	2009	2010	2011	2012	2013	2014	2014/2008
A1 Zagreb-Split-Ploče	12643	12814	11968	11941	12827	12001	12242	12566	-1,93538
A2 Zagreb-Macelj	14341	13359	11133	11087	11039	11696	12216	11645	-12,8303
A3 Bregana-Zagreb-Lipovac	15000	15387	14611	14289	14387	13542	13865	14085	-8,46169

A4 Zagreb-Goričan	7219	7820	7560	7053	7294	6657	6749	6931	-11,3683
A5 Beli Manastir-Osijek-BiH	2196	2735	2793	2437	2534	2379	2383	2430	-11,1517
A6 Rijeka-Zagreb	11075	11645	11678	11293	11767	11055	11058	11239	-3,48647
A7 Rupa-Križišće	7051	6781	10041	10916	11487	14337	14431	14661	116,207

Source: Traffic count on roads of the Republic of Croatia, Hrvatske ceste, d.o.o., Zagreb, 2015.

Based on information from Table 1 negative traffic growth on the Croatian motorway network is evident for the period from 2008 to 2014. Negative traffic growth corresponds to negative economic trends in the Republic of Croatia. To bear this in mind is important since the accuracy of forecasting traffic demand is rather low in practice (Quinet, 2008). For example, traffic growth on the motorway Rijeka – Zagreb (A6) is planned at the annual rate of 4,5% from 2010 to 2020 and onwards. However, this traffic growth unfortunately has failed to come and consequently income from road tolls.   Similarly, realized average annual traffic in the year 2017 on the motorway A1, for example, for selected sections (Bosiljevo2 - Ogulin, Ogulin - Brinje, Posedarje – Zadar, Vučevica – Dugopolje) was by 24,86% smaller than forecasted (Rupčić,2019). Accordingly, this period can be called the period of decrease and stagnation for Croatian motorways as well as the period to think seriously about monetizing and privatizing Croatian motorways (Kosor, 2013).

The growth of average traffic and traffic income that followed after 2015 was abruptly stopped by the pandemic caused by the Covid-19 virus that emptied motorways both in Croatia and other European countries. In April 2020 traffic on Croatian motorways was smaller by 75 and paid road tolls by 71 percent. In Austria traffic decreased by 80 % on motorways and in Great Britain traffic came down to traffic from 1955. Here an inevitable question arises as to whether Croatian motorways are able to respond to that challenge and whether traffic can be increased after the pandemic in the long term.

3. DATA AND METHODS

To palpably present traffic demand development on selected motorways in the Republic of Croatia shown by average annual daily traffic, information given in Table 2 are taken as a starting point.

Table 2. Average annual daily traffic on Croatian motorways, 2007 - 2018

Motor way	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
A1	126 43	128 14	119 68	119 41	128 27	120 01	122 42	125 66	13. 128	14. 051	15. 140	15. 810
A2	143 41	133 59	111 33	110 87	110 39	116 96	122 16	116 45	12. 243	12. 819	12. 975	13. 409

A3	150 00	153 87	146 11	142 89	143 87	135 42	138 65	140 85	14. 740	15. 807	16. 216	17. 093
A4	721 9	782 0	756 0	705 3	729 4	665 7	674 9	693 1	7.3 33	8.0 10	8.7 22	9.2 18
A5	219 6	273 5	279 3	243 7	253 4	237 9	238 3	243 0	2.5 59	2.8 32	2.9 64	3.1 85
A6	110 75	116 45	116 78	112 93	117 67	110 55	110 58	112 39	11. 893	12. 783	13. 554	14. 228
A7	705 1	678 1	100 41	109 16	114 87	143 37	144 31	146 61	15. 054	14. 408	16. 356	18. 798
Total	695 25	705 41	697 84	690 16	713 35	716 67	729 44	735 57	769 50	807 10	859 27	917 41

Source: Traffic count on roads of the Republic of Croatia, Hrvatske ceste, d.o.o., Zagreb, 2019.

On the basis of collected data from Table 3, firstly the total realized traffic for selected motorways for the period from 2007 to 2008 will be analysed with descriptive statistics methods. Afterwards, average annual growth rates of total traffic on the indicated seven motorways will be defined and then for every respective motorway separately and then, based on the growth rate method, the average annual daily traffic for all indicated seven motorways respectively until the year 2030 will be estimated.

Average annual growth rates for the indicated period will be calculated according to the formula

$$i = \sqrt[n]{\frac{X2018}{X2007}} \qquad (1)$$

where the following symbols stand for:
i – average annual growth rate
X_{2018} – average annual daily traffic in the year 2018
X_{2007} - average annual daily traffic in the year 2007
n – number of years in the observed period (11)

Estimation of average annual daily traffic (AADT) on single motorways will be calculated according to the formula

$$AADT = X_{2018} \times (1 + i)^n \qquad (2)$$

4. RESEARCH RESULTS AND DISCUSSION

Total average annual daily traffic on selected Croatian motorways spanned a range as shown in Figure 3.

Figure 3. Range of total average annual daily traffic on selected Croatian motorways, 2007 − 2018.
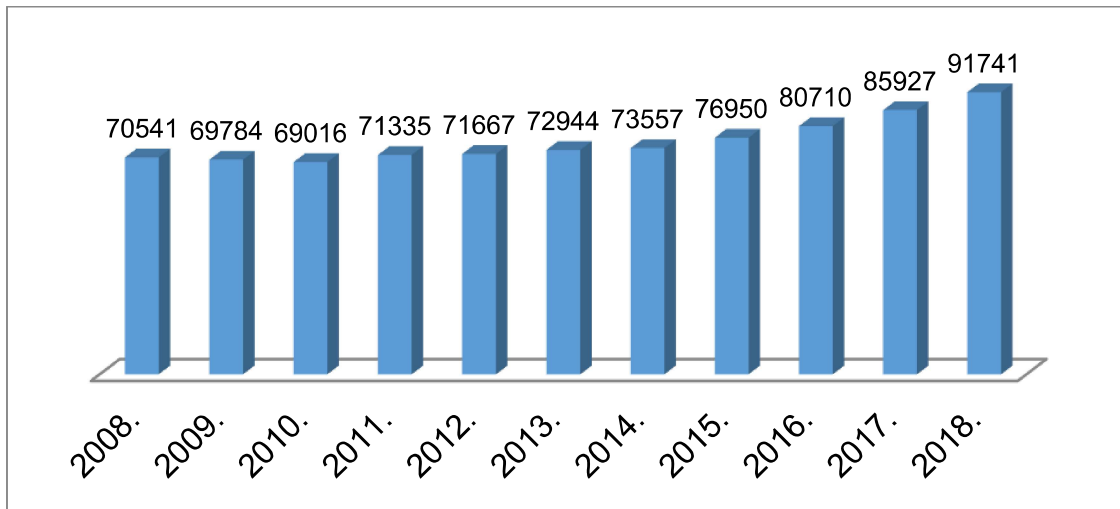
Pursuant to the Graph in the period from 2007 to 2015 stagnation of average annual daily traffic on Croatian motorways is evident. After 2015 a significant growth of average annual daily traffic is evident so that total average annual daily traffic in the year 2018 was bigger by 14 791 vehicles. The smallest total average annual daily traffic amounted to 69 016 vehicles in the year 2010 and the biggest of 91 741 vehicles in the year 2018 (cf. table 3). The total average annual daily traffic on seven selected Croatian motorways amounted to 75 308 vehicles (SD=7 253).

Table 3. Descriptive statistics of the total average annual daily traffic on selected Croatian motorways

Mean	75308,08
Standard Error	2093,735
Median	72305,5
Standard Deviation	7252,91
Minimum	69016
Maximum	91741
Sum	903697
Count	12
Confidence Level (95,0%)	4608,279

Based on the data from Table 1 the total growth percentage and average annual growth rate on selected motorways for the period from 2007 to 2018 were calculated (cf. table 4).

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Table 4. Realized growth rate and average annual growth rate on selected motorways

Motorway	Realized growth rate 2018/2007	and – average annual growth rate in the period 2007-2018
A1	25,04943	2,05%
A2	-6,49885	-0,61%
A3	13,95333	1,19%
A4	27,69082	2,25%
A5	45,03643	3,44%
A6	28,46953	2,30%
A7	166,6005	9,32%
Total	31,95397	2,55%

Based on the data from Table 4 it is evident that the negative growth of average annual daily traffic was recorded only on the motorway A2. The biggest growth rate was recorded on the motorway A7 that represents the extension of Rijeka bypass as one of the most congested roads in the Republic of Croatia.

Based on the calculated average annual growth rates and by applying the formula (2), the average annual daily traffic on selected Croatian motorways for the years 2025 and 2030 was estimated (cf. Table 5).

Table 5. Estimation of average annual traffic on selected Croatian motorways

Motorway	X_{2018}	1+i	2025	2030
A1	15.810	1,02053	18227	20176
A2	13.409	0,99391	12848	12461
A3	17.093	1,011945	18574	19711
A4	9.218	1,022471	10769	12035
A5	3.185	1,034379	4035	4778
A6	14.228	1,023036	16687	18700
A7	18.798	1,093238	35084	54788
Total	91.741	1,025528	109445	124146

According to estimations produced, the motorway A7, which so far has been constructed only from Rijeka to Križišće, will record the biggest annual daily traffic in the year   2030 and the motorway A5 counting only 4778 vehicles will record the smallest average annual daily traffic. The average annual daily traffic on the motorway A5 will still be insufficient i.e. possibilities of this motorway will stay unused. The average annual daily traffic on the motorway A2 will show a slight

decrease in the following period. The total average annual daily traffic could be increased by 35.35 %.

5. CONCLUSION

On the basis of the results obtained in this paper a conclusion can be drawn that the traffic on Croatian motorways, measured by average annual daily traffic, will show a growth trend. The total average annual daily traffic on observed seven motorways could be increased from 91 741 to 124 146 or by 32 405. In order to increase traffic demand significantly it is necessary to finish the motorway network in the Republic of Croatia but also the motorway network in its surroundings in order to use the current potentials of the Croatian motorway network as much as possible. Specifically, in the following period traffic on certain motorways could continue to be under the profitability rate. The main deficiency of this paper is that it doesn't take into consideration traffic demand factors such as the number and structure of population, income amount, material production and consumption, geographical and traffic position of the country as it rests only on secondary data on traffic demand trends in the past.   In future researches, the emphasis should be placed on identifying basic factors that will form future traffic demand on Croatian motorways and putting these factors into the context of future traffic requirements.

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